2013 38th International Conference on Infrared, Millimeter, and Terahertz Waves

(IRMMW-THz 2013)

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1 - 6 September 2013

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Mainz, September 1 - 6, 2013

Wednesday, September 4

	Congress Hall				
08:55 - 09:50	Plenary Talk We-Pl1 and **K. J. Button Prize Ceremony**				
09:50 - 10:35	Plenary Talk We-Pl2				
10:35 - 11:00	Coffee Break (Rhein Foyer)				
	Gutenberg 1	Gutenberg 2	Gutenberg 3	Gutenberg 4	Congress Hall
11:00 - 12:30	**We1** High Power Sources 5	**We2** Photomixers	**We3** THz Metamaterials	**We4** Detectors 5	
12:30 - 14:00	Lunch Break (on your own)				
14:00 - 15: 30	**We5** High Power Sources 6	**We6** Waveguides 1	**We7** Metamaterial Symp. 1	**We8** THz Spectr. Systems 2	**We9** Remote Detec. & Imag.
15:30 - 16:00	Coffee Break (Rhein Foyer)				
16:00 - 17:30	**We10** THz Metrology	**We11** Waveguides 2	**We12** Metamaterial Symp. 2	**We13** THz Spectr. Systems 3	**We14** Near field imaging
17:30 - 19:00	Poster Session P2 (Rhein Foyer West)				

Thursday, September 5

	Congress Hall				
08:55 - 09:50	Plenary Talk Th-Pl1 and **Best Student Paper Prize**				
09:50 - 10:35	PlenaryTalk Th-Pl2				
10:35 - 11:00	Coffee Break (Rhein Foyer)				
	Gutenberg 1	Gutenberg 2	Gutenberg 3	Gutenberg 4	Congress Hall
11:00 - 12:30	**Th1** Graphene 2	**Th2** Metal Meshes	**Th3** THz Spectr.: Liquids	**Th4** Imaging	
12:30 - 14:00	Lunch Break (on your own)				
14:00 - 15: 30	**Th5** Electr. Sourc. & Detec.	**Th6** Solid State Physics	**Th7** Quasi-optical Devices	**Th8** Sensing	
15:30 - 16:00	Coffee Break (Rhein Foyer)				
16:00 - 17:30	**Th10** Mixers	**Th11** Superconductors	**Th12** THz Spectr.: Semico. 1	**Th13** Non-destructive Test.	
17:30 - 18:45	Poster Session P3 (Rhein Foyer West)				
19:00 - 23:00	Conference Dinner				

Friday, September 5

	Congress Hall				
09:00 - 09:45	Plenary Talk Fr-Pl1				
09:45 - 10:30	Plenary Talk Fr-Pl2				
10:30 - 11:00	Coffee Break (Rhein Foyer)				
	Gutenberg 1	Gutenberg 2	Gutenberg 3	Gutenberg 4	Congress Hall
11:00 - 12:30	**Fr1** THz Spectroscopy 2	**Fr2** THz Spectr.: Semico. 2	**Fr3** Parametric Sources	**Fr4** Modulators	
12:45 - 13:00	Concluding remarks (Congress Hall)				

Monday	Congress Hall
	Opening Ceremony and Plenary Session
09:00 – 09:30	**Welcome** René Beigang, *Conference chair* Gian Piero Gallerano, *IRMMW-THz Society chair* Burkard Hillebrands, *University of Kaiserslautern* Karsten Buse, *Fraunhofer IPM* **Opening of the conference** Malu Dreyer, *Minister President of the State of Rhineland-Palatinate*
09:30 – 10:15	Plenary session Mo-Pl1 **Infrared Nanoscopy And Nanospectroscopy - From Nanoscale Chemical Identification Of Polymers To Real-Space Imaging Of Graphene Plasmons** *Rainer Hillenbrand* *CIC nanoGUNE, Spain*
10:15 – 11:00	Plenary session Mo-Pl2 **Discoveries Of New Interstellar Molecules In The Last Decade With Sub-Millimeter Spectroscopy In Space** *Di Li* *National Astronomical Observatories, China* *Space Science Institute, USA*
11:00 – 11:30	**Coffee Break (Rhein Foyer)**

Monday	Gutenberg 1	Gutenberg 2
	Mo1 High Power Sources 1	**Mo2 Novel THz Emitters 1**
11:30 – 11:45	Mo1-1 (invited talk) **Overview Of Fusion Gyrotron Development Programs At 110 GHz, 117.5 GHz, 140 GHz, And 170 GHz** *Stephen Cauffman; Monica Blank; Philipp Borchard; Kevin Felch* *Communications & Power Industries, United States*	Mo2-1 **Steerable Emission Of THz Radiation By Optical Coherent Control** *Heiko Füser; Mark Bieler* *Physikalisch-Technische Bundesanstalt, Germany*
11:45 – 12:00		Mo2-2 **Broadband Terahertz Wave Generation From Ridge Waveguide** *Kei Takeya[1]; Shuzhen Fan[1]; Hajime Takeuchi[1]; Kodo Kawase[2]* *[1]Nagoya University, Japan; [2]Nagoya University and RIKEN, Japan;*
12:00 – 12:15	Mo1-3 **Installation Of A 154 GHz Mega-Watt Gyrotron And Its Contribution To The Extension Of Plasma Parameter Regime In LHD** *Takashi Shimozuma[1]; Hiromi Takahashi[1]; Satoshi Ito[1]; Shin Kubo[1]; Yasuo Yoshimura[1]; Hiroe Igami[1]; Masaki Nishiura[1]; Shinya Ogasawara[2]; Ryohei Makino[2] et al.* *[1]National Institute for Fusion Science, Japan; [2]Nagoya University, Japan*	Mo2-3 **Experimental Demonstration Of Phase-Matched THz Generation In Plasma-Activated Silicon Nano-Photonic Emitters** *Simon Sawallich; Christopher Matheisen; Michael Nagel; Thorsten Wahlbrink; Jens Bolten; Heinrich Kurz* *AMO GmbH, Germany*

Gutenberg 3	Gutenberg 4	Congress Hall
Mo3 THz Optics	**Mo4 Detectors 1**	
Mo3-1 **Longitudinal Fields In Focused Terahertz Beams** *Stephan Winnerl; Ralf Hubrich; Martin Mittendorff; Harald Schneider; Manfred Helm* *Helmholtz-Zentrum Dresden-Rossendorf, Germany*	Mo4-1 (invited talk) **Toward Low-NEP Room-Temperature THz MOSFET Direct Detectors In CMOS Technology** *Janusz Grzyb[1]; Hani Sherry[2]; Andreia Cathelin[2]; Andreas Kaiser[3]; Ullrich Pfeiffer[1]* *[1]University of Wuppertal, Germany; [2]STMicroelectronics, France; [3]ISEN/IEMN, France*	
Mo3-2 **Hartmann Sensor For Wavefront Measurements At Terahertz Frequencies** *Michael Greiner-Bär[1]; Heiko Richter[1]; Nils Deßmann[1]; Johannes Pfund[2]; Martin Wienold[3]; Lutz Schrottke[3]; Holger T. Grahn[3]; Heinz-Wilhelm Hübers[1]* *[1]DLR, Germany; [2]Optocraft, Germany; [3]PDI, Germany*		
Mo3-3 **Development Of High-Efficiency Etalons With An Optical Shutter For Terahertz Laser Pulses** *Masaaki Tsubouchi; Takayuki Kumada* *Japan Atomic Energy Agency, Japan*	Mo4-3 **Noise Performance Of RTD-Gated Plasma-Wave HEMT THz Detectors** *Jimy Encomendero Risco[1]; Berardi Sensale Rodriguez[2]; Huili Grace Xing[1]* *[1]University of Notre Dame, United States; [2]University of Utah and University of Notre Dame, United States*	

Monday	Gutenberg 1	Gutenberg 2
	Mo1 High Power Sources 1	**Mo2 Novel THz Emitters 1**
12:15 – 12:30	Mo1-4 **460 GHz Second Harmonic Gyrotrons For A 700 MHz DNP-NMR Spectroscopy** *Toshitaka Idehara[1]; Yoshinori Tatematsu[1]; Y. Yamaguchi[1]; R. Ikeda[1]; I. Ogawa[1]; T. Saito[1]; Y. Matsuki[2]; K. Ueda[2]; T. Fujiwara[2]; M. Toda[3]* *[1]University of Fukui, Japan; [2]Osaka University, Japan; [3]JEOL Resonance Co., Ltd, Japan*	Mo2-4 **Enhanced Terahertz Emission From Ultrathin Semiconductor Films** *Gopakumar Ramakrishnan; Gopika Ramanandan; Aurèle Adam; Paul Planken* *Delft University of Technology, Netherlands*
12:30 – 12:45	Mo1-5 **Experiment-Theory Comparison Of Non-Stationary And Chaotic Regimes In Gyrotrons** *Falk Braunmueller; Jeremy Genoud; Stefano Alberti; Jean-Philippe Hogge; Minh Quang Tran; Trach-Minh Tran; Quentin Vuillemin* *CRPP (EPFL), Switzerland*	Mo2-5 **Terahertz Emission Spectroscopy Of InAs Nanowires** *Gyuseok Lee[1]; Meehyun Lim[1]; Youngwoong Do[1]; Soonsung Lee[1]; Hyeona Kang[1]; Jae Cheol Shin[2]; Haewook Han[1]* *[1]POSTECH, Republic of Korea; [2]Photonics-Energy center, Korea Photonics Technology Institute, Republic of Korea*
12:45 – 13:00	Mo1-6 **Optimization And 3D Analysis Of High Frequency Gyrotrons** *Mikhail Glyavin[1,3]; Gregory Nusinovich[2]; Naum Ginzburg[1,3]; A. G. Luchinin[1]; V. N. Manuilov[1,3]; A. S. Sedov[1]; N. A. Zavolsky[1] et al.* *[1]Institute of Applied Physics RAS, Russian Federation; [2]IREAP, University of Maryland, United States; [3]Nizhny Novgorod State University, Russian Federation*	Mo2-6 **Terahertz Emission From Vertically-Aligned Single-Walled Carbon Nanotube Films** *Meehyun Lim[1]; Gyusoek Lee[1]; Theerapol Thurakitseree[2]; Shigeo Maruyama[2]; Ikmo Park[3]; Haewook Han[1]* *[1]POSTECH, Republic of Korea; [2]University of Tokyo, Japan; [3]Ajou University, Republic of Korea*
13:00 – 14:00	**Lunch (on your own)**	

Gutenberg 3	Gutenberg 4	Congress Hall
Mo3 THz Optics	**Mo4 Detectors 1**	
Mo3-4 **Evidence Of THz Diffraction By Fabrics** *Emilie Herault; Maxence Hofman; Frederic Garet; Jean-Louis Coutaz* *IMEP-LAHC, France*	Mo4-4 **Room Conditions THz Detector Using Graphene FET** *Akram Mahjoub; Yuichi Ochiai* *Chiba University, Japan*	
Mo3-5 **Double Fourier Modulation For A TeraHertz Space Interferometer** *G. M. Klemencic[1], for the FP7-FISICA Consortium[2]* *[1]Cardiff University, United Kingdom; [2]http://www.fp7-fisica.eu/*	Mo4-5 **Characterization Of A Glow Discharge Detector With Terahertz Time Domain Spectroscopy** *Kamil Cinar[1]; Hakan Altan[1]; Asaf Behzat Sahin[2]* *[1]Middle East Technical University, Turkey; [2]Yildirim Beyazit University, Turkey*	
	Mo4-6 **THz Leaky Lens Antenna Coupled KIDs For Broadband Imaging And Spectroscopy** *Andrea Neto[1]; Nuria Llombart[1]; Jochem Baselmans[2]; Stephen Yates[2]; Andrey Baryshev[2]* *[1]TU Delft, Netherlands;* *[2]SRON, Netherlands*	
Lunch (on your own)		

Monday	Gutenberg 1	Gutenberg 2
	Mo5 High-Power Sources 2	**Mo6 Novel THz Emitters 2**
14:00 – 14:15	Mo5-1 (invited talk) **Progress Of High Power Long Pulse Gyrotron For Fusion Application** *Keishi Sakamoto; Ken Kajiwara; Yasuhisa Oda; Kazuo Hayashi; Ryosuke Ikeda; Koji Takahashi; Takayuki Kobayashi; Shinichi Moriyama* *Japan Atomic Energy Agency, Japan*	Mo6-1 **THz Radiation From Magneto-Optically Induced Ultrafast Photocurrents In Bulk GaAs** *Christian B. Schmidt; Shekhar Priyadarshi; Mark Bieler* *Physikalisch-Technische-Bundesanstalt, Germany*
14:15 – 14:30		Mo6-2 **Plasmonic Gratings For Enhanced THz Emission From Metalsemiconductor Thin Films** *Gopika Ramanandan; Aurèle Adam; Paul Planken* *Delft University of Technology, Netherlands*
14:30 – 14:45	Mo5-3 (invited talk) **Experiment For Over 200 kW Oscillation Of A 295 GHz Pulse Gyrotron** *Teruo Saito[1]; Yuusuke Yamaguchi[1]; Shinji Ikeuchi[1]; Yoshinori Tatematsu[1]; Ryosuke Ikeda[1]; Isamu Ogawa[1]; Toshitaka Idehara[1]; Shin Kubo[2]; Takashi Shimozuma[2];Masaki Nishiura[2]; Kenji Tanaka[2]; Jun Kasa[1]* *[1]University of Fukui, Japan; [2]National Institute for Fusion Science, Japan*	Mo6-3 **Intense And Ultra-Broadband Terahertz Generation From Metal Foil** *Cunlin Zhang; Liangliang Zhang; Kaijun Mu* *Capital Normal University, China*

Gutenberg 3	Gutenberg 4	Congress Hall
Mo7 QCLs 1	**Mo8 Detectors 2**	**Mo9 THz Spectr.: Biomolec.**
Mo7-1 (invited talk) **Fast, Sensitive And Low-Noise Nanowire And Graphene Field Effect Transistors For Room-Temperature Detection Of THz Quantum Cascade Lasers Emission** *Miriam Serena Vitiello[1]; D. Coquillat[2]; L. Viti[1]; L. Romeo[1]; L. Vicarelli[1]; D. Ercolani[1]; A. C. Ferrari[3]; M. Polini[1]; L. Sorba[1]; V. Pellegrini[1]; W. Knap[2]; A. Tredicucci[1]* *[1]NEST, Istituto Nanoscienze-CNR and Scuola Normale Superiore, Italy; [2]Université Montpellier 2 and CNRS, France; [3]Engineering Department, Cambridge University, United Kingdom*	Mo8-1 (invited talk) **A Micro-Cantilever Based Photoacoustic Detector Of Terahertz Radiation For Chemical Sensing** *Ivan Medvedev[1]; Douglas Petkie[1]; Ronald Coutu[2]; Nathan Glauvitz[2]* *[1]Wright State University, United States; [2]Air Force Institute of Technology, United States*	Mo9-1 **Crystallization Of Sucrose Monitored By Terahertz Pulsed Spectroscopy** *Philip Taday; Rob May* *TeraView, United Kingdom* Mo9-2 **Terahertz Spectroscopy Of Cyanobenzaldehyde Isomers** *Shaumik Ray[1]; Jyotirmayee Dash[1]; Kathirvel Nallappan[1]; Ashootosh Ambade[2]; Kavita Joshi[2]; Vaibhav Kaware[3]; Bala Pesala[1]* *[1]CSIR-CEERI, India; [2]CSIR-NCL, India; [3]National Chemical Laboratory, India*
Mo7-3 (invited talk) **High Power Terahertz Quantum Cascade Laser At 63 µm** *Dana Turcinkova; Keita Otani; Giacomo Scalari; Mattias Beck; Jerome Faist* *ETH Zurich/Institute for Quantum Electronics, Switzerland*	Mo8-3 **Superconducting High-T_c Hot Electron Bolometers Used As THz Mixers: Predicted Performance By Hot Spot Modeling** *Alain Kreisler; Romain Ladret; Annick Degardin* *SUPELEC - LGEP, France*	Mo9-3 **Experimental And Theoretical Studies On THz Spectra Of Phenylthiourea Compounds** *Zhang Di[1]; Zhilong Ding[1]; Tiantian Guo[1]; Jun Zhou[1]; Xianlong Wang[2]; Junsheng Yu[2]; Xiaodong Chen[1]* *[1]Terahertz Science and Technology Research Center, China; [2]School of Life Science and Technology, UESTC, China*

Monday	Gutenberg 1	Gutenberg 2
	Mo5 High-Power Sources 2	**Mo6 Novel THz Emitters 2**
14:45 – 15:00		Mo6-4 **THz-Emission Probe Of Surface-Electronic Transitions In A Topological Insulator** *Li-Guo Zhu* *Institute of Fluid Physics, China Academy of Engineering Physics, China*
15:00 – 15:15	Mo5-5 **2 MW Cw RF Load For Gyrotrons** *Lawrence Ives[1]; Maxwell Mizuhara[1]; Philipp Borchard[2]; Jeffrey Neilson[3]; George Collins[1]; Takayuki Kobayashi[4]; Shinichi Moriyama[4]* *[1]Calabazas Creek Research, Inc., United States; [2]Dymenso LLC, United States; [3]Lexam Research, United States; [4]Japan Atomic Energy Agency, Japan*	Mo6-5 **THz Emission Of Narrow-Gap HgCdTe Films And HgTe/CdTe Quantum Wells Structures** *Sergey Morozov[1]; Vladimir Gavrilenko[1]; Vladimir Rumyantsev[1]; Kirill Marem'yanin[1]; Alexandr Antonov[1]; Ludmila Krasil'nikova[1]; Nikolay Mihailov[2];* *[1]IPM RAS, Russian Federation; [2]ISP SB RAS, Russian Federation*
15:15 – 15:30		Mo6-6 **PIC Simulations And Experimental Design Of A Cherenkov Millimetre-Wave Source** *Alan Phipps[1]; Amy MacLachlan[1]; Craig Robertson[1]; Ivan Konoplev[2]; Alan Phelps[1]; Adrian Cross[1]* *[1]University of Strathclyde, United Kingdom; [2]University of Oxford, United Kingdom*
15:30 – 16:00	**Coffee Break (Rhein Foyer)**	

Gutenberg 3	Gutenberg 4	Congress Hall
Mo7 QCLs 1	**Mo8 Detectors 2**	**Mo9 THz Spectr.: Biomolec.**
	Mo8-4 **Design And Characterization Of A TES Bolometer For Fourier Transform Spectroscopy In The FIR** *Mathias Kehrt; Jörn Beyer; Christian Monte; Jörg Hollandt* *Physikalisch-Technische Bundesanstalt, Germany*	Mo9-4 **Quantitative Study Of Lipid Head Group Structure Effect On Long-Range Hydration Dynamics With Terahertz Spectroscopy** *Da-Hye Choi[1]; Heyjin Son[1]; Seonghoon Jung[2]; Jaehun Park[2]; Gun-Sik Park[1]* *[1]Seoul National University, Republic of Korea; [2]Pohang Accelerator Laboratory, Republic of Korea*
Mo7-5 **1.9 THz Indirect Injection $Al_{0.175}Ga_{0.825}As/GaAs$ Quantum Cascade Laser Operating At Extreme Higher Temperature** *Tsung-Tse Lin; Miho Sasaki; Hideki Hirayama* *RIKEN, Japan*	Mo8-5 **Performance Of The Antenna Coupled Micro-Bolometers Characterized By The Quasi-Optical Measurements At Frequencies 0.1-1.0 THz** *Irmantas Kasalynas[1]; Andrej Svigelj[2]; Juozas Adamonis[1]; Vladimir Kornijcuk[1]; Ramunas Adomavicius[1]; Arūnas Krotkus[1] et al.* *[1]Center for Physical Sciences and Technology, Lithuania; [2]University of Ljubljana, Slowenia*	Mo9-5 **Analysis Of Hydration And Dehydration On Xanthine Related Compounds During Pharmaceutical Granulation Process Using Terahertz Spectroscopy** *Tomoaki Sakamoto[1]; Tetsuo Sasaki[2]; Hiroko Kimura[2]; Yukio Hiyama[1]; Noriko Katori[1]; Haruhiro Okuda[1]* *[1]National Institute of Health Sciences, Japan; [2]Shizuoka University, Japan*
Mo7-6 **High-Frequency Modulation Spectroscopy With A THz Quantum-Cascade Laser** *René Eichholz[1]; Heiko Richter[1]; Martin Wienold[2]; Lutz Schrottke[2]; Holger T. Grahn[2]; Heinz-Wilhelm Hübers[1]* *[1]German Aerospace Center, Germany; [2]Paul-Drude-Institut für Festkörperphysik, Germany*	Mo8-6 **Fast Room Temperature THz Bolometers** *Sergey Cherednichenko; Stella Bevilacqua* *Chalmers University of Technology, Sweden*	Mo9-6 **Secondary Structure Evident In The Far Infrared Spectra Of Peptides** *Robert Falconer[1]; Anton Middelberg[2]; Tao Ding[3]* *[1]University of Sheffield, United Kingdom; [2]University of Queensland, Australia; [3]National University of Singapore, Singapore*
Coffee Break (Rhein Foyer)		

Monday	Gutenberg 1	Gutenberg 2
	Mo10 High-Power Sources 3	**Mo11 THz Commun. 1**
16:00 – 16:15	Mo10-1 **233 GHz Ultra-Wide Band TWTA: PPM Integrated Sheet Electron Beam Transport And PIC Analysis** *Anisullah Baig; Diana Gamzina; Larry Barnett; Calvin Domier; Neville Luhmann* *University of California - Davis, United States*	Mo11-1 (invited talk) **22 Gbps Wireless Communication System At 0.4 THz** *Guillaume Ducournau[1]; Pascal Szriftgiser[2]; Fabio Pavanello[1]; Philip Latzel[1]; Alexandre Beck[1]; Tahsin Akalin[1]; Emilien Peytavit[1]; Mohammed Zaknoune[1]; Denis Bacquet[1]; Jean-François Lampin[1]* *[1]IEMN, France; [2]PhLAM, France*
16:15 – 16:30	Mo10-2 **Reflection Of Gyrotron TE_{0n} Modes At Open-Ended Circular Waveguide** *Manfred Thumm[1]; Walter Kasparek[2]; Dietmar Wagner[3]; Andreas Wien[4]* *[1]Karlsruhe Institute of Technology (KIT), Germany; [2]University of Stuttgart, IGVP, Germany; [3]Max-Planck-Institute for Plasma Physics, Germany; [4]IMST GmbH, Germany*	
16:30 – 16:45	Mo10-3 **KIT Gyrotron Development For Future Fusion Applications** *John Jelonnek; Kostas Avramidis; Joachim Franck; Gerd Gantenbein; Klaus Hesch; Stefan Illy; Jianbo Jin; Anton Malygin; Ioannis Pagonakis; Tomasz Rzesnicki; Andrey Samartsev; Theo Scherer; Andreas Schlaich; Martin Schmid et al.* *Karlsruhe Institute of Technology (KIT), Germany*	Mo11-3 **200 GHz Communication System Using Unipolar InAs THz Rectifiers** *Guillaume Ducournau[1]; Andreas Westlund[2]; Paul Sangaré[1]; Christophe Gaquière[1]; Per-Ake Nislon[2]; Ludovic Desplanque[1]; Jean-Louis Codron[1]; Xavier Wallart[1]; Ignacio Iniguez de La Torre[3]; Jeff Millithaler[3] et al.* *[1]IEMN, France; [2]CHALMERS, Sweden; [3]Univ. Salamanca, Spain;*

Gutenberg 3	Gutenberg 4	Congress Hall
Mo12 QCLs 2	**Mo13 THz Cameras**	**Mo14 THz Spectr. Systems 1**
Mo12-1 (invited talk) **High Performance Room-Temperature Terahertz Intracavity Difference-Frequency Generation In Quantum Cascade Lasers** *Karun Vijayraghavan[1]; Yifan Jiang[1]; Aiting Jiang[1]; Frederic Demmerle[2]; Gerhard Boehm[2]; Xiaojun Wang[3]; Mariano Troccoli[3]; Markus Amann[2]; Mikhail Belkin[1]* *[1]University of Texas at Austin, United States; [2]Walter Schottky Institut, Technische Universität München, Germany; [3]Adtech Optics, United States*	Mo13-1 **Reflection 2D Real Time THz Camera To Image And Identify Sugar Pellets** *Simon Joly[1]; Jérôme Meilhan[1]; Stéphane Pocas[1]; Jean-Louis Ouvrier-Buffet[1]; Wilfried Rabaud[1]; Frédéric Garet[2]; François Simoens[1]* *[1]CEA Leti-MINATEC, France; [2]IMEP-LAHC, University of Savoie, France*	Mo14-1 **Ultra-Broadband Dielectric THz Spectroscopy With Air-Biased-Coherent-Detection** *Francesco D'Angelo; Mischa Bonn; Dmitry Turchinovich* *Max Planck Institute for Polymer Research, Germany*
	Mo13-2 **High-Performance Metamaterial MM-To-IR Converter For MM-Wave Imaging** *Andrey Paulish[1]; Peter Zagubisalo[1]; Sergey Kuznetsov[2]* *[1]Novosibirsk Branch of Institute of Semiconductor Physics "TDIAM", Russian Federation; [2]Novosibirsk State University, Russian Federation*	Mo14-2 **Polarization Dependent Study Of THz ABCD** *Jing Zhang; Xi-Cheng Zhang* *Wuhan National Labortary for Optoelectronics, Huazhong University of Science and Technology, China*
Mo12-3 (invited talk) **Direct Optical Sampling Of A Modelocked Terahertz Quantum Cascade Laser** *Jean Maysonnave[1]; Joshua Freeman[1]; Nathan Jukam[2]; Pierrick Cavalié[1]; Kenneth Maussang[1]; Harvey Beere[3]; David Ritchie[3]; Juliette Mangeney[1] et al.* *[1]Laboratoire Pierre Aigrain, Ecole Normale Supérieure, France; [2]Ruhr-Universität Bochum, Germany; [3]University of Cambridge, United Kingdom*	Mo13-3 **Design And Microfabrication Of Frequency Selective Uncooled Micro-Bolometer Focal Plane Array For Terahertz Imaging** *El-Hassane Oulachgar[1]; Philip Mauskopf[2]; Samir Ilias[1]; Jacques-Edmond Paultre[1]; Dominique D'Amato[1]; Marc Terroux[1]; Timothy Pope[1]; Christine Alain[1] et al.;* *[1]Institut National d'Optique, Canada; [2]Cardiff University, United Kingdom*	Mo14-3 **Femtosecond Coherent Control Of THz Spectra Driven By Free- And Coupled Electrons In Gas Plasma** *Alexander Shkurinov[1]; Olga Kosareva[1]; See Leang Chin[2]; Xi-Cheng Zhang[3]* *[1]Lomonosov Moscow State University, RU; [2]Universite Laval, CA; [3]The Institute of Optics, University of Rochester, USA*

Monday	Gutenberg 1	Gutenberg 2
	Mo10 High-Power Sources 3	**Mo11 THz Commun. 1**
16:45 – 17:00	Mo10-4 **Developing Terahertz Sources With Longitudinal Polarisation Components For The Energy Modulation Of Relativistic Electrons** *Matthew Cliffe[1]; David Walsh[2]; Darren Graham[1]; Steven Jamison[3]; Wendy Flavell[1]* *[1]The University of Manchester, United Kingdom; [2]University of Dundee, United Kingdom; [3]STFC, United Kingdom*	Mo11-4 **Broadband Channel Measurements Between 50 GHz And 325 GHz: Comparison Of Different Propagation Scenarios** *Thomas Kürner[1]; Thomas Kleine-Ostmann[2]; Mohammed Salhi[2]; Marius Kannicht[2]; Thorsten Schrader[2]* *[1]Institut für Nachrichtentechnik, TU Braunschweig, Germany; [2]Physikalisch-Technische Bundesanstalt (PTB), Germany*
17:00 – 17:15	Mo10-5 **Synthesis Of Multimode Waveguide Converters Using Full-Wave EFIE Field Analysis Method** *Anton Gashturi, Dmitry Sobolev, Gregory Denisov* *Institute of Applied Physics, Russian Academy of Sciences, Russian Federation*	Mo11-5 (invited talk) **Digital THz Communication Links In The Atmosphere** *Daniel Grischkowsky; Yihong Yang; Mahboubeh Mandehgar* *Oklahoma State University, United States*
17:15 – 17:30	Mo10-6 **Quasi-Optical Theory Of Relativistic Submillimeter Cherenkov Amplifier And Oscillators** *Naum Ginzburg; Andrei Malkin; Vladislav Zaslavsky; Ilya Zheleznov; Alexander Sergeev* *IAP RAS, Russian Federation*	
17:30 – 19:00	**Poster session P1 (Rhein Foyer West)**	

Gutenberg 3	Gutenberg 4	Congress Hall
Mo12 QCLs 2	**Mo13 THz Cameras**	**Mo14 THz Spectr. Systems 1**
	Mo13-4 **High-Speed THz Semiconductor Imaging Camera** *Viacheslav Muravev; Gombo Tsydynzhapov; Anton Fortunatov; Igor Kukushkin* *TeraSense, Russian Federation*	Mo14-4 **One-Pulse High-Resolution THz Time-Domain Spectroscopy: Development And Applications** *Vitaly Kubarev[1]; Evgeny Chesnokov[2]; Pavel Koshliakov[2]* *[1]BINP, Russian Federation;* *[2]ICKC, Russian Federation*
Mo12-5 **Tapered Terahertz Quantum Cascade Lasers** *Weidong Chu[1]; Yanfang Li[1]; Junqi Liu[2]; Fengqi Liu[2]; Suqing Duan[1]* *[1]Institute of Applied Physics and Computational Mathematics, China; [2]Institute of Semiconductors, Chinese Academy of Sciences, China*	Mo13-5 **Real-Time CMOS Terahertz Camera Employing Plane-To-Plane Imaging With A Focal-Plane Array Of Field-Effect Transistors** *Maris Bauer; Sebastian Boppel; Alvydas Lisauskas; Viktor Krozer; Hartmut G. Roskos* *Physikalisches Institut, Johann Wolfgang Goethe-University, Germany*	Mo14-5 **Precise And Convenient Reflection THz-Time Domain Spectroscopy With A Movable Transparent Sample Holder** *Norihisa Hiromoto[1]; Toru Nagashima[1]; Saroj Tripathi[2]; Masanori Takeda[1]; Makoto Aoki[1]* *[1]Shizuoka University, Japan;* *[2]Nagoya University, Japan*
Mo12-6 **Transient Analysis Of Substrate Heating Effects In A Terahertz Quantum Cascade Laser Using An Ultrafast NbN Superconducting Detector** *Alexander Valavanis[1]; Paul Dean[1]; Alexander Scheuring[2]; Mohammed Salih[1]; Axel Stockhausen[2]; Stefan Wuensch[2] et al.* *[1]University of Leeds, United Kingdom; [2]Karlsruhe Institute of Technology, Germany*	Mo13-6 **Video-Rate THz Imaging Applications Using A 384x288 Pixel Camera** *Martin Bolduc; Marc Terroux; Linda Marchese; Alain Bergeron* *INO - Institut National d'Optique, Canada*	Mo14-6 **Compact, Portable Terahertz Systems For On-Site Inspection Applications** *Albert Redo-Sanchez; Norman Laman; Brian Schulkin; Thomas Tongue* *Zomega Terahertz Corporation, United States*
Poster session P1 (Rhein Foyer West)		

Monday, September 2nd

Mo Pl1 **09:30 - 10:15** **Monday Plenary 1** **Congress Hall**
Chair: René Beigang

Infrared Nanoscopy And Nanospectroscopy - From Nanoscale Chemical Identification Of Polymers To Real-Space Imaging Of Graphene Plasmons **1**
Rainer Hillenbrand
CIC nanoGUNE Consolider, Spain

We demonstrate nanoscale IR imaging and spectroscopy by recording the elastically scattered light from an AFM tip. Applications such as chemical mapping of polymers, free-carrier semiconductor profiling and real-space mapping of plasmons in metal nanostructures and graphene will be discussed.

Mo Pl2 **10:15 - 11:00** **Monday Plenary 2** **Congress Hall**
Chair: René Beigang

Discoveries Of New Interstellar Molecules In The Last Decade With Sub-millimeter Spectroscopy In Space **N/A**
Di Li
National Astronomical Observatories, China
Space Science Institute, USA

The human knowledge of interstellar gases was largely made possible by key technological developments in spectroscopic instruments for astronomy, particularly in radio and millimeter bands. The last decade has seen major advancements in space-based sub-millimeter spectrometers, which bring about discoveries of new interstellar molecules, such as molecular oxygen (O_2).

Mo1 **11:30 - 13:00** **High-Power Sources 1** **Gutenberg 1**
Chair: Manfred Thumm

Mo1-1 11:30 **Overview Of Fusion Gyrotron Development Programs At 110 GHz, 117.5 GHz, 140 GHz, And 170 GHz** **4**
Stephen Cauffman; Monica Blank; Philipp Borchard; Kevin Felch
Communications & Power Industries, United States
Communications and Power Industries (CPI) is currently developing megawatt-class gyrotrons for fusion plasma heating and current drive across a range of frequencies, for use at several different fusion research facilities. These gyrotrons are currently at different stages of development, fabrication, and test. Design features will be compared, available test data will be presented, and future plans will be described.

Mo1-3 12:00 **Installation Of A 154 GHz Mega-Watt Gyrotron And Its Contribution To The Extension Of Plasma Parameter Regime In LHD** **7**
Takashi Shimozuma[1]; Hiromi Takahashi[1]; Satoshi Ito[1]; Shin Kubo[1]; Yasuo Yoshimura[1]; Hiroe Igami[1]; Masaki Nishiura[1]; Shinya Ogasawara[2]; Ryohei Makino[2]; Yoshinori Mizuno[1]; Kohta Okada[1]; Sakuji Kobayashi[1]; Takashi Mutoh[1]; Ryutaro Minami[3]; Tsuyoshi Kariya[3]; Tsuyoshi Imai[3]
[1]National Institute for Fusion Science, Japan; [2]Nagoya University, Japan; [3]University of Tsukuba, Japan
A new 154 GHz/1 MW gyrotron was developed and installed in the Electron Cyclotron Resonance Heating system of LHD. The maximum output power of 1.16 MW/1 sec was achieved. Total injected power into a plasma reached 4.4 MW with the existing three 77 GHz gyrotrons' power. The 154 GHz gyrotron contributed to extend the plasma parameters to higher temperature and density region.

Mo1-4 12:15 **460 GHz Second Harmonic Gyrotrons For A 700 MHz DNP-NMR Spectroscopy 9**
Toshitaka Idehara[1]; Yoshinori Tatematsu[1]; Y. Yamaguchi[1]; R. Ikeda[1]; I. Ogawa[1]; T. Saito[1]; Y. Matsuki[2]; K. Ueda[2]; T. Fujiwara[2]; M. Toda[3]
[1]University of Fukui, Japan; [2]Osaka University, Japan; [3]JEOL Resonance Co., Ltd, Japan
Development of two 460 GHz second harmonic gyrotrons for 700 MHz DNP-NMR spectroscopy is presented. One gyrotron is frequency-fixed and the other is frequency tunable in the bandwidth of 1.5 GHz. In addition, the former has a function of frequency modulation.

Mo1-5 12:30 **Experiment-theory Comparison Of Non-stationary And Chaotic Regimes In Gyrotrons 11**
Falk Braunmueller; Jeremy Genoud; Stefano Alberti; Jean-Philippe Hogge; Minh Quang Tran; Trach-Minh Tran; Quentin Vuillemin
CRPP (EPFL), Switzerland
The behaviour of a gyrotron oscillator designed for DNP-NMR spectroscopy within the non-stationary operating regime is investigated in detail and compared to numerical simulations. The response of the device to the control parameters is explored and a variety of non-stationary regimes are categorized. The main features observed in the experiment could be reproduced in the simulation, including the observed behavior in the chaotic regime.

Mo1-6 12:45 **Optimization And 3D Analysis Of High Frequency Gyrotrons 13**
Mikhail Glyavin[1,3]; Gregory Nusinovich[2]; Naum Ginzburg[1,3]; A. G. Luchinin[1]; V. N. Manuilov[1,3]; A. S. Sedov[1]; N. A. Zavolsky[1]; V. Yu. Zaslavsky[1,3]; I. V. Zotova[1]; V. E. Zapevalov[1]
[1]Institute of Applied Physics RAS, Russian Federation; [2]IREAP, University of Maryland, United States; [3]Nizhny Novgorod State University, Russian Federation
The possibilities to obtain efficient operation of sub-THz gyrotrons at cyclotron harmonics are analyzed and the evolution of gyrotron optimal parameters is presented. 3D PIC simulations of THz band gyrotrons have been performed. The reasonable agreement with experimental results is demonstrated, that allows one to analyze some effects resulting from ellipticity of cavities, non-uniform emission and misalignment.

Mo2 11:30 - 13:00 Novel THz Emitters 1 Gutenberg 2
Chair: Hartmut Roskos

Mo2-1 11:30 **Steerable Emission Of THz Radiation By Optical Coherent Control 15**
Heiko Füser; Mark Bieler
Physikalisch-Technische Bundesanstalt, Germany
We report optical coherent control of the emission direction of THz radiation by excitation of bulk GaAs with femtosecond laser pulses. Changing the phase of the optical excitation, steering angles of ~8 degrees are realized. A simple model is introduced to analyze the underlying parameters.

Mo2-2 11:45 **Broadband Terahertz Wave Generation From Ridge Waveguide 17**
Kei Takeya[1]; Shuzhen Fan[1]; Hajime Takeuchi[1]; Kodo Kawase[2]
[1]Nagoya University, Japan; [2]Nagoya University and RIKEN, Japan
Cherenkov phase-matched terahertz (THz) wave generation from a MgO:$LiNbO_3$ ridge waveguide was studied using optical rectification. Time-domain spectroscopy (TDS) results showed a single-cycle pulse with femtosecond pulse pumping. The spectrum covered the range of 0.1 ~ 7 THz, with a signal-to-noise ratio of over 50 dB. The output power measured by a Si bolometer and a deuterated triglycine sulfate (DTGS) pyroelectric detector are shown and compared to that of a commercial photoconductive antenna (PCA). This system is believed to be a promising THz source for low-cost, compact, robust, and highly integrated TDS, THz imaging, and tomography systems.

Mo2-3 12:00 **Experimental Demonstration Of Phase-matched THz Generation In Plasma-activated Silicon Nano-photonic Emitters 19**
Simon Sawallich; Christopher Matheisen; Michael Nagel; Thorsten Wahlbrink; Jens Bolten; Heinrich Kurz
AMO GmbH, Germany
We present THz emission based on phase-matched difference frequency generation from ultra-short laser pulses with $\lambda = 1560$ nm in a plasma-activated silicon nanophotonic waveguide with second-order nonlinearity. Phase-matching is achieved using a hybrid-approach with coplanar transmission lines.

Mo2-4 12:15 **Enhanced Terahertz Emission From Ultrathin Semiconductor Films 21**
Gopakumar Ramakrishnan; Gopika Ramanandan; Aurèle Adam; Paul Planken
Delft University of Technology, Netherlands
Terahertz emission by ultrafast laser excitation of semiconductors is done conventionally in bulk wafers or thin films thicker than the optical penetration depth. Here we present counter-intuitive-results where enhanced terahertz emission is made possible by using ultrathin films of semiconductors.

Mo2-5 12:30 **Terahertz Emission Spectroscopy Of InAs Nanowires 23**
Gyuseok Lee[1]; Meehyun Lim[1]; Youngwoong Do[1]; Soonsung Lee[1]; Hyeona Kang[1]; Jae Cheol Shin[2]; Haewook Han[1]
[1]POSTECH, Korea, Republic of; [2]Photonics-Energy Center, Korea Photonics Technology Institute, Korea, Republic of
We measured terahertz (THz) emission from the vertically aligned indium arsenide (InAs) nanowires using THz time-domain spectroscopy. The photoexcited InAs nanowires were grown by metalorganic chemical vapor deposition on type <111> silicon substrate. Experimental results shows that THz emission mechanism of InAs nanowires are very different from that of bulk InAs substrates.

Mo2-6 12:45 **Terahertz Emission From Vertically-Aligned Single-Walled Carbon Nanotube Films 24**
Meehyun Lim[1]; Gyusoek Lee[1]; Theerapol Thurakitseree[2]; Shigeo Maruyama[2]; Ikmo Park[3]; Haewook Han[1]
[1]POSTECH, Korea, Republic of; [2]The University of Tokyo, Japan; [3]Ajou University, Korea, Republic of
We experimentally investigated the terahertz (THz) photoresponse of vertically-aligned single-walled carbon nanotube (SWCNT) films by using optical pumping method. The SWCNT film was grown on the fused quartz substrate by using the alcohol catalytic CVD process. We observed that the strong THz radiation is emitted from the photoexcited SWCNT film. Our finding is the first demonstration of THz pulse emission for the unbiased SWCNT-based films.

Mo3 11:30 - 13:00 THz Optics Gutenberg 3
Chair: Norihisa Hiromoto

Mo3-1 11:30 **Longitudinal Fields In Focused Terahertz Beams 25**
Stephan Winnerl; Ralf Hubrich; Martin Mittendorff; Harald Schneider; Manfred Helm
Helmholtz-Zentrum Dresden-Rossendorf, Germany
We measure transverse as well as longitudinal terahertz field components in the focus of both radially and linearly polarized beams. A phase shift of $\pi/2$ between the transverse and longitudinal field contributions is found in both cases for all frequency components. Furthermore tighter focusing of the longitudinal components of the radially polarized beam as compared to the transverse components of the linearly polarized beam is demonstrated.

Mo3-2 11:45 **Hartmann Sensor For Wavefront Measurements At Terahertz Frequencies 27**

Michael Greiner-Bär[1]; Heiko Richter[1]; Nils Deßmann[1]; Johannes Pfund[2]; Martin Wienold[3]; Lutz Schrottke[3]; Holger T. Grahn[3]; Heinz-Wilhelm Hübers[1]
[1]DLR, Germany; [2]Optocraft, Germany; [3]PDI, Germany

The measurement of the wavefront of a terahertz (THz) beam is essential for the development of any optical instrument operating at THz frequencies. We have realized a Hartmann wavefront sensor for the THz frequency range. The sensor is based on an aperture plate consisting of a regular square pattern of holes and a microbolometer camera. The performance of the sensor is demonstrated by characterizing the wavefront of a THz beam emitted by a quantum-cascade laser.

Mo3-3 12:00 **Development Of High-Efficiency Etalons With An Optical Shutter For Terahertz Laser Pulses 29**

Masaaki Tsubouchi; Takayuki Kumada
Japan Atomic Energy Agency, Japan

A high-efficiency etalon operated in the THz region has been proposed to generate a THz pulse train. To achieve high-conversion efficiency to the pulse train, an optical shutter is employed in this etalon. A THz pulse train and its comb-shaped spectrum have been realized by the use of the proposed etalon with the optical shutter.

Mo3-4 12:15 **Evidence Of THz Diffraction By Fabrics 31**

Emilie Herault; Maxence Hofman; Frederic Garet; Jean-Louis Coutaz
IMEP-LAHC, France

In security applications, items or substances of interest are generally hidden and therefore, for body inspection, must be identified through clothes. We show that diffractive behavior of fabrics when illuminated by THz wave can complicate such approach. This effect is demonstrated performing an angle-resolved THz time-domain spectroscopy experiment and confirmed by a HFSS numerical simulation.

Mo3-5 12:30 **Double Fourier Modulation For A TeraHertz Space Interferometer 33**

G. M. Klemencic[1], for the FP7-FISICA Consortium[2]
[1]Cardiff University, United Kingdom; [2]http://www.fp7-fisica.eu/consortium/

Space-borne THz interferometry will be a natural long-term development following the recent success of observatories such as *Spitzer* and *Herschel*, and the forthcoming SPICA observatory. A three-year EU FP-7 funded technology development programme is underway, aimed at raising the maturity of double Fourier modulation for spectral and spatial interferometry. Part of the programme involves the enhancement and use of a laboratory test-bed interferometer, which will be used to evaluate beam combination, data processing, and calibration methods.

Mo4 11:30 - 13:00 Detectors 1 Gutenberg 4
Chair: Alexander Shkurinov

Mo4-1 11:30 **Toward Low-NEP Room-Temperature THz MOSFET Direct Detectors In CMOS Technology 35**

Janusz Grzyb[1]; Hani Sherry[2]; Andreia Cathelin[2]; Andreas Kaiser[3]; Ullrich Pfeiffer[1]
[1]University of Wuppertal, Germany; [2]STMicroelectronics, France; [3]ISEN/IEMN, France

This paper reports on the impact of antenna impedance frequency characteristics on a broadband low-NEP operation of THz MOSFET direct detectors. New Si-lens integrated high-impedance on-chip ring antennas were developed based on a systematic co-design procedure with MOSFET device. They allowed achieving the world record values both in terms of responsivity and noise equivalent power for detector arrays implemented in a bulk 65 nm CMOS technology. Only few representative design examples out of the complete test array are presented. A peak optical voltage responsivity (Rv) of 2200 and a minimum noise equivalent power (NEP) of 14 pW/√Hz at 200 Hz chopping frequency were measured at 724 GHz for one of the detectors,

whereas some other demonstrated broadband operation with an optical NEP below 50 pW/√Hz for at least 650-970 GHz.

Mo4-3 12:00 **Noise Performance Of RTD-gated Plasma-wave HEMT THz Detectors 37**

Jimy Encomendero Risco[1]; Berardi Sensale Rodriguez[2]; Huili Grace Xing[1]
[1]University of Notre Dame, United States; [2]University of Utah and University of Notre Dame, United States

In this paper, we study the noise performance of RTD-gated plasma-wave HEMT THz detectors. It is shown that noise in these devices is dominated by gate tunneling shot noise, and that a smaller effective electron mass promises much improved noise performance by boosting the responsivity while slightly decreasing the noise spectral density (NSD). This implies that it is desirable to realize RTD-gated plasma-wave HEMT THz detectors in material systems with low effective mass.

Mo4-4 12:15 **Room Conditions THz Detector Using Graphene FET 38**

Akram Mahjoub[1]; S. Suzuki[1]; Y. Iso[1]; T. Ouchi[1]; N. Aoki[1]; K. Miyamoto[1]; T. Yamaguchi[2]; T. Omatsu[1]; J.P. Bird[3]; D.K. Ferry[4]; K. Ishibashi[2]; Y. Ochiai[1]
[1]Graduate School of Advanced Integration Science, Chiba University, Chiba, Japan; [2]Advanced Device Laboratory, (RIKEN), Wako, Saitama, Japan; [3]Department of Electrical Engineering, University at Buffalo, SUNY, Buffalo, NY, United States; [4]Department of Electrical Engineering & Center for Solid State Electronics Research, ASU, United States

Graphene with its unique electric, thermal, and optical properties has proven to be a promising candidate for many of the next generation electronics application. In this report, we try to provide a clear undeniable evidence that proves our success in the development of a THz nano-sensor using the graphene nano-carbon material as a mean to utilize the thermoelectric current that can be generated due to the bolometric effect at room ambient conditions.

Mo4-5 12:30 **Characterization Of A Glow Discharge Detector With Terahertz Time Domain Spectroscopy 40**

Kamil Cinar[1]; Hakan Altan[1]; Asaf Behzat Sahin[2]
[1]Middle East Technical University, Turkey; [2]Yildirim Beyazit University, Turkey

The capability of low cost glow discharge detectors (GDDs) for detection of terahertz (THz) radiation draws attention recently. In order to employ them in applications such as THz imaging these studies have typically focused on the response of the GDD at specific frequencies. To better understand the spectral behavior of glow discharges, we have not only examined the response of the GDD at a specific frequency of 118 GHz, but also we examined the interaction mechanism of GDDs with THz radiation using terahertz time domain spectroscopy (THz-TDS) in a broader range of frequencies between 0.05 THz - 0.5 THz.

Mo4-6 12:45 **THz Leaky Lens Antenna Coupled KIDs For Broadband Imaging And Spectroscopy 42**

Andrea Neto[1]; Nuria Llombart[1]; Jochem Baselmans[2]; Stephen Yates[2]; Andrey Baryshev[2]
[1]TUDelft, Netherlands; [2]SRON, Netherlands

This contribution presents the first demonstration of a linear polarized ultra wide bandwidth antenna, the Leaky Lens Antenna, coupled to a Kinetic Inductance Detector (KID). The two of them function as an ultra-sensitive receiver over a bandwidth ranging from 0.15 GHz to 1.5 THz. The system has been manufactured and characterized in terms of power efficiency, and radiation pattern properties. The agreement between the expectations and the measurements is excellent.

Mo5 **14:00 - 15:30** **High-Power Sources 2** **Gutenberg 1**
Chair: Gun Sik Park

Mo5-1 14:00 **Progress Of High Power Long Pulse Gyrotron For Fusion Application 43**
Keishi Sakamoto; Ken Kajiwara; Yasuhisa Oda; Kazuo Hayashi; Ryosuke Ikeda; Koji Takahashi; Takayuki Kobayashi; Shinichi Moriyama
Japan Atomic Energy Agency, Japan
Recent progress of JAEA high power long pulse gyrotron is reported. Multi-frequency oscillations and their Gaussian beam outputs are demonstrated at 170 GHz, 137 GHz and 104 GHz. For the full power modulation, clear 5 kHz modulation was demonstrated using double anode switching. Furthermore, novel anode power supply system was fabricated to simplify the gyrotron power supply system.

Mo5-3 14:30 **Experiment For Over 200 kW Oscillation Of A 295 GHz Pulse Gyrotron 46**
Teruo Saito[1]; Yuusuke Yamaguchi[1]; Shinji Ikeuchi[1]; Yoshinori Tatematsu[1]; Ryosuke Ikeda[1]; Isamu Ogawa[1]; Toshitaka Idehara[1]; Shin Kubo[2]; Takashi Shimozuma[2]; Masaki Nishiura[2]; Kenji Tanaka[2]; Jun Kasa[1]
[1]University of Fukui, Japan; [2]National Institute for Fusion Science, Japan
A high power sub-THz gyrotron for use in the collective Thomson scattering diagnostics of fusion plasmas is under development. It operates at the fundamental harmonic with a frequency of 295 GHz. In recent experiments, we have succeeded in over 200 kW oscillation of this gyrotron.

Mo5-5 15:00 **2 MW CW RF Load For Gyrotrons 48**
Lawrence Ives[1]; Maxwell Mizuhara[1]; Philipp Borchard[2]; Jeffrey Neilson[3]; George Collins[1]; Takayuki Kobayashi[4]; Shinichi Moriyama[4]
[1]Calabazas Creek Research, Inc., United States; [2]Dymenso LLC, United States; [3]Lexam Research, United States; [4]Japan Atomic Energy Agency, Japan
Development is complete for a 2 MW CW, RF load for millimeter wave power transmitted in HE_{11} waveguide. A rotating launcher uniformly distributes the power over loss surfaces and minimizes returned power. Successful operation with a 1.5 MW long pulse gyrotron is described.

Mo6 **14:00 - 15:30** **Novel THz Emitters 2** **Gutenberg 2**
Chair: X.-C. Zhang

Mo6-1 14:00 **THz Radiation From Magneto-optically Induced ultrafast Photocurrents In Bulk GaAs 50**
Christian B. Schmidt; Shekhar Priyadarshi; Mark Bieler
Physikalisch-Technische-Bundesanstalt, Germany
We study THz emission from magneto-optically induced ultrafast photocurrents in a GaAs crystal. Analyzing currents appearing in the direction of the externally applied magnetic field, we observe different current dynamics for linearly- and circularly-polarized excitation.

Mo6-2 14:15 **Plasmonic Gratings For Enhanced THz Emission From Metal-semiconductor Thin Films 52**
Gopika Ramanandan; Aurèle Adam; Paul Planken
Delft University of Technology, Netherlands
THz emission from thin film Schottky junctions is enhanced using plasmonic nano-gratings. Enhancement factors of up to 5.6 are observed in the emitted electric field, corresponding to a power enhancement factor of ~34.

Mo6-3 14:30 **Intense And Ultra-broadband Terahertz Generation From Metal Foil 54**
Cunlin Zhang; Liangliang Zhang; Kaijun Mu
Capital Normal University, China
It has been observed that Terahertz (THz) wave was radiated from nanostructured metal gratings and metal films, which was illuminated by femtosecond laser pulse. In this paper, we got more than 60 μJ intense single THz pulse, and the maximum spectrum was distributed from 0.3 to 149 THz. Theoretical calculation was performed to explain the generation mechanism.

Mo6-4 14:45 **THz-emission Probe Of Surface-electronic Transitions In A Topological Insulator 55**
Li-Guo Zhu
Institute of Fluid Physics, China Academy of Engineering Physics, China
Upon femtosecond laser pumping of a topological insulator Bi2Se3, we observed efficient THz generation from the surface electrons. By performing polarization-resolved studies on the emitted THz spectrum, two emission mechanisms are identified. THz emission spectroscopy provides a valuable spectroscopic tool for studies of the dynamics of the surface electrons in centrosymmetric topological insulators.

Mo6-5 15:00 **THz Emission Of Narrow-Gap HgCdTe Films And HgTe/CdTe Quantum Wells Structures 57**
Sergey Morozov[1]; Vladimir Gavrilenko[1]; Vladimir Rumyantsev[1]; Kirill Marem'yanin[1]; Alexandr Antonov[1]; Ludmila Krasil'nikova[1]; Nikolay Mihailov[2]; Sergey Dvotetskiy[2]
[1]Institute for Physics of Microstructures RAS, Russian Federation; [2]ISP SB RAS, Russian Federation
Investigation into emission of THz radiation in narrow gap HgCdTe layers and QWs is presented. The results are compared with THz photoconductivity spectra and relaxation kinetics. A possibility of THz lasing in CdHgTe waveguide QW structures is discussed.

Mo6-6 15:15 **PIC Simulations And Experimental Design Of A Cherenkov Millimetre-Wave Source 59**
Alan Phipps[1]; Amy MacLachlan[1]; Craig Robertson[1]; Ivan Konoplev[2]; Alan Phelps[1]; Adrian Cross[1]
[1]University of Strathclyde, United Kingdom; [2]University of Oxford, United Kingdom
Numerical 3D PIC code simulations show that Slow-Wave-Structures SWSs demonstrate excellent potential as a virtual dielectric in a Cherenkov based Backward Wave Oscillator (BWO). CST Microwave Studio confirms internal mode coupling between volume $TM_{0,6}$ and surface $HE_{20,1}$ modes resulting in the creation of a high-Q cavity, necessary for the Cherenkov mechanism to be exploited. MAGIC 3D demonstrates output powers of ~100kW within a 5ns timeframe at W-Band frequencies (75-110)GHz. Successful numerical modeling underpins the experimental investigation of a practical device currently in production.

Mo7 14:00 - 15:30 Quantum Cascade Lasers 1 Gutenberg 3
Chair: Alessandro Tredicucci

Mo7-1 14:00 **Fast, Sensitive And Low-noise Nanowire And Graphene Field effect Transistors For Room-temperature Detection Of THz Quantum Cascade Lasers Emission 61**
Miriam Serena Vitiello[1]; D. Coquillat[2]; L. Viti[1]; L. Romeo[1]; L. Vicarelli[1]; D. Ercolani[1]; A. C. Ferrari[3]; M. Polini[1]; L. Sorba[1]; V. Pellegrini[1]; W. Knap[2]; A. Tredicucci[1]
[1]NEST, Istituto Nanoscienze-CNR and Scuola Normale Superiore, Italy; [2]Université Montpellier 2 and CNRS, France; [3]Engineering Department, Cambridge University, United Kingdom
Antenna-coupled field effect transistors have been developed as plasma-wave THz detectors in both InAs nanowire and graphene channel materials. Room temperature operation has been achieved up to 3 THz, with noise equivalent power levels $< 10^{-10}$ W/√Hz, and high-speed response already suitable for large area THz imaging applications.

Mo7-3 14:30 **High Power Terahertz Quantum Cascade Laser At 63 µm 64**

Dana Turcinkova; Keita Otani; Giacomo Scalari; Mattias Beck; Jerome Faist
ETH Zurich/Institute for Quantum Electronics, Switzerland

We present a terahertz quantum cascade laser providing 875 mW two-facet output power in pulsed mode, at a frequency around 4.7 THz and at a heatsink temperature of 10 K. The laser has a single plasmon waveguide. The active region is based on four quantum wells with longitudinal optical phonon extraction.

Mo7-5 15:00 **1.9 THz Indirect Injection $Al_{0.175}Ga_{0.825}As$/GaAs Quantum Cascade Laser Operating At Extreme Higher Temperature 67**

Tsung-Tse Lin; Miho Sasaki; Hideki Hirayama
RIKEN, Japan

Terahertz quantum cascade lasers (THz QCLs) are a promising semiconductor THz source to realize the expected widely compact size THz applications. Currently limitation of THz QCLs is the limited maximum operation temperature (T_{max}) and the extension of the operation frequency. Here we propose one $Al_{0.175}Ga_{0.825}As$/GaAs indirect injection design QCLs operated near 1.9 THz with 160 K. Indirect scattering assisted selective injection design with higher Al composition barrier expected to approach low frequency with high temperature operation.

Mo7-6 15:15 **High-frequency Modulation Spectroscopy With A THz Quantum-cascade Laser 69**

René Eichholz[1]; Heiko Richter[1]; Martin Wienold[2]; Lutz Schrottke[2]; Holger T. Grahn[2]; Heinz-Wilhelm Hübers[1]
[1]German Aerospace Center, Germany; [2]Paul-Drude-Institut für Festkörperphysik, Germany

A terahertz absorption spectrometer with a quantum-cascade laser (QCL) for high-resolution molecular spectroscopy is realized. The spectrometer is based on high-frequency (up to 50 MHz) modulation of the QCL frequency. This allows for the determination of the absorption coefficient and dispersion of the absorbing medium along with a very precise measurement of the line shape of the absorption feature. The design and performance of the spectrometer are presented, and its sensitivity and frequency calibration are discussed.

Mo8 14:00 - 15:30 Detectors 2 Gutenberg 4
Chair: Masa Tonouchi

Mo8-1 14:00 **A Micro-Cantilever Based Photoacoustic Detector Of Terahertz Radiation For Chemical Sensing 71**

Ivan Medvedev[1]; Douglas Petkie[1]; Ronald Coutu[2]; Nathan Glauvitz[2]
[1]Wright State University, United States; [2]Air Force Institute of Technology, United States

A Microelectromechanical system (MEMS) cantilever pressure sensor was designed, modeled, fabricated, and tested for sensing the photoacoustic response of gases to Terahertz (THz) radiation. This paper describes manufacturing, experimental set-up and the most recent spectroscopic results, which demonstrate the capabilities of this spectroscopic technique.

Mo8-3 14:30 **Superconducting High-T_c Hot Electron Bolometers Used As THz Mixers: Predicted Performance By Hot Spot Modeling 74**

Alain Kreisler; Romain Ladret; Annick Degardin
SUPELEC - LGEP, France

High-T_c hot electron bolometers (HEB) are promising THz mixers due to their expected wide bandwidth, large mixing gain and low intrinsic noise. In this paper, we have simulated the DC characteristics, conversion loss and noise of YBaCuO HEBs with a hot spot model usually dedicated to low-T_c devices.

Mo8-4 14:45 **Design And Characterization Of A TES Bolometer For Fourier Transform Spectroscopy In The FIR 76**
Mathias Kehrt; Jörn Beyer; Christian Monte; Jörg Hollandt
Physikalisch-Technische Bundesanstalt, Germany
A new composite bolometer for Fourier transform spectroscopy was designed for the range from 0.1 aiming to achieve a higher dynamic range at similar detectivity as commercially available silicon composite bolometers. It is based on a thin film metal mesh absorber, a superconducting thermistor and SiN membrane technology.

Mo8-5 15:00 **Performance Of The Antenna Coupled Microbolometers Characterized By The Quasi-optical Measurements At Frequencies 0.1-1.0 THz 78**
Irmantas Kasalynas[1]; Andrej Svigelj[2]; Juozas Adamonis[1]; Vladimir Kornijcuk[1]; Ramunas Adomavicius[1]; Arūnas Krotkus[1]; Gintaras Valusis[1]; Aleksander Sesek[2]; L. Pavlovic[2]; Janez Trontelj[2]
[1]Center for Physical Sciences and Technology, Lithuania; [2]University of Ljubljana, Slovenia
Performance of the antenna-coupled detectors was measured by the quasi-optical setup in wide frequency range from 0.1 to 1.0 THz. Studied sensors were based on the titanium microbolometers coupled with the double-dipole- or log-periodic type antenna for room temperature THz detection. The THz radiation of the selectively filtered broadband LTG-GaAs photoconductive emitter and the system generating narrow band THz bursts were used for measurements.

Mo8-6 15:15 **Fast Room Temperature THz Bolometers 80**
Sergey Cherednichenko; Stella Bevilacqua
Chalmers University of Technology, Sweden
A responsivity of >100 V/W was measured at room temperature for nano scale bolometers integrated with planar spiral antennas covering a frequency range from 100 GHz to 3 THz. Currently a NEP of about 200 pW/Hz$^{0.5}$ was experimentally obtained.

Mo9 14:00 - 15:30 THz Spectroscopy: Biomolecules Congress Hall
Chair: Bernd Fischer

Mo9-1 14:00 **Crystallization Of Sucrose Monitored By Terahertz Pulsed Spectroscopy 82**
Philip Taday; Rob May
TeraView, United Kingdom
Terahertz ATR spectroscopy was used to monitor the crystallization of sugar on confectionary products. The time-dependent spectroscopy could be used to follow phase transition from the aqueous phase into a glassy state followed by a crystallization of the sugar on the ATR window. Terahertz pulsed imaging was also used to investigated the final product.

Mo9-2 14:15 **Terahertz Spectroscopy Of Cyanobenzaldehyde Isomers 83**
Shaumik Ray[1]; Jyotirmayee Dash[1]; Kathirvel Nallappan[1]; Ashootosh Ambade[2]; Kavita Joshi[2]; Vaibhav Kaware[3]; Bala Pesala[1]
[1]CSIR-CEERI, India; [2]CSIR-NCL, India; [3]National Chemical Laboratory, India
Cyanobenzaldehyde isomers have been investigated using THz spectroscopy demonstrating several distinct resonances from 2 to 21 THz. DFT simulations have been carried out to understand the origin of resonances which show good agreement with experimental results. THz spectroscopy of isomers provides valuable information for designing molecules with customizable THz resonances.

Mo9-3 14:30 **Experimental And Theoretical Studies On THz Spectra Of Phenylthiourea Compounds 85**

Zhang Di[1]; Zhilong Ding[1]; Tiantian Guo[1]; Jun Zhou[1]; Xianlong Wang[2]; Junsheng Yu[2]; Xiaodong Chen[1]

[1]Terahertz Science and Technology Research Center, China; [2]School of Life Science and Technology, UESTC, China

THz spectroscopy is a promising technique to study intermolecular interactions and molecular dynamics in organic crystals. In this work, aromatic thiourea compounds with methyl substituents were used as model systems to study the intermolecular interactions between aromatic rings and the dynamics of the methyl internal rotation which falls into the terahertz region. The THz spectra of two phenylthiourea derivatives, 4-methylthiocarbanilide and 1-(2-hydroxyethyl)-1-methyl-3-phenylthiourea, which are pharmaceutical intermediates, were measured using a TeraView TPS Spectra 3000 spectrometer at different concentrations in the mixture pellets with polyethylene powder. Three well-defined peaks were consistently observed at 1.22, 1.47 and 2.01 THz in the spectra of the former compound, and at 1.22, 1.57 and 2.00 THz in the spectra of the latter compound. The calculations using density functional theory of the isolated molecule model of the compounds reproduced these peaks well. It indicates that the absorption peaks should be caused by the low-frequency intramolecular vibrational modes of organic fragments, such as benzene rings, methyl group and 2-hydroxyethyl group.

Mo9-4 14:45 **Quantitative Study Of Lipid Head Group Structure Effect On Long-range Hydration Dynamics With Terahertz Spectroscopy 87**

Da-Hye Choi[1]; Heyjin Son[1]; Seonghoon Jung[2]; Jaehun Park[2]; Gun-Sik Park[1]

[1]Seoul National University, Korea, Republic of; [2]Pohang Accelerator Laboratory, Korea, Republic of

Activation energy of phospholipids in aqueous solution was obtained by terahertz (THz) time domain spectroscopy. The THz absorption as a function of temperature, an Arrhenius plot, yields activation energy of water relaxation process. Head group structure and phase dependence of the activation energy is reported.

Mo9-5 15:00 **Analysis Of Hydration And Dehydration On Xanthine Related Compounds During Pharmaceutical Granulation Process Using Terahertz Spectroscopy 88**

Tomoaki Sakamoto[1]; Tetsuo Sasaki[2]; Hiroko Kimura[2]; Yukio Hiyama[1]; Noriko Katori[1]; Haruhiro Okuda[1]

[1]National Institute of Health Sciences, Japan; [2]Shizuoka University, Japan

Hydration and dehydration processes during a pharmaceutical granulation process of xanthine related compounds were investigated using terahertz/far-infrared, mid-infrared and near-infrared electromagnetic waves. Certain kinds of xanthine related compounds and binders gave hydration and/or dehydration.

Mo9-6 15:15 **Secondary Structure Evident In The Far Infrared Spectra Of Peptides 90**

Robert Falconer[1]; Anton Middelberg[2]; Tao Ding[3]

[1]University of Sheffield, United Kingdom; [2]University of Queensland, Australia; [3]National University of Singapore, Singapore

Interpretation of the far-infrared spectra of polypeptides is not straightforward. Peptides have peaks between 300-500 cm^{-1} that are diagnostic of their secondary structure confirming earlier work with polyamides. The helical peptide had a peak at 380 cm^{-1} and the beta-sheet peptide had a peak at 445 cm^{-1}. The cyclic helical peptide KARAD also had peaks at 385, 402 and 470 cm^{-1} which were not present in the linear isomer. Below 300 cm^{-1} the spectra are complex and still defy understanding but are evidently data-rich and worthy of further research.

Mo10 **16:00 - 17:30** **High-Power Sources 3** **Gutenberg 1**
Chair: Gregory Nusinovich

Mo10-1 16:00 **233 GHz Ultra-Wide Band TWTA: PPM Integrated Sheet Electron Beam Transport And PIC Analysis 92**
Anisullah Baig; Diana Gamzina; Larry Barnett; Calvin Domier; Neville Luhmann
University of California - Davis, United States
We report on the design and development of a PPM integrated 233 GHz staggered vane sheet beam TWTA. The permanent magnetic (NdFeB) based focusing lens structure for the sheet electron beam transport has been designed for a gun operated at 19 kV. For a beam tunnel of 830 μm * 160 μm, a transmitted current of ~ 200 mA is achieved for > 40 mm length channel. For 19 kV operation, the TWTA circuit has been re-designed. The EM/PIC simulation analysis predicts ~ 40 GHz cold band width and ~ 20 GHz hot bandwidth for a power gain of > 25 dB. The PCM based transmission results, TWT circuit cold test, and the pulsed proof of concept hot test status will be presented in the conference.

Mo10-2 16:15 **Reflection Of Gyrotron TE_{0n} Modes At Open-Ended Circular Waveguide 94**
Manfred Thumm[1]; Walter Kasparek[2]; Dietmar Wagner[3]; Andreas Wien[4]
[1]Karlsruhe Institute of Technology (KIT), Germany; [2]University of Stuttgart, IGVP, Germany; [3]Max-Planck-Institute for Plasma Physics, Germany; [4]IMST GmbH, Germany
Reflection of TE_{0n} modes (n = 1-6) at an oversized, open-ended circular waveguide was investigated theoretically employing scattering matrix codes, a FDTD code and UTD as well as the first time experimentally. The measurements utilized mode converters for generation of pure TE_{0n} modes and a wavenumber spectrometer for directive mode analysis in the oversized waveguide. The computed total power reflection is 4.1 to 13.4 dB lower than calculated from free space wave and waveguide mode impedances, in agreement with experiments.

Mo10-3 16:30 **KIT Gyrotron Development For Future Fusion Applications 96**
John Jelonnek; Kostas Avramidis; Joachim Franck; Gerd Gantenbein; Klaus Hesch; Stefan Illy; Jianbo Jin; Anton Malygin; Ioannis Pagonakis; Tomasz Rzesnicki; Andrey Samartsev; Theo Scherer; Andreas Schlaich; Martin Schmid; Dirk Strauss; Manfred Thumm; Jianghua Zhang
Karlsruhe Institute of Technology (KIT), Germany
Europe is making a significant joint effort to develop high power microwave sources (gyrotrons) for nuclear fusion applications. KIT is taking a large part in this. It is involved into the developments for W7-X and ITER, and it is starting research for gyrotrons which, in future, shall operate at multi-megawatt levels at above 200 GHz and shall allow step-frequency tunability. To enable this, KIT is setting up a new gyrotron test facility. The presentation will provide a comprehensive overview on the 2013 status and plans of the gyrotron development at KIT.

Mo10-4 16:45 **Developing Terahertz Sources With Longitudinal Polarisation Components For The Energy Modulation Of Relativistic Electrons 98**
Matthew Cliffe[1]; David Walsh[2]; Darren Graham[1]; Steven Jamison[3]; Wendy Flavell[1]
[1]The University of Manchester, United Kingdom; [2]University of Dundee, United Kingdom; [3]STFC, United Kingdom
Laser driven terahertz radiation sources have been developed to enable energy modulation of relativistic electron bunches on a sub-picosecond timescale. Photoconductive and nonlinear optical generation schemes capable of providing the required > 1MV cm^{-1} field strengths, and longitudinal polarisation components, are discussed.

Mo10-5 17:00 **Synthesis Of Multimode Waveguide Converters Using Full-Wave EFIE Field Analysis Method 100**

Anton Gashturi, Dmitry Sobolev, Gregory Denisov

Institute of Applied Physics, Russian Academy of Sciences, Russian Federation

We propose the use of combination of synthesis method of multimode waveguides and the EFIE analysis method. The synthesis uses the fields on the waveguide wall which are simply expressed in terms of surface current calculated with EFIE approach.

Mo10-6 17:15 **Quasi-optical Theory Of Relativistic Submillimeter Cherenkov Amplifier And Oscillators 102**

Naum Ginzburg; Andrei Malkin; Vladislav Zaslavsky; Ilya Zheleznov; Alexander Sergeev

IAP RAS, Russian Federation

Within the quasi-optical approach, we study evanescent waves propagation along a periodically corrugated surface and their excitation by a relativistic electron beam. The main features of amplifier and oscillators schemes are described including the increments, starting currents, electron efficiency and forming of self-consistent spatial structure of the radiation field. The feasibility of realization of relativistic surface-wave devices in the submillimeter wavelength range is demonstrated.

Mo11 16:00 - 17:30 THz communications 1 Gutenberg 2
Chair: Daniel Mittleman

Mo11-1 16:00 **22 Gbps Wireless Communication System At 0.4 THz 104**

Guillaume Ducournau[1]; Pascal Szriftgiser[2]; Fabio Pavanello[1]; Philip Latzel[1]; Alexandre Beck[1]; Tahsin Akalin[1]; Emilien Peytavit[1]; Mohammed Zaknoune[1]; Denis Bacquet[1]; Jean-François Lampin[1]

[1]IEMN, France; [2]PhLAM, France

By combining a UTC-PD as a THz emitter and a 400 GHz Schottky-based heterodyne detection, we realized an indoor THz link working up to 22 Gbps at 400 GHz carrier frequency with ultra-low THz power. The eye diagram at receiver is clearly opened are the system is working with only 1 μW received THz power.

Mo11-3 16:30 **200 GHz Communication System Using Unipolar InAs THz Rectifiers 106**

Guillaume Ducournau[1]; Andreas Westlund[2]; Paul Sangaré[1]; Christophe Gaquière[1]; Per-Ake Nislon[2]; Ludovic Desplanque[1]; Jean-Louis Codron[1]; Xavier Wallart[1]; Ignacio Iniguez de La Torre[3]; Jeff Millithaler[3]; Tomas Gonzales[3]; Javier Mateos[3]; Jan Grahn[4]

[1]IEMN, France; [2]CHALMERS, Sweden; [3]Univ. Salamanca, Spain; [4]CHALMERS, Spain

We report on the first use of a THz detector based on InAs rectifying nanochannels in a communication system. The transmitter is composed of an electronic multiplication chain, externally amplitude modulated at the input signal. The system has been driven at 200 GHz and up to 500 Mbps data signals have been transmitted in an indoor configuration. In contrast to most nanodevices, the InAs detector has a low impedance (580 Ω) and is therefore easily loaded by 50 Ω electronics. The data rate limitation is mainly coming from parasitics coupled in the board.

Mo11-4 16:45 **Broadband Channel Measurements Between 50 GHz And 325 GHz: Comparison Of Different Propagation Scenarios 108**

Thomas Kürner[1]; Thomas Kleine-Ostmann[2]; Mohammed Salhi[2]; Marius Kannicht[2]; Thorsten Schrader[2]

[1]Institut für Nachrichtentechnik, TU Braunschweig, Germany; [2]Physikalisch-Technische Bundesanstalt (PTB), Germany

For the modeling and design of communication systems in the lower THz frequency range the propagation conditions need to be known. We show a comparison of ultra-broadband channel measurements from 50 GHz to 325 GHz in different scenarios related to typical office and industry environments.

Mo11-5 17:00 **Digital THz Communication Links In The Atmosphere 110**
Daniel Grischkowsky; Yihong Yang; Mahboubeh Mandehgar
Oklahoma State University, United States
Our measurements and linear dispersion theory calculations show that it is possible to have high performance THz links in the atmosphere. A direct 95 GHz, 20 km ground link at 10 Gb/s would have a power loss of 9 dB due to water vapor at RH 58 % ($10 g/m^3$) and 20 $^{\circ}$C and O_2 absorption, and a diffraction loss of 36 dB for 1 m dia. antennas. A direct 250 GHz, 40,000 km satellite link at 20 Gb/s would have a 2 km (equivalent to the zenith integration) water vapor loss of 8 dB and a diffraction loss of 76 dB with 5 m ground and 2 m satellite antennas.

Mo12 16:00 - 17:30 Quantum cascade lasers 2 Gutenberg 3
Chair: Miriam Vitiello

Mo12-1 16:00 **High Performance Room-temperature Terahertz Intracavity Difference-frequency Generation In Quantum Cascade Lasers 112**
Karun Vijayraghavan[1]; Yifan Jiang[1]; Aiting Jiang[1]; Frederic Demmerle[2]; Gerhard Boehm[2]; Xiaojun Wang[3]; Mariano Troccoli[3]; Markus Amann[2]; Mikhail Belkin[1]
[1]University of Texas at Austin, United States; [2]Walter Schottky Institut, Technische Universität München, Germany; [3]Adtech Optics, United States
Room-temperature, narrow-linewidth terahertz quantum cascade laser sources based on intracavity Cherenkov difference-frequency generation with emission over the 2 to 4 THz range and a maximum power of 0.12 mW is demonstrated.

Mo12-3 16:30 **Direct Optical Sampling Of A Modelocked Terahertz Quantum Cascade Laser 115**
Jean Maysonnave[1]; Joshua Freeman[1]; Nathan Jukam[2]; Pierrick Cavalié[1]; Kenneth Maussang[1]; Harvey Beere[3]; David Ritchie[3]; Juliette Mangeney[1]; Sukhdeep Dhillon[1]; Jérôme Tignon[1]
[1]Laboratoire Pierre Aigrain, Ecole Normale Supérieure, CNRS (UMR 8551), France; [2]Lehrstühl für Angewandte Festkörperphysik, Ruhr-Universität, Germany; [3]Semiconductor Physics, Cavendish Laboratory, University of Cambridge, United Kingdom
Quantum Cascade Lasers are promising sources of Terahertz radiation. Picosecond pulses generation with these lasers is currently at its infancy and their detection is difficult. An intensity electro-optic sampling method is used here to demonstrate 19 ps FWHM pulses from a QCL via active modelocking.

Mo12-5 17:00 **Tapered Terahertz Quantum Cascade Lasers 116**
Weidong Chu[1]; Yanfang Li[1]; Junqi Liu[2]; Fengqi Liu[2]; Suqing Duan[1]
[1]Institute of Applied Physics and Computational Mathematics, China; [2]Institute of Semiconductors, Chinese Academy of Sciences, China
Terahertz quantum cascade lasers with tapered waveguide structure are reported. It is found there is an optimized tapered angle with which the peak output power of the devices with same total length reaches the maximum. The far-field divergence of the laser beam depends on the tapered angle as well as the driven current. The existence of the optimized tapered angle and the current-dependent far-field pattern may be attributed to the self-focusing effect in the devices.

Mo12-6 17:15 **Transient Analysis Of Substrate Heating Effects In A Terahertz Quantum Cascade Laser Using An Ultrafast NbN Superconducting Detector 118**
Alexander Valavanis[1]; Paul Dean[1]; Alexander Scheuring[2]; Mohammed Salih[1]; Axel Stockhausen[2]; Stefan Wuensch[2]; Konstantin Il'in[2]; Siddhant Chowdhury[1]; Suraj Khanna[1]; Michael Siegel[2]; Giles Davies[1]; Edmund Linfield[1]
[1]University of Leeds, United Kingdom; [2]Karlsruhe Institute of Technology, Germany
We use an ultrafast NbN superconducting detector to investigate dynamic bulk heat-storage effects in a THz QCL. A first-order heat-accumulation model is used to obtain reliable estimates of the thermal resistance and heat capacity from the measured

temperature variation.

Mo13 **16:00 - 17:30** **THz Cameras** **Gutenberg 4**
Chair: Frank Ellrich

Mo13-1 16:00 **Reflection 2D Real Time THz Camera To Image And Identify Sugar Pellets 120**
Simon Joly[1]; Jérôme Meilhan[1]; Stéphane Pocas[1]; Jean-Louis Ouvrier-Buffet[1]; Wilfried Rabaud[1]; Frédéric Garet[2]; François Simoens[1]
[1]CEA Leti-MINATEC, France; [2]IMEP-LAHC, UMR-CNRS 5130, University of Savoie, France
Substance standoff identification in reflection optical arrangement is tested with our uncooled bolometer 2D camera: we image in real-time the reflected and backscattered radiation from a large actively illuminated surface containing sugar pellets. Reflectances extracted from these images show good agreement with spectroscopy measurements.

Mo13-2 16:15 **High-Performance Metamaterial MM-to-IR Converter For MM-wave Imaging 122**
Andrey Paulish[1]; Peter Zagubisalo[1]; Sergey Kuznetsov[2]
[1]Novosibirsk branch of Institute of Semiconductor Physics "TDIAM", Russian Federation; [2]Novosibirsk State University, Russian Federation
A simple MM-wave imaging system based on high-performance metamaterial MM-to-IR converter and IR camera is proposed, theoretically and experimentally investigated. The energy conversion efficiency of MM waves into IR radiation is over 90 %. The main characteristics of MM-wave imager are discussed.

Mo13-3 16:30 **Design And Microfabrication Of Frequency Selective Uncooled Microbolometer Focal Plane Array For Terahertz Imaging 124**
El-Hassane Oulachgar[1]; Philip Mauskopf[2]; Samir Ilias[1]; Jacques-Edmond Paultre[1]; Dominique D'Amato[1]; Marc Terroux[1]; Timothy Pope[1]; Christine Alain[1]; Patrice Topart[1]; Hubert Jerominek[1]
[1]Institut National d'Optique, Canada; [2]Cardiff University, United Kingdom
A THz frequency selective microbolometer focal plane array (FPA) with 35 μm pixel pitch and a resolution of 384x288 pixels was recently developed at INO. The FPA was fabricated on a CMOS readout circuit using MEMS surface micromachining techniques. The uncooled microbolometer detectors, based on vanadium oxide technology, were optimized for detection at 4.25 THz. A high performance frequency selective THz camera operating at 4.25 THz was also demonstrated.

Mo13-4 16:45 **High-speed THz Semiconductor Imaging Camera 126**
Viacheslav Muravev; Gombo Tsydynzhapov; Anton Fortunatov; Igor Kukushkin
TeraSense, Russian Federation
A high-speed room temperature THz imaging system is developed. The sensor consists of an array (64x64) of plasmonic semiconductor detectors. The detectors have broadband responsivity of up to 20 V/W in the frequency range 10 GHz – 1 THz. Pixel-to-pixel deviation of the sensor parameters is not larger than 20 %. The sensor with an amplification electrical circuit provide shot times of 100 ms. The sensor is fabricated using standard semiconductor fab cycles. Therefore, the device is an ideal object for low-cost mass production.

Mo13-5 17:00 **Real-time CMOS Terahertz Camera Employing Plane-to-plane Imaging With A Focal-plane Array Of Field-effect Transistors 127**
Maris Bauer; Sebastian Boppel; Alvydas Lisauskas; Viktor Krozer; Hartmut G. Roskos
Physikalisches Institut, Johann Wolfgang Goethe-University, Germany
We present a terahertz camera working at 590 GHz at real-time frame-rates of 16 frames per second (fps). An array of 12x12 field-effect transistors has been fabricated in a 150-nm CMOS process and is used as the camera's image sensor. The averaged single-pixel noise-equivalent-power is 43 pW/√Hz, the voltage single-pixel responsivity is 340 V/W. For an effective power of 104 μW distributed over the sensor area and a single pixel

integration time of 2.5 ms, a dynamic range of more than 10 dB for full-frame images at 33 Hz update rate is observed. The array, which does not yet contain integrated preamplifiers, serves as a test-bed for the development of heterodyne imaging also to be described in the presentation.

Mo13-6 17:15 **Video-rate THz Imaging Applications Using A 384x288 Pixel Camera 129**
Martin Bolduc; Marc Terroux; Linda Marchese; Alain Bergeron
INO - Institut National d'Optique, Canada
Video-rate THz reflection imaging, at 450 GHz using a high-resolution INO 384x288 pixel camera core, of pills in blister packs further contained within their final commercial packages is reported. These results open the door to deployable real-time THz cameras for see-through imaging applications, providing a tool for NDE quality control and security inspection of goods within their final packaging.

Mo14 16:00 - 17:30 THz Spectroscopy Systems 1 Congress Hall
Chair: Krzysztof Iwaszczuk

Mo14-1 16:00 **Ultra-Broadband Dielectric THz Spectroscopy With Air-Biased-Coherent-Detection 131**
Francesco D'Angelo; Mischa Bonn; Dmitry Turchinovich
Max Planck Institute for Polymer Research, Germany
We present results on ultra-broadband THz-TDS on silicon using air biased coherent detection (ABCD) technique. We find that the positioning of the sample in the spectrometer, leading to the spatial shift of THz focus, is crucial for accurate spectroscopy results.

Mo14-2 16:15 **Polarization Dependent Study Of THz ABCD 133**
Jing Zhang; Xi-Cheng Zhang
Wuhan National Labortary for Optoelectronics, Huazhong University of Science and Technology, China
We study the polarization dependence of THz wave air-biased-coherent-detection. By changing the polarization state of fundamental beam and DC field, the polarization of the THz field induced second harmonic is measured.

Mo14-3 16:30 **Femtosecond Coherent Control Of THz Spectra Driven By Free- And Coupled Electrons In Gas Plasma 134**
Alexander Shkurinov[1]; Olga Kosareva[2]; See Leang Chin[3]; Xi-Cheng Zhang[4]
[1]Lomonosov Moscow State University, Russian Federation; [2]aLomonosov Moscow State University, Russian Federation; [3]Universite Laval, Canada; [4]The Institute of Optics, University of Rochester, United States
We demonstrate in the experiment and simulations that interference between two contributions into the terahertz wave generation in a femtosecond filament, namely, the free electron photocurrent and the nonlinear polarization of neutrals, can be used for the femtosecond coherent control of the THz spectra.

Mo14-4 16:45 **One-pulse High-resolution THz Time-domain Spectroscopy: Development And Applications 136**
Vitaly Kubarev[1]; Evgeny Chesnokov[2]; Pavel Koshliakov[2]
[1]BINP, Russian Federation; [2]ICKC, Russian Federation
Development and applications of one-pulse time-domain spectroscopy on terahertz Novosibirsk free-electron laser is described. Spectrometer with Fabry-Perot etalon in reference branch is used for NovoFEL pulse diagnostics with measuring time of 0.4-0.5 ns. More long HCN-gas reference was applied for high resolution (38 MHz; $1.8 \cdot 10^{-5}$) gas spectroscopy. Spectral resolution of the method as expected to be directly proportional to a measuring time.

Mo14-5 17:00 **Precise And Convenient Reflection THz-Time Domain Spectroscopy With A Movable Transparent Sample Holder 138**

Norihisa Hiromoto[1]; Toru Nagashima[1]; Saroj Tripathi[2]; Masanori Takeda[1]; Makoto Aoki[1]

[1]Shizuoka University, Japan; [2]Nagoya University, Japan

In order to realize accuracy and convenience in the reflection THz-TDS, we propose and fabricate a movable THz-transparent sample holder to eliminate the misplacement errors between reference and sample, and make an analysis software to derive optical constants of a sample without approximation. Precise complex refractive indexes of pure water, and creams and gels used in medical examinations were obtained by the reflection measurement using these techniques.

Mo14-6 17:15 **Compact, Portable Terahertz Systems For On-site Inspection Applications 140**

Albert Redo-Sanchez; Norman Laman; Brian Schulkin; Thomas Tongue

Zomega Terahertz Corporation, United States

This paper describes an example of using a compact Terahertz (THz) system to analyze the layered structure of a composite plastic samples in a non-destructive manner. Time-domain data is analyzed to measure the thickness of each layer of the sample and determine the presence or absence of adhesive bonding the plastic parts. The presence and position of the adhesive is clearly visible in the THz images and the measured thickness shows an excellent agreement with nominal thickness.

Mo P1 17:30 – 19:00 Poster 1 Rhein Foyer West

Mo P1-1 **Metamorphic Ultrafast Photoconductive Materials In The 1-µm Wavelength Region For Efficient Terahertz Emission 141**

Norihiko Sekine; Isao Morohashi; Kouichi Akahane; Iwao Hosako

NICT, Japan

We have developed ultrafast photoconductive InGaAs/InAlAs structures for operation in the 1-µm wavelength region. The structures were grown metamorphically on GaAs substrates and show both an ultrafast photo-carrier lifetime and a high resistance.

Mo P1-2 **Dependence Of THz Optical Constants On Orientational Alignment Of Liquid Crystals 143**

Mira Naftaly; Richard Dudley

National Physical Laboratory, United Kingdom

The optical constants, birefringence and dichroism of liquid crystals BL037 and GT3-23001 are investigated in the frequency range 0.4-4 THz using time-domain spectroscopy. A specially designed bias cell is described which allows the orientational dependence of optical properties to be observed.

Mo P1-3 **Terahertz Conductivity Spectra In Semiconductors With Nanoscale Modulation 144**

Hynek Nemec[1]; Jan Mrozek[2]

[1]Institute of Physics, Academy of Sciences of the Czech Republic, Czech Republic; [2]Terahertz Conductivity Spectra in Semiconductors with Nanoscale Modulation, Czech Republic

Terahertz response of charge carriers moving in a potential with nanoscale modulation is investigated theoretically. We describe characteristic spectral features related to charge localization and to depolarization fields resulting from the system inhomogeneity.

Mo P1-4 **Identification Of Official Rhubarb Samples Based On THz Spectra And Least Squares Support Vector Machine 146**

Zhuoyong Zhang; Jingrong Wang; Zhenwei Zhang; Jian Zuo; Yuhong Xiang; Cunlin Zhang

Capital Normal University, China

Terahertz time-domain spectroscopy (THz-TDS) combined with emphatic orthogonal

signal correction (EOSC) and least squares support vector machine (LS-SVM) has been applied to establishing qualitative analysis model for identifying 41 official and unofficial rhubarb samples. The correction factors of the model have been determined by bootstrapped Latin-partitions. The spectra were pretreated by autoscaling and Savitzky - Golay smoothing (the window size is 5, the polynomial order is 3), and a comparison of two pretreatment methods for the classified accuracy was implemented. The results showed that the identification accuracy of 97.84±1.62 % could be accomplished by using the pretreatment methods of autoscaling and EOSC, which is higher than the classified accuracy of 87.45±3.03 % by using Savitzky - Golay smoothing method. The proposed method was proved to be a convenient, non-polluting, accurate, and nondestructive approach for identifying rhubarb samples. The developed procedure can be easily implemented for controlling quality in rhubarb production.

Mo P1-5 **Novel Conception Of The Terahertz-range Spectrometer Based On Fabry-Perot Interferometer 148**

Ivan Tzibizov[1]; Andrey Kaveev[1]; Grigory Kropotov[1]; Dmitry Tsypishka[1]; Alexander Zhdanov[2]; Andrey Ivanov[2]
[1]Tydex J. S. Co, Russian Federation; [2]Samara State Technical University, Russian Federation

We have developed novel THz spectrometer based on Fabry-Perot interferometer. The novelty of the device is related to the metal-covered high-resistivity silicon mirrors. Also an original body of mathematics which allows broadband incident signal spectrum reconstruction was elaborated.

Mo P1-6 **Terahertz Time-domain Characterization Of Various Fabrics 149**

John Molloy[1]; Mira Naftaly[1]; Gregory Lanskii[2]; K.A. Kokh[2]; Yury Andreev[2]
[1]National Physical Laboratory, United Kingdom; [2]Institute of Monitoring of Climatic and Ecological Systems SB RAS, Russian Federation

A variety of fabrics are examined using THz time-domain spectroscopy. Different types of textiles are shown to have different THz optical properties, which may be employed to combat textile counterfeiting.

Mo P1-7 **Developments Of Multi-Extreme THz ESR System And Its Application To Cr-Jarosite 150**

Hitoshi Ohta[1]; Susumu Okubo[1]; Takahiro Sakurai[2]; Eiji Ohmichi[3]; Weimin Zhang[1]; Tokuro Shimokawa[4]; Ryohei Nakata[3]; Koji Okuta[5]; Shigeo Hara[5]; Hirohiko Sato[5]
[1]Kobe University, Molecular Photoscience Research Center, Japan; [2]Kobe University, Center for Support to Research and Education Activities, Japan; [3]Kobe University, Graduate School of Science, Japan; [4]Kobe University, Center for Collaborative Research and Technology Development, Japan; [5]Chuo University, Department of Physics, Japan

Multi-extreme THz ESR measurements have been performed on Cr-jarosite, which is an ideal model substance of highly frustrated kagome antiferromagnet. The analysis of antiferromagnetic resonances observed at 1.9 K revealed the Dzyaloshinsky-Moriya interaction, which plays an important role on the ground state.

Mo P1-8 **Metamaterials Based Broadband THz Absorber 152**

Ying Xiong; Qi-Ye Wen; Man-Man Mo; Huai-Wu Zhang
University of Electronic Science and Technology of China, China

In this paper, we have presented the simulation results on a novel metamaterial absorber, which can work in the terahertz regime. The results show that the absorber has a smooth broadband absorption peak of 400 GHz with the absorptivity over 95 %.

Mo P1-9 **Mechanism Of Electromagnetically Induced Transparency Like Phenomena With Metamaterials In Terahertz Region 153**

Hiroki Morita[1]; Youhei Nishiyama[1]; Fumiaki Miyamaru[1]; Toshihiro Nakanishi[2]; Masao Kitano[2]; Mitsuo Takeda[1]
[1]Shinshu University, Japan; [2]Kyoto University, Japan

We experimentally and numerically investigate spectral response that resembles electromagnetically induced transparency (EIT) phenomenon by using two planar metamaterials. The one of them consists of a cut wire (CW) with low quality factor and two SRRs with high quality factor, the other consists of a split ring resonator (SRR) with high quality factor located within a closed ring resonator (CRR) with low quality factor. By using FDTD simulation, we investigate the detailed mechanism of EIT-like phenomenon that occurs in the coupled system between two bright resonant modes.

Mo P1-10 **Broadband Black Coating For Terahertz Radiometry 155**

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National Institute of Metrology, China

We report an easy fabricated, broadband and high-absorbance coating for terahertz radiometry. The spectral properties of this coating in THz region were characterized with a home-made terahertz time-domain spectrometer. The measured spectral reflectance is less than 0.3 % ranging from 0.2 THz to 0.5 THz and less than 0.1 % ranging from 0.5 THz to 2.0 THz.

Mo P1-11 **Total Absorber For THz-Spectroscopy 157**

Richard Knipper[1]; Thomas Mayerhöfer[2]; Uwe Hübner[2]; Torsten May[2]; Hans-Georg Meyer[2]; Dana Cialla[1]; Karina Weber[1]; Jürgen Popp[1]
[1]IPC Jena - Institut für Physikalische Chemie, Germany; [2]IPHT Jena, Germany

Following an established concept of IR spectroscopy, the total absorber was transferred to the THz wavelength. This allows for measurement of effects interesting for life-science applications like DNA hybridization and molecular resonances. The complete process from simulations to measurements will be addressed.

Mo P1-12 **Thermal Analysis Of III-V HBV Diode Structures On InP, GaAs, Silicon And Diamond Substrates 158**

Aleksandra Malko; Aik Yean Tang; Josip Vukusic; Tomas Bryllert; Huan Zhao; Jan Stake
Chalmers University of Technology, Sweden

Thermal analysis of $In_{0.53}Ga_{0.47}As$ and GaAs Heterostructure Barrier Varactors diodes on InP, GaAs, silicon and diamond substrates are presented. The physical dimensions of the analysed structures correspond to the dimensions of a high power integrated HBV frequency multipliers for W-band (70 – 110 GHz). It is shown that material transfer to substrates with higher thermal conductivities will reduce thermal resistance by 21 % and approximately 50 % for $In_{0.53}Ga_{0.47}As$ and GaAs HBVs, respectively. Thus, an enhanced thermal handling capability of the HBV multiplier sources can be obtained.

Mo P1-13 **Is Amplification Of Semiconductor Plasmons Possible Despite Carrier Collisions And Diffusion? 160**

Oleksiy Sydoruk
Imperial College London, United Kingdom

A theoretical model is developed that takes into account the detrimental effects of carrier collisions and diffusion on the amplification of drifting plasmons reflecting from conducting boundaries. It is found that, despite collisions and diffusion, amplification is possible for realistic parameters.

Mo P1-14 **Evaluation Of Interfacial Water On Super-hydrophilic Surface By THz-TDS 161**

Satoshi Yamauchi[1]; Yoh Imai[1]; Masayoshi Tonouchi[2]
[1]Ibaraki University, Japan; [2]Osaka University, Japan

Transmission-type THz-TDS was applied to characterize water on super-hydrophilic surface of anatase-TiO_2 layer fabricated by plasma-assisted deposition. Absorption coefficient of water with the thickness of 300 mm on the layer was in good agreement to that of free water before the surface was converted to the super-hydrophilicity but decreased on the super-hydrophilic surface after UV-irradiation. The complex dielectric constant was fitted by double Debye-model and could be explained by a model of double water layers consisting of free water and interfacial water near the super-hydrophilic surface after UV-irradiation. The slow relaxation time of 37 ps in the interfacial layer with the thickness of 45 mm was significantly large comparing to the value of 7.7 ps in free water.

Mo P1-15 **Self-consistent, Time-dependent Gyrotron Linear Analysis In Non-homogeneous RF-structures 163**

Falk Braunmueller; Trach-Minh Tran; Stefano Alberti; Jeremy Genoud; Jean-Philippe Hogge; Minh Quang Tran; Quentin Vuillemin
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We present an analysis of the linear behavior of the gyrotron interaction in both the forward-wave regime with positive parallel wavevector, $k_{||}$ and the backward-wave regime with $k_{||} < 0$. The considered electromagnetic (EM) structures are longitudinally non-homogeneous and the electron beam properties have, in general, also a longitudinal dependence. The set of time-dependent linearized self-consistent interaction equations allows to calculate the self-consistent starting-current for a given $TE_{m,p}$ transverse mode. These effects have to be included in particular for the backward-wave regime for which the longitudinal EM field profile is fully determined by selfconsistent effects. The analysis can be used for calculating the starting conditions for parasitic oscillations occurring in beamducts and/or the launcher section following the gyrotron cavity.

Mo P1-16 **Detailed Characterization Of A Frequency-tunable 260GHz Gyrotron Oscillator Planned For DNP/NMR Spectroscopy 165**

Jean-Philippe Hogge[1]; Falk Braunmueller[1]; Stefano Alberti[1]; Jeremy Genoud[1]; Trach-Minh Tran[1]; Quentin Vuillemin[1]; Minh Quang Tran[1]; Jean-Philippe Ansermet[2]; Philippe Cuanillon[2]; Alessandro Macor[3]; Emile de Rijk[3]; Pedro Saraiva[2]
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The detailed characterization of a modular 260GHz, frequency-tunable, CW-gyrotron equipped with a matching optics unit allowing full-polarization control of the rf-wave is presented. The integration of the gyrotron-system with the NMR spectrometer is outlined.

Mo P1-17 **Nonlinear Optical Spectrum Of Two-Dimensional Electron Gas With Rashba Spin-Orbit Interaction In THz Frequency Regime 167**

Yee Sin Ang[1]; Chao Zhang[1]; Qinjun Chen[2]
[1]University of Wollongong, Australia; [2]Institute of Superconducting and Electronic Materials, Australia

We theoretically calculate the nonlinear optical spectrum of two-dimensional electron gas in the presence of Rashba spin-orbit interaction in terahertz frequency regime. For Rashba coupling parameter in the order of 0.4 eVÅ, the nonlinear optical response exceeds the linear response with the application of an external electric field strength in the order of 10^3 V/cm.

Mo P1-18 **Design Of A W-band TE_{01} Mode Gyro-TWT Amplifier With A Lossy Ceramic-loaded Circuit 169**

Chaohai Du; P. K. Liu
School of Electronics Engineering and Computer Science, Peking University, China

A pulse prototype of a W-band TE_{01} mode gyrotron traveling-wave tube (gyro-TWT) amplifier is designed, and it features high gain and broadband capabilities. Theoretical investigation predicts that, when the magnetic injection gun (MIG) is optimized to generate an electron beam of voltage 70 kV, current 3 A, high pitch factor 1.5, and low axial-velocity spread about 5 %, the gyro-TWT amplifier is of excellent performance, including being driven to saturation with input power $P_{in} < 0.4$ W, highest efficiency of 32.4 %, and the bandwidth of 4.2 GHz with output power exceeding 50 kW.

Mo P1-19 **Large Birefringence Liquid Crystal In Terahertz Range With Temperature Tuning 171**

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We report the terahertz spectrum of a high birefringence liquid crystalline mixture 2002 from 0.2 to 1.6 THz, using terahertz time domain spectroscopy (THz-TDS). Furthermore, the phase transition from nematic to isotropic phases was observed using temperature-dependent THz-TDS.

Mo P1-20 **On Propagation Characteristics Of Waveguide-like ABS-Structures In 60 And 300 GHz Communications 173**

Sebastian Rey[1]; Alexander Fricke[1]; Mounir Achir[2]; Philippe Le Bars[2]; Thomas Kleine-Ostmann[3]; Thomas Kürner[1]
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Future communication systems in the Terahertz range are promising very high data rates. Here a measurement setup designed for short intra- or range inter-device communication is presented. Exemplary measurement results are given for waveguide-like ABS structures. In addition the possibility to model the propagation properties with a ray tracing approach is evaluated.

Mo P1-21 **Reflection And Transmission Properties Of Plastic Materials At THz Frequencies 175**

Philippe Le Bars[1]; Alexander Fricke[2]; Sebastian Rey[2]; Mounir Achir[3]; Thomas Kleine-Ostmann[4]; Thomas Kürner[2]
[1]CANON Research Centre France, France; [2]Institut für Nachrichtentechnik Technische Universität Braunschweig, Germany; [3]CANON Research Center France, Germany; [4]Physikalisch-Technische Bundesanstalt, Germany

Reflection and transmission properties of materials common in electronic devices are investigated for the frequency ranges of 50 GHz to 75 GHz as well as 270 GHz to 320 GHz. Material parameters are extracted by fitting the measurement results with Transfer Matrix Method simulations.

Mo P1-22 **Mode Purity Estimation Of The Gyrotron RF Beam 177**

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In this paper, the implementation of a phase retrieval algorithm for determining the phase profile of gyrotron output beams from measured intensity patterns at different planes is described along with a novel mode estimation technique based on a surface matching algorithm. A simulated Gaussian beam at different planes is considered as input of the phase retrieval algorithm. The proposed mode estimation technique supports the accurate mode estimation of different linearly polarized modes present in gyrotron output RF beam.

Mo P1-23 WITHDRAWN

Mo P1-24 **An Automatic Unfolding Method For Terahertz Spectra 179**

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Terahertz (THz) time domain spectroscopy is considered as an attractive tool for material diagnostics and analysis. Despite existing characteristic fingerprints in THz spectra, extraction of these feature information is tough to achieve because of scattering phenomenon. Several methods have been proposed for mitigating scattering effects. However, little attempts are made to unfold THz spectra for extracting parameters of absorption peaks with the distraction of scattering. In this report, an automatic unfolding method for THz spectra is proposed based on multidimensional peak searching and quadratic programming. The obtained Lorentzian parameters for the absorption peaks are accurate and repeatable, thus holding potential for material recognition and quantitative analysis.

Mo P1-25 **Planar Type Liquid Crystal Phase Shifter Based On The Microstripline Structure 181**

Kenji Ito[1]; Toshiaki Nose[2]; Takuya Iisaka[2]; Yusuke Ito[2]; Takayuki Sasamori[2]; Yoji Isota[2]; Ryouta Ito[2]; Michinori Honma[2]; Takeshi Watanabe[1]
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Novel conversion circuit, which connects normal microstripline (MSL) and inverted-MSL (I-MSL) structure, is designed to attain planar type liquid crystal (LC) phase shifter based on the MSL structure. The new circuit enables us to introduce a thin LC layer easily on the MSL substrate by using normal sandwich cell structure. Here, fundamental phase shift properties are estimated, and then the conversion circuit, which is the key part of the device, is optimized to improve the device performance.

Mo P1-26 **The Research Of THz Enhancement Transmittance Based On Metamaterials 183**

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THz parametric oscillators (TPOs) based on phonon-polariton scattering in a $LiNbO_3$ crystal are one of promise methods of obtaining high power tunable THz radiation. However, how to effectively reduce the absorption and enhance the transmittance of terahertz (THz) in $LiNbO_3$ still remains a question. In this paper, we present a numerical simulation solution of antireflection coating using metamaterials based on Lithium niobate substrates. This structure effectively reduces the reflection and enhances the transmission near a specifically designed terahertz (THz) frequency band. Nearly 1.7 % of reflection rate and over 94.7 % of transmission rate are obtained near 1.2~1.3 THz. Such a design can promote THz wave, which has been generated in or pass through Lithium niobate, to radiate to outside space.

Mo P1-27 **Controlled Porosity Reservoir Cathodes And Photocathodes 185**

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Research is continuing to develop controlled porosity reservoir cathodes and photocathodes. Advances in design tools, fabrication techniques will be presented as well as available test results for thermionic cathodes and photocathodes.

Mo P1-28 WITHDRAWN

Mo P1-29 **Cold Field Emitters For Electron Devices Operating In Technical Vacuum 187**

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The miniature cold field emitters are very attractive for utilization in low-power gyrotrons operating in range of short millimeter and terahertz waves and using for plasma diagnostics. Two types of developing and investigating cold field emitters prospective for this application are described in the report.

Mo P1-30 **Repetition Rate Tuning Of An Ultrafast Ytterbium Doped Fiber Laser For Terahertz Time-Domain Spectroscopy 189**

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Repetition rate tuning enables the fast acquisition of THz pulse profiles. By using this method we demonstrate a compact and broadband terahertz time domain spectroscopy system (THz TDS) driven by ytterbium doped fiber laser source. The importance of this method is realized in that Yb:doped fiber lasers can be amplified to sub-millijoule pulse strengths more easily than other types of fiber lasers. Hence, it has the potential to be used in excite-THz probe experiments. Furthermore, the repetition rate-tuning adds flexibility in the excite-probe techniques. These attributes as well as THz generation and detection are investigated with the laser that was developed.

Mo P1-31 **Dielectric Properties Of Sb_2Te_3 Thin Films Studied By Terahertz Time-domain Spectroscopy 191**

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We have fabricated Sb_2Te_3 thin films, with different thicknesses by controlling the deposition times, using pulsed laser deposition. We studied the dielectric properties using terahertz time domain spectroscopy (TDS). The real and imaginary parts of the complex refractive index of Sb_2Te_3 thin films were presented.

Mo P1-32 **Time-Domain Spectroscopy Of Novel Nematic Liquid Crystals In The Terahertz Range 193**

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The dielectric properties of nematic liquid crystal (LC) mixtures are measured from 300 GHz to 1500 GHz. Measurements are performed in a standard THz TDS setup. Refractive index and extinction coefficient for parallel and perpendicular orientation are calculated and compared to results obtained at 19 GHz. The investigated mixtures are of interest for Terahertz devices as their properties stay almost constant from 19 GHz to 1500 GHz.

Mo P1-33 **On Ohmic Losses Decrease In THz BWO-Clinotron Oscillators 195**

Sergey Ponomarenko; Sergey Kishko; Eduard Khutoryan; Alexei Kuleshov; Boris Yefimov
Usikov Institute of Radiophysics and Electronics of NASU, Ukraine

A novel oscillator with multistage grating is proposed in this paper. The capability of efficient millimeter and submillimeter wavelength generation is discussed. The prototype of W-band oscillator with nonuniform grating has been developed. The operating frequency range of 100 GHz is chosen due to significant influence of ohmic losses on the BWO operating parameters and available equipment.

Mo P1-34 **Numerical Investigations On The Effects Of Electron Beam Misalignment On Beam-wave Interaction In A High-power Coaxial Gyrotron 197**

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We investigate, by numerical simulations, the effects of a misaligned (i.e. shifted with respect to the resonator axis) electron beam on the beam-wave interaction in a 170 GHz, 2 MW coaxial gyrotron. The correlation of the simulations results with the experimental findings, which motivated the present study, is discussed.

Mo P1-35 **Improvement Of Transmission Characteristics Of A Terahertz Step Attenuator 199**

Hitoshi Iida; Moto Kinoshita; Yozo Shimada
National Institute of Advanced Industrial Science and Technology, Japan

This paper presents a method of improving the transmission characteristics of a terahertz step attenuator. The transmittance of the step attenuator was measured using a terahertz time-domain spectrometer (THz-TDS). Flat transmittances at each attenuation step were obtained at frequencies up to 3 THz by combining several 6-µm-thick metalized film attenuators (MFAs). The attenuator had no significant polarization dependence over a wide frequency range. Good short-term and long-term repeatability were also confirmed.

Mo P1-36 **New Antenna Topology Coupled To A New Waveguide Structure For THz Radiation And Propagation 201**

Enrique Garcia[1]; Sascha Preu[2]; Alejandro Rivera[3]; Stefan Malzer[2]; Gottfried Dohler[2]; Mario Mendez[3]; Dmitri Lioubttchenko[4]; Antti Raisanen[4]; Daniel Segovia[3]
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In this manuscript, we present a new antenna topology applied to the so called THz gap, based on using a dielectric rod antenna avoiding the use of the classical lens for collimating the emitted/received power. The scope and future perspective of the manuscript is beyond this idea: we develop this topology with the perspective of being the optimum antenna system to be coupled in a THz waveguide easy manufactured and with extremely low propagation losses, as we present here.

Mo P1-37 **Photothermoelastic Response Of Zincblende Crystals To THz-frequency Quantum Cascade Laser Radiation 202**

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We investigate the photothermoelastic response of ZnTe and GaP crystals irradiated by THz-frequency radiation from a quantum cascade laser. We present a full theoretical description of this interaction that agrees well with the measured response.

Mo P1-38 **Some Properties Of Coherent Smith-Purcell Radiation From Electron Bunches And Gratings Of Finite Dimensions. 204**

Ivan Konoplev[1]; Faissal Bakkali Taheri[1]; George Doucas[1]; Armin Reichold[1]; Riccardo Bartolini[1]; Nicolas Delerue[2]; Christine Clarke[3]
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There is a strong interest in the development of single shot diagnostics of fs relativistic electron bunches within a number of research areas including compact particle accelerators and THz and X-ray sources of radiation. The goal of this work is to investigate some properties of coherent Smith-Purcell radiation and to use it for the

reconstruction of the longitudinal profile of a fs-long electron bunch.

Mo P1-39 **Linac Based Broadband Source Of THz Coherent Smith-Purcell Radiation 206**

Ivan Konoplev[1]; Alexander Aryshev[2]; Junji Urakawa[2]; Konstantin Lekomtsev[2]; Mikhail Shevelev[2]; Andrei Seryi[1]
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Development of compact source of high-intensity, coherent, broadband, THz radiation is still at its initial stage. Such sources are required for a broad range of the researches including metrology, biology, security and etc. Here we discuss one of the schemes for generating the THz coherent radiation.

Mo P1-40 **Phase Noise Investigation In Terahertz Time-Domain Spectroscopy Measurements 208**

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Ecole Polytechnique, France

We present a detailed study of the influence of time jitter in terahertz time-domain measurements. It proves to be particularly important in TDS based imaging measurements and can strongly influence the quality of the images.

Mo P1-41 **Simulations Of High Power Gyrotron Operation During Window Arc 209**

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During tests of a megawatt-class 140 GHz gyrotron for the fusion experiment Wendelstein 7-X, a window RF arc was documented with a high-resolution spectral measurement system. The arc event coincided with strong perturbations of the nominal cavity mode $TE_{-28,8}$ and a final mode switch to a neighbour mode. Simulations using a self-consistent interaction code (SELFT) have reproduced the main features of the event and provide additional information on the development of the modes during the window RF arc.

Mo P1-42 **Terahertz Emission From Lateral Surge Currents And Suppression Of dipoles Under A Metal Mask 211**

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Pulsed broadband terahertz emission can be observed from lateral diffusion currents near the surface of a partially metallic masked semiconductor after ultrafast photoexcitation. We present a theoretical mechanism for the emission based on diffusion and dipole suppression under the metal mask with supporting experimental and theoretical evidence.

Mo P1-43 **Fast 3D Computed Tomography Using Intense Terahertz Pulses 213**

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We demonstrated fast 3D terahertz computed tomography by using real-time line projection of an intense terahertz beam. Peak-to-peak amplitude of the pulsed terahertz electric field and a standard reconstruction algorithm were used to performed final 3D reconstruction of test samples with a total acquisition time to only 6 minutes.

Mo P1-44 **InGaAs-based Large Area Photoconductive Emitters For 1.55 µm Excitation 215**

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We present a scalable large-area terahertz (THz) emitter designed for excitation with 1.55 µm pump radiation. It is based on an InGaAs heterostructure combined with a microstructured electrode pattern. Electric fields of more than 2.5 V/cm in the THz focus are reached, the spectrum of the pulses extends up to 3 THz.

Mo P1-45 **Improvement Of Electron Beam Quality And Gyrotron Efficiency By Optimization Of Electric Field Distribution In The Gun Region 217**

Oleg Louksha; Dmirtiy Samsonov; Gennadi Sominski; Sergey Syomin
St. Petersburg State Polytechnical University, Russian Federation

A technique for controlling electric field distribution in the near-cathode region of a magnetron-injection gun has been developed. The possibility to improve the quality of the helical electron beam by regulated non-uniformity of electric field is studied experimentally and using computer modelling. This technique is applied to enhance the efficiency of a 74.2 GHz, 100 kW gyrotron.

Mo P1-46 WITHDRAWN

Mo P1-47 **Converting Polarization Of Sub-THz Waves Using Planar Bilayer Metastructures 219**

Sergey Kuznetsov; Mikhail Astafyev; Andrey Arzhannikov
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We present the results of theoretical and experimental investigations for different types of chiral and achiral frequency selective polarization converters designed for sub-THz band. The converters are implemented as planar bilayer metastructures and exhibit good performance versus alternative polarization converting devices.

Mo P1-48 **Terahertz Photoconductive Antennas At 800 nm, 1000 nm, And 1550 nm: A Performance Comparison 221**

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Terahertz photoconductive antennas are fabricated on low-temperature-grown GaAs, low-temperature-grown $In_{0.3}Ga_{0.7}As$, and beryllium (Be) doped low-temperature-grown lattice-matched $In_{0.53}Ga_{0.47}As$–$In_{0.52}Al_{0.48}As$ multi-quantum wells material systems for 800 nm, 1000 nm, and 1550 nm operation wavelengths. Several narrow band and broad band antenna designs are fabricated and tested under pulse and cw excitation, and their performances in terms of signal to noise ratio, dynamic rand, and bandwidth are compared.

Mo P1-49 **Compact Fiber-Coupled THz Photoconductive Antenna Module For 1550 nm Wavelength Range 222**

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A compact, robust, and portable fiber-coupled THz photoconductive antenna module is described. A new technique is used to focus the output light of the fiber on the chip and fix the fiber in place to provide rugged packaging. THz measurements in pulse mode confirm the performance of this module. The fiber coupled unit is very versatile and can be used in both time domain and frequency domain THz systems. A multi-quantum well InGaAs/InAlAs material is used as the photoconductive material.

Mo P1-50 **All-fiber-based, Asynchronous-optical-sampling THz Time-domain Spectroscopy Using Dual Mode-locked Fiber Lasers And Fiber-coupled Photoconductive Antennae 224**

Yi-Da Hsieh[1]; Yuki Iyonaga[2]; Takeshi Yasui[3]; Keiko Kitagishi[4]; Tsutomu Araki[2]
[1]Osaka university, Taiwan; [2]Osaka university, Japan; [3]University of Tokushima, Japan; [4]Otsuka Electronics Co.,Ltd., Japan

We constructed an all-optical-fiber-based, ASOPS-THz-TDS system using combination of dual fiber lasers and fiber-coupled photoconductive antennae. We confirmed its spectral bandwidth and signal-to-noise ratio comparable to the previous, free-space-based ASOPS-THz-TDS system.

Mo P1-51 **Implementation Of Step-Frequency Continuous-Wave Scheme In Millimeter-wave Inline Holography For Interferences Elimination 226**

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A millimeter-wave (MMW) inline holographic imaging method based on step-frequency continuous-wave (SFCW) scheme is presented. By decomposing the received SFCW power in range domain, background and twin-image interferences can be well separated and removed. Experimental results on typical objects demonstrate the good performance of the approach.

Mo P1-52 **A G-Band Cascode MHEMT Medium Power Amplifier 228**

Yolanda Campos Roca[1]; Axel Tessmann[2]; Volker Hurm[2]; Hermann Massler[2]; Matthias Seelmann-Eggebert[2]; Arnulf Leuther[2]
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A balanced amplifier has been designed and fabricated. The monolithic millimeter-wave integrated circuit (MMIC) has been realized in a 35-nm InAlAs/InGaAs metamorphic high electron mobility transistor (mHEMT) process in grounded coplanar waveguide (GCPW) technology. It demonstrates a measured small-signal gain better than 19 dB between 180 and 200 GHz. The measured saturated output power achieves a maximum value of 10.2 dBm between 180 and 190 GHz.

Mo P1-53 **Experimental Verification Of A Self-Consistent Calculation For Continuous Frequency-Tune With A 400 GHz Band Second Harmonic Gyro-BWO 230**

Yuusuke Yamaguchi[1]; Yoshinori Tatematsu[1]; Teruo Saito[1]; Taiki Kuwahaha[1]; Ryosuke Ikeda[1]; Isamu Ogawa[1]; Toshitaka Idehara[1]; Olgierd Dumbrajs[2]
[1]Research Center for Development of Far-Infrared Region, University of Fukui, Japan; [2]Institute of Solid State Physics, University of Latvia, Kengaraga Street 8, LV-1063, Riga, Latvia, Latvia

A self-consistent code is introduced to develop a continuous frequency tunable gyro-BWO. A cavity is designed with $TE_{8,5}$ mode for 400 GHz band second harmonic oscillation. The experimental verification has been carried out and 2 GHz tunability is observed with output powers of higher than 40 W.

Mo P1-54 **Application Of A Potential Profile For Controlling The Beam Laminarity in A Magnetron Injection Gun 232**

Yuusuke Yamaguchi; Yoshinori Tatematsu; Teruo Saito; Ryosuke Ikeda; Isamu Ogawa; Toshitaka Idehara
Research Center for Development of Far-Infrared Region, University of Fukui, Japan

A method is described to form a laminar electron beam for a high power gyrotron. An optimum potential profile is investigated to adjust each electron trajectory in between cathode and 1st anode. A high quality laminar beam is realized with a wide operation window.

Mo P1-55 **Terahertz Generation From Monoclinic $BiVO_4$/Gold Thin Film Interfaces 234**

Nishant Kumar; Fatwa Abdi; Wilson Smith; Paul Planken; Aurèle Adam
Delft University of Technology, Netherlands

We report on the observation of terahertz (THz) radiation emitted from monoclinic bismuth vanadate ($BiVO_4$) and gold (Au) thin film interfaces, irradiated with femtosecond laser pulses. The emitted terahertz pulses show a second-order dependence on the pump power. THz radiation was measured for different thicknesses of $BiVO_4$ and the possible reasons for this thickness dependence are also discussed.

Mo P1-56 **Experimental Characterization Of Photoconductive Antennas For Tunable Continuous-wave THz Generation 236**

Kiwon Moon; Jeongyoung Choi; Namje Kim; Han-Cheol Ryu; Sang-Pil Han; Hyunsung Ko; Jeong-Woo Park; Kyung Hyun Park
Electronics and Telecommunications Research Institute (ETRI), Korea, Republic of

The photomixer enables continuous-wave, frequency-tunable terahertz (THz) emitter and detector by using conventional photonics technology. To increase the emission and detection efficiency, various antennas have been adopted. In this work, we provide experimental characterizations of various kinds of antenna-integrated photomixers by measuring reference THz pulse from an InAs crystal.

Mo P1-57 **Terahertz Generation By AlGaAs Nanowires 238**

Valerii Trukhin[1]; Anton Buyskih[2]; Aleksey Buravlev[1]; Georgii Cirlin[2]; Leonid Samoilov[3]; Mike Kaliteevski[2]; Yurii Samsonenko[1]
[1]Ioffe Physical Technical Institute, Russian Federation; [2]St Petersburg Academic University, Russian Federation; [3]NRU ITMO, Russian Federation

The results of investigation of terahertz generation in $Al_{0.2}Ga_{0.8}As$ nanowires by the optical excitation of femtosecond pulses are presented. It is shown that the radiation is generated by excitation of photocarriers in nanowires. The time-resolved dynamics of photocarriers were studied by optical-pump terahertz generation-probe time-domain spectroscopy.

Mo P1-58 **Distributed Feedback Terahertz QCLs With A Quasi-periodic Penrose Patterning 239**

Alberto Ronzani[1]; Michele Nobile[1]; Alessandro Tredicucci[1]; Miriam Vitiello[1]; Lianhe Li[2]; Edmund Linfield[2]
[1]NEST, Istituto Nanoscienze-CNR and Scuola Normale Superiore, Italy; [2]School of Electronic and Electrical Engineering, University of Leeds, United Kingdom

We developed vertical emitting THz QCL sources having an optical resonator based on a quasi-periodic patterning of the top metal layer of a double-metal waveguide. The designed pattern induces a distributed feedback effect capable of providing optical feedback as well as vertical extraction in a sharply collimated far field.

Mo P1-59 **Carriers Transport In GaAs Nanowires 241**

Valerii Trukhin[1]; Aleksey Buravlev[1]; Veer Dhaka[2]; Georgii Cirlin[3]; Ilia Mustafin[4]; Mike Kaliteevski[3]; Harri Lipsanen[2]; Leonid Samoilov[4]; Yurii Samsonenko[1]
[1]Ioffe Physical Technical Institute, Russian Federation; [2]Aalto University, Finland; [3]St Petersburg Academic University, Russian Federation; [4]NRU ITMO, Russian Federation

The results of investigation of electronic transport in GaAs nanowires are presented. The time-resolved dynamics of photocarriers were studied by optical-pump terahertz generation-probe time-domain spectroscopy.

Mo P1-60 **Ultra-Broadband Integrated Photonic 200-300 GHz Transmitters For Wireless Radio-over-Fiber Applications 242**

Vitaly Rymanov; Ivan Flammia; Sebastian Babiel; Melanie Wachholz; Sebastian Dülme; Andreas Stöhr
Universität Duisburg-Essen, Germany

Here, we report on planar photonic transmitters employing high-speed 1.55 μm photodiodes. Within the 200-300 GHz band, the device exhibits a 6-dB bandwidth along

with a polarization penalty of ~2.2 dB. Besides, the chip area is reduced thanks to a novel integration approach in the antenna structure.

Mo P1-61 **First Operation Of A D-Band Megawatt Gyrotron With Elliptically Brazed Diamond Window. 244**

Gerd Gantenbein; Manfred Thumm; Gunter Dammertz; John Jelonnek; Andreas Schlaich; Andrey Samartsev
IHM/KIT-nord, Germany

Recent experimental results of the development of frequency step tunable gyrotron suitable for cw operation are presented. In the last experimental measurements a newly developed CVD diamond brewster window which is elliptically brazed was tested in a short pulse regime up to 2 ms pulse length. It is shown that the window is capable to transfer an RF-power of up to 1.3 MW operating in the frequency range 124-162 GHz.

Mo P1-62 **Inter-sublevel Dephasing In Quantum Dots 246**

Martin Teich[1]; Harald Schneider[1]; Jayeeta Bhattacharyya[1]; Stephan Winnerl[1]; Luke Wilson[2]; Manfred Helm[1]
[1]Helmholtz-Zentrum Dresden-Rossendorf, Germany; [2]Sheffield University, United Kingdom

We use the Dresden Free-Electron-Laser (FELBE) to investigate intersublevel coherence times in semiconductor quantum dots (QDs) by degenerate four-wave mixing (DFWM) spectroscopy. We know from pump-probe measurements on a series of quantum dot samples with varying intersublevel energy that intersublevel relaxation times of the s-p intersublevel transition can become very long (up to 1.5 ns). Due to the discrete nature of these sublevels, intersublevel coherence times should exhibit similar time constants at low temperatures where "pure dephasing" is suppressed.

Mo P1-63 **Sub-THz Waves Generation By Magnetized Plasma With Strong Turbulence Driven By High-current REB 247**

Yuriy Trunev[1]; Andrey Arzhannikov[2]; Vitaliy Astrelin[1]; Aleksandr Burdakov[1]; Ivan Ivanov[1]; Igor Kandaurov[1]; Sergei Kuznetsov[2]; Viktor Kurkuchekov[1]; Maksim Makarov[1]; Konstantin Mekler[1]; Sergei Polosatkin[1]; Sergei Popov[1]; Vladimir Postupaev[1]; Andrey Rovenskikh[1]; Stanislav Sinitsky[1]; Igor Timofeev[1]; Manfred Thumm[3]; Leonid Vyacheslavov[1]
[1]Budker Institute of Nuclear Physics, Russian Federation; [2]Novosibirsk State University, Russian Federation; [3]Karlsruhe Institute of Technology, Germany

The specific power density 1 kW/cm^3 of sub-THz-wave emission from plasma in the multi-mirror trap GOL-3 during injection of 0.5 MV, 2 kA/cm^2 10-μs-relativistic electron beam (REB) at plasma densities $n_e \approx (1\text{-}6)\cdot 10^{14}$ cm^{-3}, electron temperatures $T_e \approx$ 1 keV and magnetic field B ≈ 4 T was measured in the frequency band 200-500 GHz.

Mo P1-64 **Investigation On Silicon Based Solar Cell By Ultrafast Terahertz Spectroscopy 249**

Ze-Ren Li; Li-Guo Zhu
Institute of Fluid Physics, China Academy of Engineering Physics, China

Silicon is widely used for solar energy harvesting applications. Here we investigate the dynamics and transport properties of photoexcited carriers in silicon nanowires by ultrafast terahertz spectroscopy. The carrier lifetime was observed to approach 0.7 ns, and the carrier mobility to be ~1000 cm^2/(Vs). We found that Silicon nanowire arrays fabricated by the metal-assisted chemical etching is better for solar cell application.

Mo P1-65 **Simulation Of Parasitic Gyrotron Interaction In Beam Tunnels 251**

Ioannis Chelis[1]; Konstantinos Avramidis[2]; John Vomvoridis[1]
[1]National Technical University of Athens, Greece; [2]Karlsruhe Institute of Technology, Germany

The possibility of parasitic gyrotron interaction in a realistic stacked beam-tunnel geometry is proposed and investigated. The simulation methodology presented here involves the combination of a cold electromagnetic code with a fixed-field interaction code. The presented scheme can simulate the beam-wave interaction and calculate starting currents for this type of parasitic interaction in gyrotron beam-tunnels.

Mo P1-66 **Thermomechanical Influence Of Gyrotron Power Modulation On The Collector Of A 2MW, 170 GHz Gyrotron 253**

Stefan Illy[1]; Ioannis Pagonakis[1]; Alessandro Vaccaro[2]
[1]Karlsruhe Institute of Technology (KIT), IHM, Germany; [2]Karlsruhe Institute of Technology (KIT), IAM-AWP, Germany

To control different types of magnetohydrodynamic (MHD) instabilities in ITER, various amplitude modulation scenarios for the gyrotrons of the Electron Cyclotron (EC) system are required. This work focuses on the impact of different modulation scenarios on the power loading on the collector wall of a 2 MW gyrotron, which has been originally proposed as the EU gyrotron for ITER. In addition, first investigations of the transient thermal behavior of the collector structure have been performed.

Mo P1-67 **Excitation Spectroscopy Of Terahertz Emitters And Detectors Made From $A_{III}B_V$ Semiconductors 255**

Ramûnas Adomavièius; Andrius Arlauskas; Juozas Adamonis; Arūnas Krotkus
Center for Physical Sciences and Technology, Lithuania

Terahertz emitters and detectors made from $A_{III}B_V$ semiconductors were investigated by means of a tunable wavelength laser system. THz excitation spectra of InAs and InSb has been investigated. It was shown that subsidiary valley position can be determined quite accurately. As terahertz detectors, the photoconductors manufactured from GaAs and InGaAs epitaxial layers grown by MBE at low substrate temperatures were investigated. It was revealed that the investigated materials can be used for manufacturing THz optoelectronic components sensitive to 1 μm and 1.5 μm wavelength laser radiation, respectively.

Mo P1-68 **A Dispersive Single-Shot Mid IR Spectrometer With μs Time Resolution 257**

Ulrich Schade[1]; Eglof Ritter[2]; Klaus-Peter Hofman[2]
[1]HZB/BESSY II, Germany; [2]Charité-Universitätsmedizin Berlin, Germany

We show the concept of a dispersive mid-IR spectrometer to record single-shot spectra in the μs-time range with a high SNR. A linear FPA-detector is combined with a dispersive Féry-prism arrangement. In addition, diffraction limited infrared synchrotron radiation is used to optimally illuminate the entrance aperture of the spectrometer.

Mo P1-69 **The THz User Facility FELBE At The Radiation Source ELBE Of Helmholtz-Zentrum Dresden-Rossendorf 258**

Wolfgang Seidel; Stephan Winnerl
Helmholtz-Zentrum Dresden-Rossendorf, Germany

The FELBE user facility located at the Helmhotz-Zentrum Dresden-Rossendorf operates two free-electron lasers (FELs). The FELs are based on the superconducting electron linear accelerator ELBE, which provides short (picosecond) electron bunches with energies up to 35 MeV at a 13 MHz repetition rate. Here we discuss the basic parameters of the FELs and the experimental opportunities at the facility.

Mo P1-70 **Preliminary Study On The Effects Of Emitter Surface Roughness On Gyrotron Electron Beam Quality 259**

Jianghua Zhang; Stefan Illy; Ioannis Pagonaki; John Jelonnek
Karlsruhe Institute of Technology (KIT), Germany

The effect of the emitter surface roughness on the quality of an electron beam emitted by a gyrotron magnetron injection gun (MIG) has been studied. Several different shapes of microstructures (imperfections) have been modeled on the emitter surface. A modified version of the two-dimensional, finite-difference beam optics code ESRAY has been used for the numerical simulations. Results for the different shapes and different sizes of the microstructures are shown.

Mo P1-71 **Spectroscopic Investigation Of The Far-infrared Properties Of Liquid Crystals 261**

Marco Reuter[1]; Nico Vieweg[1]; Bernd Michael Fischer[2]; Przemyslaw Kula[3]; Roman Dabrowski[3]; Mehmet Ali Celik[1]; Gernot Frenking[1]; Martin Koch[1]; Peter Uhd Jepsen[4]
[1]Philipps-Universität Marburg, Germany; [2]Philipps-Universität Marburg, Honduras; [3]Military University of Technology, Poland; [4]Technical University of Denmark, Denmark

Liquid crystals are one of the most promising base materials for switchable devices at THz frequencies. Therefore, a precise understanding of the optical parameters is crucial. Here, we present the refractive indices and absorption coefficients for 5 CB and an isothiocyanate terminated liquid crystal over a broad frequency range from 0.3 THz to 15 THz.

Mo P1-72 **Compact Single-Shot Terahertz Time-Domain Spectroscopy System For Magneto-Optics With A Mini-Coil Pulsed Magnet 263**

Ayana M. Andalcio[1]; Patrick E. Breen[1]; Lisa Anne Hendricks[1]; Tapash J. Sarkar[1]; G. Timothy Noe[1]; Gary L. Woods[1]; Junichiro Kono[1]; Jean Leotin[2]
[1]Rice University, United States; [2]Laboratoire National des Champs Magnetiques Intenses de Toulouse, France

To study low-energy magnetic dynamics and excitations in condensed matter systems in high magnetic fields, we are developing a unique terahertz time-domain magneto-optical spectroscopy system. The system is based on a compact single-shot terahertz spectroscopy setup using an echelle optic combined with a repetitive mini-coil pulsed magnet.

Mo P1-73 **Electro-Thermal Modelling For Millimeter-Wave Circuit Design 265**

Carlos G. Pérez-Moreno; Jesús Grajal; Diego Pardo
Technical University of Madrid (UPM), Spain

This work presents a physics-based numerical electro-thermal model for Schottky diodes capable of evaluating the thermal effects on the electrical performance of devices and circuits. This model is able to calculate internal temperature distributions and identify regions where heat is generated, providing useful information for device design and circuit reliability.

Mo P1-74 **Fast Electron Trapping In Anodized TiO_2 Nanotubes 267**

Christian Wehrenfennig[1]; Claudia M. Palumbiny[2]; Lukas Schmidt-Mende[3]; Michael B. Johnston[1]; Henry J. Snaith[1]; Laura M. Herz[1]
[1]University of Oxford, United Kingdom; [2]Technische Universität München, Germany; [3]Universität Konstanz, Germany

We studied charge transport in anodized TiO_2 nanotubes in the context of their application in dye-sensitized solar cells. Optical-pump-THz-probe spectroscopy revealed short free carrier lifetimes of about 15-30 ps, which we attribute to shallow trapping.

Mo P1-75 **Enhanced Terahertz Emission From GaAs And GaAs-MnAs Nanowires 268**

Ramûnas Adomavièius[1]; Anton Koroliov[2]; Andrius Arlauskas[2]; Arūnas Krotkus[2]; Aloyzas Šiušys[3]; Anna Reszka[3]; Janusz Sadowski[3]
[1]Center for Physical Sciences and Technology, Lithuania; [2]Center for Physical Sciences and Technology,, Lithuania; [3]Institute of Physics, Polish Academy of Sciences, Poland

THz pulse emission from GaAs and GaAs-MnAs nanowire (NW) samples illuminated by femtosecond laser pulses has been studied. The amplitude of THz pulses emitted by nanowire samples was more than twice larger than that radiated from GaAs substrate. It was found that terahertz emissivity of NW samples rapidly decreases with increasing laser photon energy - behavior that could be explained by localized surface plasmon resonances in GaAs and GaAs-MnAs NWs. The plasmon enhanced absorption has been identified as a major factor for intense THz emission from our samples.

Mo P1-76 **A Study Of Ultrafast Extrinsic Photoconductivity vs Wavelength In ErAs:GaAs Photoconductive Switches 270**

John Middendorf; Elliott Brown
Wright State University, United States

Extrinsic photoconductivity in an ErAs:GaAs photoconductive (PC) switch is studied as a function of wavelength from 1535 nm to 1793 nm and 2516 nm to 3293 nm; which corresponds to photon energies of 0.69 to 0.81 eV (0.48 to 0.57 U_G) and 0.37 to 0.49 eV (0.26 to 0.35 U_G). A gradual decline is seen in photoconductive response vs wavelength in the higher energy range, and practically no response in the lower energy range. Also, a series of local peaks is seen in the higher range, suggesting that the absorption is associated with quantum-dot-to-band electron transitions. This is an important step in understanding the new method of creating THz sources from ultrafast extrinsic photoconductivity.

Mo P1-77 **Analysis Of Terahertz Metamaterial Perfect Absorber By Using A Novel Quasi-Static RLC Circuit Model 272**

Seongsin Margaret Kim; Mohammad Parvinnezhad Hokmabadi; David Wilbert; Patrick Kung
University of Alabama, United States

Here we present a novel quasi-static dynamic RLC model for terahertz perfect absorbers. The model fits perfectly to both simulation and measurement data for our designed absorber. By using this model we analyze our simulated and fabricated perfect absorber to figure out operational mechanism behind these kinds of absorbers. The model can explain well the physical principle behind these kinds of absorbers based on interference theory of reflected waves.

Mo P1-78 **Critical Comparison Of The THz Performance From ErAs:GaAs And Br-Irradiated $In_{0.53}Ga_{0.47}As$ 1.55-µm-Driven Photoconductive Antennas 274**

Matthieu Martin[1]; John Middendorf[1]; Elliott Brown[1]; Juliette Mangeney[2]
[1]Wright State University, United States; [2]Institut d'Electronique Fondamentale, CNRS UMR 8622, Université Paris-Sud, France

We compare the THz pulses generated by photoconductive antennas made from two different materials: ErAs:GaAs and Br-irradiated InGaAs. The THz pulses were generated using the same 1550 nm THz time-domain spectroscopy set-up. The detection was realized with an electrooptic crystal, allowing a direct comparison of the performance from the different antennas.

Mo P1-79 **Injectorless Quantum Cascade Lasers As Low Threshold THz Sources 276**

Frederic Demmerle
Walter Schottky Institut, TU München, Germany

We present a novel device concept for a low threshold terahertz source. Our device is based on difference frequency generation in a dual-wavelength quantum cascade laser for terahertz emission and utilizes a Čerenkov phase matching scheme. The active region is an injectorless design to reach lower current threshold densities than injectorbased devices.

Mo P1-80 **Orientational Dependence Of Inter-meta-atom Interactions In The Split-Ring And Circular-Ring Resonator Arrays 277**

Hideaki Kitahara; Yuya Yakiyama; Keisuke Takano; Masanori Hangyo
Institute of Laser Engineering, Osaka University, Japan

The dependence of the transmission spectra for the array composed of the planar split-ring and circular-ring on meta-atom orientation has been studied experimentally and by simulation in the terahertz region. We observe the systematic change of the spectra with the meta-atom orientation and interpreted it by the interaction among the meta-atoms in the periodic array structure.

Mo P1-81 **Project Of Powerful THz-Band FEL Driven By Induction Linac 279**

Nikolai Peskov[1]; Naum S. Ginzburg[1]; Alim K. Kaminsky[2]; Sergey V. Kuzikov[1]; Elkuno A. Perelshtein[2]; Andrey V. Savilov[1]; Sergey N. Sedykh[2]
[1]Institute of Applied Physics Russian Academy of Science, Russian Federation; [2]Joint Institute for Nuclear Research, Russian Federation

Possibility of JINR-IAP FEL driven by linac LIU-3000 to operate at THz frequency band has been studied. Present paper describes recent design of the oscillator and results of simulations for key elements of the oscillator, such as RF-undulator and Bragg resonator with quasi-cutoff feedback wave.

Mo P1-82 **Phase-locking Of A 3.4-THz Quantum Cascade Laser Using A Harmonic Super-lattice Mixer 281**

Andrey V. Khudchenko[1]; D.J. Hayton[1]; A.M. Baryshev[2]; R.J. Gao[3]; T-Y. Kao[4]; Q. Hu[4]; D.G. Pavelyev[5]; J.N. Hovenier[6]; J.L. Reno[7]; V.L. Vaks[8]
[1]Netherlands Institute for Space Research SRON, Netherlands; [2]Netherlands Institute for Space Research SRON and NOVA/Kapteyn Astronomical Institute, Netherlands; [3]Netherlands Institute for Space Research SRON and Kavli Institute of Nanoscience, Delft University o, Netherlands; [4]Department of Electrical Engineering and Computer Science, MIT, United States; [5]Radiophysics department of Nizhny Novgorod State University, Russian Federation; [6]Kavli Institute of Nanoscience, Delft University of Technology, Netherlands; [7]Sandia National Laboratories, Albuquerque, United States; [8]Institute for Physics of Microstructures of the Russian Academy of Sciences, Russian Federation

We report on a phase locking experiment of a 3.4 THz Quantum Cascade Laser (QCL) by using only room temperature electronics. A super-lattice harmonic mixer was used to produce a bit signal between the QCL signal and the 18th harmonic of a 190 GHz reference generator. The beat signal more than 30 dB above the noise level for 1 MHz RBW was observed. Such a signal to noise ratio was sufficient to provide high quality phase-locking and synchronize to a microwave reference up to 99 % of the emitted QCL power.

Tuesday	Congress Hall
	Plenary Session
09:00 – 09:45	Plenary session Tu-Pl1 **How Millimeter Waves Interact With Nanometer- And Sub-Nanometer-Sized Gaps** *Dai-Sik Kim* *Seoul National University, Republic of Korea*
09:45 – 10:30	Plenary session Tu-Pl2 **THz Near-Field Imaging And Micro-Spectroscopy** *Paul Planken* *Delft University of Technology, The Netherlands*
10:30 – 11:00	**Coffee Break (Rhein Foyer)**

Tuesday	Gutenberg 1	Gutenberg 2
	Tu1 High Power Sources 4	**Tu2 PCAs 1**
11:00 – 11:15	Tu1-1 (invited talk) **New Results On The Physics Of THz Gyrotrons** *Stefano Alberti[1]; Falk Braunmueller[1]; Trach-Minh Tran[1]; Jeremy Genoud[1]; Quentin Vuillemin[1]; Jean-Philippe Hogge[1]; Minh-Quang Tran[1]; Jean-Philippe Ansermet[2]; Alessandro Macor[2]; Emile de Rijk[2]* *[1]CRPP/EPFL, Switzerland; [2]IPMC/EPFL, Switzerland*	Tu2-1 **Enhancing The Amplitude Stability Of A Photomixer-Based Terahertz System By Photocurrent Normalization** *Axel Roggenbuck[1]; Malte Langenbach[2]; Komalavalli Thirunavukkuarasu[2]; Holger Schmitz[2]; Anselm Deninger[1]; Joachim Hemberger[2]; Markus Grüninger[2]* *[1]TOPTICA Photonics AG, Germany; [2]Universität zu Köln, Germany*
11:15 – 11:30		Tu2-2 **Terahertz Detection Sensitivity Enhancement By Incorporating Plasmonic Gratings In Photoconductive Detectors** *Mona Jarrahi; Ning Wang; Christopher W. Berry; Mohammad R. Hashemi* *University of Michigan, United States*
11:30 – 11:45	Tu1-3 **Long Pulse Operation Of A Dual Frequency Gyrotron For JT-60SA** *Takayuki Kobayashi; Masayuki Sawahata; Masayuki Terakado; Shinichi Hiranai; Kenji Wada; Yoshikatsu Sato; Jun Hinata; Kenji Yokokura; Katsumichi Hoshino; Ken Kajiwara; Yasuhisa Oda; Koji Takahashi et al.* *Japan Atomic Energy Agency, Japan*	Tu2-3 **A Travelling-Wave Type p-i-n Photomixer With A Thin Absorption Layer.** *Sang-Pil Han; Jeong Woo Park; Namje Kim; Hyunsung Ko; Kiwon Moon; Kyung Hyun Park; Namje Kim; Hyunsung Ko; Kiwon Moon; Kyung Hyun Park* *ETRI, Republic of Korea*

Gutenberg 3	Gutenberg 4	Congress Hall
Tu3 THz Commun. 2	**Tu4 QCLs Applications**	
Mo3-1 (invited talk) **Enhanced THz Generation For Wireless Communications Using Short Optical Pulses** *Lothar Moeller[1]; Alexandre Shen[2]* *[1]Alcatel-Lucent, United States; [2]Alcatel-Lucent, France*	Tu4-1 **THz Quantum Cascade Laser-Based Quartz Enhanced Photo-Acoustic Sensor** *Vincenzo Spagnolo[1]; Pietro Patimisco[2]; Angelo Sampaolo[2]; Simone Borri[3]; Harvey H. Beere[4]; David A. Ritchie[4]; Miriam S. Vitiello[5]; Gaetano Scamarcio[2]; Paolo P. Calabrese[6]* *[1]Physics Dept. Politecnico di Bari, Italy; [2]Physics Dept. University of Bari, Italy; [3]IFN-CNR UOS BARI, Italy; [4]University of Cambridge, United Kingdom; [5]NEST-CNR and Scuola Normale Superiore, Italy; [6]CNR-IFN UOS BARI, Italy*	
Tu3-3 **0.2 THz Wireless Communication Using Plasma-Wave Transistor Detector** *Stéphane Blin[1]; Lucie Tohme[1]; Guillaume Ducournau[2]; Dominique Coquillat[3]; Philippe Nouvel[1]; Annick Pénarier[1]; Wojciech Knap[1]; Jean-François Lampin[1]* *[1]IES, Université de Montpellier 2, France; [2]IEMN, France; [3]L2C, France*	Tu4-3 **Fast Terahertz Computed-Tomography Imaging With A Quantum-Cascade Laser And A Scanning Mirror** Nick Rothbart[1]; Heiko Richter[1]; *Martin Wienold[2]; Lutz Schrottke[2]; H. T. Grahn[2]; H.-W. Hübers[1]* *[1]German Aerospace Center (DLR), Germany; [2]Paul-Drude-Institut für Festkörperelektronik, Germany*	

Tuesday	Gutenberg 1	Gutenberg 2
	Tu1 High Power Sources 4	**Tu2 PCAs 1**
11:45 – 12:00	Tu1-4 **New Results of Megawatt Power Gyrotrons Development** *Alexander Litvak; Gregory Denisov* *Institute of Applied Physics of RAS, Russian Federation*	Tu2-4 **Carbon Ion Irradiated SI-GaAs Based Efficient Photoconductive THz Emitters Using Low Electrical Power** *Abhishek Singh; Sanjoy Pal; Harshad Surdi; S. S. Prabhu; Vandana Nanal; R. G. Pillay* *TIFR, India*
12:00 – 12:15	Tu1-5 **Power Improvement On Gyrotron FU CW GIII** *Yoshinori Tatematsu; Tatsuru Kawase; Ryoichi Ichioka; Yuusuke Yamaguchi; Isamu Ogawa; Ryosuke Ikeda; Toshitaka Idehara; Teruo Saito* *FIR, University of Fukui, Japan*	Tu2-5 **Photoconductive Cw THz Receiver With 20-Fold Increased THz Conversion Efficiency By Buried Interdigital Electrodes** *Dennis Stanze; Thorsten Göbel; Roman Dietz; Björn Globisch; Martin Schell* *Fraunhofer HHI, Germany*
12:15 – 12:30	Tu1-6 **Progress Of 1.5-1.7 MW/170 GHz Gyrotron Development** *Vadim Myasnikov[1]; Marina Agapova[1]; Andrey Kuftin[2]; Vladimir Zapevalov[2]; Gregory Denisov[2]; Vladimir Ilin[3]; Ludmila Belnova[1]; Aleksey Chirkov[2] et al.* *[1]GYCOM Ltd., Russian Federation; [2]IAP RAS, Russian Federation; [3]Tokamak Physics Institute, NRC "Kurchatov Institute", Russian Federation*	Tu2-6 **The Effect Of Er Fraction On THz Power Generated By Extrinsic-Photoconductive ErAs:GaAs Switches Driven At 1550 nm** *John Middendorf; Elliott Brown* *Wright State University, United States*
12:30 – 14:00	**Lunch (on your own)**	

Gutenberg 3	Gutenberg 4	Congress Hall
Tu3 THz Commun. 2	**Tu4 QCLs Applications**	
Tu3-4 **Coherent Terahertz Communication Based On DSP-Aided Radio-Over-Fiber Technology** *Atsushi Kanno[1]; Toshiaki Kuri[1]; Isao Morohashi[1]; Iwao Hosako[1]; Tetsuya Kawanishi[1]; Yuki Yoshida[2]; Yoshihiro Yasumura[2]; Ken'ichi Kitayama[2]* *[1]National Institute of Information and Communications Technology, Japan; [2]Osaka University, Japan*	Tu4-4 **Coherent Imaging With Mid-IR And THz Quantum Cascade Lasers Through Optical Feedback Interferometry** *Francesco Mezzapesa[1]; Maurangelo Petruzzella[2]; Maurizio Dabbicco[1]; Miriam Serena Vitiello[3] et al.* *[1]Università degli Studi di Bari, and IFN-CNR UOS Bari, Italy; [2]Università degli Studi di Bari, Italy; [3]NEST, CNR, Italy*	
Tu3-5 **A 16QAM Modulation Based 3Gbps Wireless Communication Demonstration System At 0.34 THz Band** *Wei Huang; Changxin Lin; Cheng Wang; Bin Lu* *China Academy Engineering Physics, China*	Tu4-5 **Spectroscopic Analysis Of Powders Through Diffuse-Reflectance Imaging Using A Frequency-Switchable Terahertz Quantum Cascade Laser** *Alex Valavanis; Paul Dean; Siddhant Chowdhury; Andrew Burnett; Suraj Khanna; Giles Davies; Edmund Linfield* *University of Leeds, United Kingdom*	
Tu3-6 **Substrate Integrated Waveguide Antenna For 60 GHz Radio-Over-Fiber Transmitter** *Ivan Flammia; Besher Khani; Andreas Stöhr* *University of Duisburg-Essen, Germany*	Tu4-6 **High Order Optical Sideband Generation With Terahertz Quantum Cascade Lasers** *Pierrick Cavalie[1]; Julien Madéo[1]; Joshua Freeman[1]; Jean Maysonnave[1]; Elodie Strupiechonski[2]; Gangyi Xu[2]; Raffaele Colombelli[2]; Harvey Beere[3]; Dave Ritchie[3] et al.* *[1]CNRS/Ecole Normale Superieure, France; [2]University Paris Sud, France; [3]University of Cambridge, United Kingdom*	
Lunch (on your own)		

Tuesday	Gutenberg 1	Gutenberg 2
	Tu5 Free Electron Lasers	**Tu6 PCAs 2**
14:00 – 14:15	Tu5-1 (invited talk) **FELIX Facility: Free Electron Laser Light Sources From 0.2 To 75 THz** *Wim J. van der Zande[1]; Britta Redlich[1]; Rienk T. Jongma[2]; Lex van der Meer[2]* *[1]Radboud University, Institute for Molecules and Materials, Netherlands; [2]Radboud University Nijmegen, Netherlands*	Tu6-1 **Generation And Detection Of THz Radiation Up To 4.5 THz Using LTG-GaAs PCAs Illuminated At 1560 nm** *Jan-Martin Rämer[1,2]; Frank Ospald[1,2]; Georg von Freymann[1,2]; René Beigang[1,2]* *[1]Fraunhofer Institute for Physical Measurement Techniques IPM, Germany; [2]Department of Physics and Research Center OPTIMAS, TU Kaiserslautern, Germany*
14:15 – 14:30		Tu6-2 **Highly Efficient Terahertz Photoconductive Switch At 1060 nm Excitation Wavelength For Multichannel THz System** *Carsten Gerth[1]; Roman J.B. Dietz[2]; Thorsten Göbel[2]; Martin Schell[2]; Anika Brahm[3]; Gunther Notni[1]; Andreas Tuennermann[1]* *[1]Fraunhofer IOF, Germany; [2]Fraunhofer HHI, Germany; [3]Friedrich Schiller University, Germany*
14:30 – 14:45	Tu5-3 **The TeraFERMI Beamline At The FERMI Free-Electron-Laser** *Andrea Perucchi[1]; Simone Di Mitri[1]; Giuseppe Penco[1]; Enrico Allaria[1]; Stefano Lupi[2]* *[1]Elettra - Sincrotrone Trieste S.C.p.A., Italy; [2]Universita di Roma "Sapienza", Italy*	Tu6-3 **Plasmonic Photoconductive Terahertz Emitters Based On Logarithmic Spiral Antenna Arrays** *Christopher Berry; Mohammed Reza Hashemi; Mona Jarrahi* *University of Michigan, United States*

Gutenberg 3	Gutenberg 4	Congress Hall
Tu7 THz Plasmonics 1	**Tu8 Detectors 3**	**Tu9 Waveguiding Structures**
Tu7-1 (invited talk) **THz Spectroscopy Of Semiconducting Plasmonic Resonators** Giorgos Georgiou[1]; Audrey *Berrier[1]; Martijn Schaafsma[1]; Michael Nagel[2]; Jaime Gomez-Rivas[1]; Hemant Tyagi[1]* *[1]FOM Institute AMOLF, Netherlands; [2]AMO GmbH, Germany*	Tu8-1 (invited talk) **1/f-Noise Prediction In Millimeter Wave Detectors Based On Quasi Vertical Schottky Diodes** *Matthias Hoefle[1]; Andreas Penirschke[1]; Oleg Cojocari[2]; Andreas Amrhein[2]; Thibaut Decoopman[3]; Petri Piironen[4]; Rolf Jakoby[1]* *[1]TU Darmstadt, Germany; [2]ACST GmbH, Germany; [3]Astrium SAS France, France; [4]ESA-ESTEC, Netherlands*	Tu9-1 **Long-Range Guided THz Radiation Coupled In Thin Layers Of Water - A Study Of The Propagation Length Characteristics** *Robert Sczech; Peter Haring Bolívar* *University of Siegen, Germany*
		Tu9-2 **Plasmonic Two Wire Terahertz Fibers With Porous Dielectric Support** *Andrey Markov; Maksim Skorobogatiy* *Ecole Polytechnique de Montreal, Canada*
Tu7-3 (invited talk) **Plasmonic Focusing On Metal And Semiconductor Disks Under Radially Polarized Terahertz Illumination** *Jan Hodapp[1]; Korbinian Kaltenecker[1,2]; Stefan Waselikowski[1]; Christian Fischer[1]; Bernd M. Fischer[2]; Markus Walther[1]; Jan Wallauer[1]* *[1]Freiburg Materials Research Center; [2]French-German Research Institute of Saint-Louis, France*	Tu8-3 **Polarization-Sensitive Broadband Sub-Terahertz-Wave Detector Implementing Planar-Antenna-Integrated Schottky Barrier Diode** *Hiroshi Ito[1]; Toshihide Yoshimatsu[2]; Hiroshi Yamamoto[1]; Tadao Ishibashi[3]* *[1]Kitasato University, Japan; [2]NTT Photonics Laboratories, Japan; [3]NTT Electronics Corporation, Japan*	Tu9-3 **Confinement And Losses Of THz Planar Goubau Lines Fabricated On A Thin Silicon Substrate** Abdallah Chahadih; Abbas *Ghaddar; Serkan Kaya; Ibrahim Türer; Gabriel Moreno; Yohann Zapart; Tahsin Akalin* *IEMN, Lille 1 University, France*

Tuesday	Gutenberg 1	Gutenberg 2
	Tu5 Free Electron Lasers	**Tu6 PCAs 2**
14:45 – 15:00	Tu5-4 **Terahertz Pump-Probe Experiment At The Synchrotron Light Source MLS** *Andreas Pohl[1]; Arne Hoehl[2]; Ralph Müller[2]; Gerhard Ulm[2]; Markus Ries[3]; Godehard Wüstefeld[3]; Sergey Pavlov[4]; Heinz-Wilhelm Hübers[4]* *[1]TU Berlin, Germany; [2]PTB, Germany; [3]HZB, Germany; [4]DLR, Germany*	Tu6-4 **Investigation Into The Role Of The Metal Mask And Pump Laser Illumination Parameters For Lateral Photo-Dember Emitters** *Mark Barnes[1]; Duncan McBryde[1]; Sam Berry[1]; Geoff Daniell[1]; Harvey Beere[2]; David Ritchie[2]; Vasilis Apostolopoulos[1]* *[1]University of Southampton, United Kingdom; [2]University of Cambridge, United Kingdom*
15:00 – 15:15	Tu5-5 **Ultrafast High-Resolution Spectroscopy Of Separate NovoFEL Pulses** *Vitaly Kubarev* *BINP, Russian Federation*	Tu6-5 **Bandwidth Improvement Of Cw THz Receivers By Be Doping Of Low Temperature Grown InGaAs/InAlAs Heterostructures** *Björn Globisch; Dennis Stanze; Roman J. B. Dietz; Thorsten Göbel; Martin Schell* *Fraunhofer Heinrich Hertz Institute, Germany*
15:15 – 15:30	Tu5-6 **Terahertz Circular Dichroism Polarimeter With An Attenuated Total Reflection Module At Novosibirsk Free Electron Laser** Yulia Choporova[1]; Valery Cherkassky[2]; Elvira Grigorieva[3] Boris Knyazev[2]; Ludmila Mostovich[3]; Dmitry Rodionov[1] [1]SB RAS, Russian Federation; [2]Novosibirsk State University, Russian Federation; [3]SB RAMS, Russian Federation	Tu6-6 **High-Speed Near-Field Imaging System Based On Photoconductive Terahertz Microprobes** *Christopher Matheisen[1]; Michael Nagel[1]; Simon Sawallich[1]; Heinrich Kurz[1]; Giorgos Georgiou[2]; Jaime Gomez-Rivas[2]* *[1]AMO GmbH, Germany; [2]FOM Institute AMOLF, Netherlands*
15:30 – 16:00	**Coffee Break (Rhein Foyer)**	

Gutenberg 3	Gutenberg 4	Congress Hall
Tu7 THz Plasmonics 1	**Tu8 Detectors 3**	**Tu9 Waveguide Structures**
	Tu8-4 **Terahertz Imaging Using InGaAs Schottky Barrier Diode Array Detectors** *Sang-Pil Han[1]; Jeong-Woo Park[1]; Hyunsung Ko[1]; Namje Kim[1]; Kiwon Moon[1]; Young-Jong Yoon[1]; Wang-Joo Lee[1]; Won-Hee Lee[1]; Min Yong Jeon[2]; Kyung Hyun Park[1]* *[1]ETRI, Republic of Korea; [2]Chungnam National University, Republic of Korea*	Tu9-4 **Optimization And Application Of On-Chip Terahertz Goubau Lines** *Christopher Russell; Christopher Wood; Andrew Burnett; Lianhe Li; Edmund Linfield; Giles Davies; John Cunningham* *University of Leeds, United Kingdom*
Tu7-5 **Surface Plasmon Propagation Along Plane Metal-Dielectric Interfaces With Air Gaps** *Guerman Zhizhin[1]; Valery Cherkassky[2]; Alexey Nikitin[1]; Vasily Gerasimov[3]; Boris Knyazev[3]; Igor Kotelnikov[3]; Gennady Kulipanov[3]* *[1]STC UI RAS, Russian Federation; [2]Novosibirsk State University, Russian Federation; [3]SB RAS, Russian Federation*	Tu8-5 **Quasi Optical Schottky Diode Detectors For Fast Ultra-Wideband Detection** *H. Hübers[1]; Arne Hoehl[2]; Alvydas Lisauskas[3]; Nikolay Sobornytskyy[3]; Oleg Cojocari[3]; Cristian Weickhmann[4]; R. Jakobi[4]* *[1]Institute of Planetary Research, German Aerospace Center (DLR), Germany; [2]PTB, Germany; [3]ACST GmbH, Germany; [4]TU Darmstadt, Germany*	Tu9-5 **Terahertz Filters Based On Planar Goubau Transmission Lines With Multi Split Rings Resonators** *Tahsin Akalin; Abdallah Chahadih; Serkan Kaya; Ibrahim Turer; Yohann Zapart; Abbas Ghaddar; Mokhtar Zehar; Gabriel Moreno* *IEMN, Lille 1 University, France*
Tu7-6 **Mid-Infrared Plasmonic Antennas Made Of Electron-Doped Epitaxial Germanium-On-Silicon** *Marco Finazzi[1]; Michele Ortolani[2]; Leonetta Baldassarre[3]; Alessandro Nucara[2]; Paolo Biagioni[1]; Jacopo Frigerio[1] et al.* *[1]Politecnico di Milano, Italy; [2]Sapienza University of Rome, Italy; [3]Istituto Italiano di Tecnologia, Italy*	Tu8-6 **Analysis Of CMOS 0.13 µm Test Structures For 0.6 To 1.5 THz Imaging** *Suzana Domingues[1]; Matteo Perenzoni[1]; David Stoppa[1]; Daniele Perenzoni[1]; Valeria Giliberti[2]; Alessandra Di Gaspare[3]; Michele Ortolani[2]* *[1]Fondazione Bruno Kessler, Italy; [2]Institute for Photonics and Nanotechnology/Sapienza University of Rome, Italy; [3]Institute for Photonics and Nanotechnology, Italy*	Tu9-6 **In-Situ Real-Time Characterization Of Spurious Modes In HE_{11} Transmission Lines With A Mitre-Bend Hole Coupler** *Burkhard Plaum[1]; Walter Kasparek[1]; Carsten Lechte[1]; Hiroshi Idei[3]; Zana Popovic[1]* *[1]Universität Stuttgart, Germany; [3]Kyushu University, Japan*
Coffee Break (Rhein Foyer)		

Tuesday	Gutenberg 1	Gutenberg 2
	Tu10 Graphene 1	**Tu11 THz Spectr.: Proteins**
16:00 – 16:15	Tu10-1 (invited talk) **Magnetic Quantum Ratchet Effect In Graphene** *Sergey Ganichev* *University of Regensburg, Germany*	Tu11-1 **Temperature And Hydration Dependence Of Low-Frequency Dynamics Of A Small Globular Protein Studied By Terahertz Time-Domain Spectroscopy** *Naoki Yamamoto; Atsuo Tamura; Keisuke Tominaga* *Kobe University, Japan*
16:15 – 16:30		Tu11-2 **Can Terahertz Time-Domain Spectroscopy Detect An Extended Hydration Layer Around Peptides?** *Robert Falconer[1]; Anton Middelberg[2]; Tao Ding[3]; Jordan Bye[1]* *[1]University of Sheffield, United Kingdom; [2]University of Queensland, Australia; [3]National University of Singapore, Singapore*
16:30 – 16:45	Tu10-3 (invited talk) **Nonlinear Terahertz Conductivity In Graphene** *Zoltan Mics[1]; Mischa Bonn[1]; Klaas-Jan Tielrooij[2]; Dmitry Turchinovich[1]* *[1]Max Planck Institute for Polymer Research, Germany; [2]Institut de Ciéncies Fotóniques, Spain*	Tu11-3 **Kinetic Terahertz Absorption Spectroscopy Of Protein Solutions** *Jessica Dielmann[1]; Valeria Conti Nibali[1]; Benjamin Born[2]; Erik Bründermann[1]; Martina Havenith[1]* *[1]Ruhr-Universität Bochum, Germany;[2]Weizmann Institute of Science, Israel*

Gutenberg 3	Gutenberg 4	Congress Hall
Tu12 THz Plasmonics 2	**Tu13 Tu8 Detectors 4**	**Tu14 THz Spectroscopy 1**
Tu12-1 **Active THz Plasmonic Waveguides And Circuits** *Giorgos Georgiou; Jaime Gómez Rivas; Hemant Kumar Tyagi* *FOM Institute AMOLF, Netherlands*	Tu13-1 (invited talk) **Optimized Tera-FET Detector Performance Based On An Analytical Device Model Verified Up To 9 THz** *Sebastian Boppel[1]; Alvydas Lisauskas[1]; Maris Bauer[1]; Martin Mundt[1]; Rimvydas Venckevičius[2]; Linas Minkevičius[2]; Dalius Seliuta[2]; Irmantas Kašalynas[2]; Bassam Khamaisi[3]; Eran Socher[3]; Gintaras Valušis[2]; Viktor Krozer[1]; Hartmut G. Roskos[1]* *[1]Physikalisches Institut, Johann Wolfgang Goethe-Universität Frankfurt, Germany; [2]Semiconductor Physics Institute of Center for Physical Science and Technology, Lithuania; [3]School of Electrical Engineering, Tel-Aviv University, Israel*	Tu14-1 (invited talk) **Study On Weak Hydrogen Bond By Terahertz And Mid-IR Spectroscopy** *Kohji Yamamoto; Kazutoshi Fukui; Kazuko Kazuko Mizuno; Masahiko Tani* *University of Fukui, Japan*
Tu12-2 **THz Plasmonic Waveguides With Low-Loss And Low-Group Velocity Dispersion Using Flexible Thin Substrate** *Djamal Gacemi[1]; Fanqi Meng[2]; Paul Crozat[2]; Juliette Mangeney[1]* *[1]Ecole Normale Superieure Paris, France; [2]Institut d'Electronique Fondamentale, France*		
Tu12-3 **Characterization Of Highly Doped Si With Surface Plasmon** *Maxim Nazarov[1]; Alexander Shkurinov[2]; Frederic Garet[3]; Jean-Louis Coutaz[3]* *[1]ILIT RAS, Russian Federation; [2]M.V.Lomonosov Moscow State University, Russian Federation; [3]IMEP-LAHC, University of Savoie, France*	Tu13-3 **Contribution Of The Gate Leakage Current To Terahertz Detection By Asymmetric Dual-Grating Gate HEMT Structures** *Dominique Coquillat[1]; Yuki Kurita[2]; Kengo Kobayashi[2]; Frederic Teppe[1]; Nina Dyakonova[1]; Christophe Consejo[1]; Dmytro But[1] et al.* *[1]Laboratoire Charles Coulomb, France; [2]Research Institute of Electrical Communication, Tohoku University, Japan*	Tu14-3 **Relation Between Anisotropic Relative Permittivity And Density Of Wood Evaluated Using THz Time Domain Transmission Spectroscopy** *Soichi Tanaka[1]; Yoshihisa Fujii[2]; Keiichiro Shiraga[2]; Yuichi Ogawa[2]* *[1]Materials Research Institute for Sustainable Development, AIST, Japan; [2]Graduate School of Agriculture, Kyoto University, Japan*

Tuesday	Gutenberg 1	Gutenberg 2
	Tu10 Graphene 1	**Tu11 THz Spectr.: Proteins**
16:45 – 17:00		Tu11-4 **Effects Of Saline On Terahertz Absorption Of Aqueous Glucose At Physiological Concentrations Probed By THz Spectroscopy** *Seongsin Margaret Kim; Michael Bolus; Soner Balci; David Wilbert; Patrick Kung University of Alabama, United States*
17:00 – 17:15	Tu10-5 **Amplification Of Terahertz Radiation By Stimulated Emission Of Plasmons In Graphene** *Olga Polischuk[1]; Taiichi Otsuji[2]; Michael Shur[3]; Viacheslav Popov[1]; Arthur Davoyan[1]; Victor Ryzhii[2] [1]Kotelnikov Institute of Radio Engineering and Electronics, Russian Federation; [2]RIEC, Tohoku University, Japan; [3]Rensselaer Polytechnic Institute, United States*	Tu11-5 **Probing Label Free Antibody Interactions With HA Protein Using Terahertz Pulsed Spectroscopy** *Yiwen Sun[1]; Jian Zuo[2]; Zhenwei Zhang[2]; Cunlin Zhang[2]; Zexuan Zhu[3] [1]Department of Biomedical Engineering, Shenzhen University, China; [2]Department of Physics, Capital Normal University, China; [3]Shenzhen University, China*
17:15 – 17:30	Tu10-6 ***Reststrahlen Band Assisted Photocurrents In Graphene*** *Christoph Drexler[1]; Leonid Golub[2]; Sergey Danilov[1]; Vadim Shalygin[3]; Peter Olbrich[1]; Rupert Huber[1]; Rositza Yakimova[4] et al. [1]University of Regensburg, Germany; [2]A.F. Ioffe Institute, Russian Federation; [3]St. Petersburg Polytechnic University, Russian Federation; [4]Linköping University, Sweden*	M11-6 **Structural Hierarchy Of Short Peptides Observed In The Terahertz Frequency Region** *Ohki Kambara[1]; Tetsuo Sasaki[1]; Jun-ichi Nishizawa[2] [1]RIE, Shizuoka University, Japan; [2]SRI, Sophia University, Japan*
18:00 – 21:00	**Excursion**	

Gutenberg 3	Gutenberg 4	Congress Hall
Tu12 THz Plasmonics 2	**Tu13 Tu8 Detectors 4**	**Tu14 THz Spectroscopy 1**
Tu12-4 **Semiconductor Plasmonic Crystals: Active Control Of THz Extinction** *Martijn Schaafsma; Jaime Gomez Rivas* *FOM Institute AMOLF, c/o Philips Research Laboratories, Netherlands*	Tu13-4 **Serially Connected MOS Terahertz Sensor Array** *Domonkos Gergelyi[1]; Péter Földesy[1]; Zoltán Kárász[1]; Csaba Füzy[2]* *[1]Pázmány Péter Catholic University, Hungary; [2]MTA-SZTAKI, Hungary*	Tu14-4 **Terahertz Frequency Optical Constants Of Montmorillonite** *Ingrid Wilke* *Rensselaer Polytechnic Institute, United States*
Tu12-5 **Plasmonic Excitations In Bi_2Se_3 Topological Insulator** *Paola Di Pietro[1]; Michele Ortolani[2]; Odeta Limaj[3]; Alessandra Di Gaspare[4]; Valeria Giliberti[2]; Flavio Giorgianni[3] et al.* *[1]INSTM UdR Trieste-ST, Italy; [2]CNR-IFN and Università di Roma "La Sapienza", Italy; [3]Università di Roma "La Sapienza" and INFN, Italy; [4]CNR-IFN, Italy;*	Tu13-5 **Fabrication And Characterization Of InAs/GaSb Strained Layer Superlattice Infrared Focal Plane Array Detectors** *Jianxin Chen[1]; Li Quan[1]; Zhicheng Xu[1]; Yi Zhou[1]; Jiajia Xu[1]; Ruijun Ding[1]; Li He[1]* *[1]Shanghai Institute of Technical Physics, Chinese Academy of Sciences, China*	Tu14-5 **Hydration Water In Protein-Salt Aqueous Solutions Observed By THz-TDS** *Katsuyoshi Aoki; Kentaro Shiraki; Toshiaki Hattori* *University of Tsukuba, Japan*
Tu12-6 **Electromagnetic Generation By Combining Electronics And Photonics: Surface Plasmon Polariton Cherenkov Light Source** *Shenggang Liu; Min Hu; Ping Zhang; Sen Gong; Tao Zhao; Renbin Zhong; Xiaoxing Chen* *University of Electronic Science and Technology of China, China*	Tu13-6 **Theoretical Characterization And Measurements Of Lens-Coupled LEKIDs** *Beatriz Blazquez; Nuria Llombart; Andrea Neto* *Delft University of Technology, Netherlands*	Tu14-6 **Role Of Growth Morphology On The Terahertz Response Of Vertically Aligned Carbon Nanotubes** *Wissem Zouaghi[1]; Mark D. Thomson[1]; Kaneez Rabia[1]; Hartmut G. Roskos[1]; Thorsten Heinlein[2]; Jörg Engstler[2]; Jörg J. Schneider[2]* *[1]Johann Wolfgang Goethe-Universität Frankfurt am Main, Germany; [2]Technische Universität Darmstadt, Germany*
Excursion		

Tuesday, September 3rd

Tu Pl1 **09:00 - 09:45** **Tuesday Plenary 1** **Congress Hall**
Chair: Dan Mittleman

How Millimeter Waves Interact With Nanometer- And Sub-Nanometer-Sized Gaps 282
Dai-Sik Kim
Seoul National University, Republic of Korea

Millimeter waves funnel through nano gaps of 0.8-20 nm, 1) creating intensity enhancements of 10^8, 2) enhancing molecular cross sections by 10^3, and 3) greatly enhancing nonlinearities and lowering transition temperatures of correlated electron systems. Nano and terahertz technologies have much to offer to each other.

Tu Pl2 **09:45 - 10:30** **Tuesday Plenary 2** **Congress Hall**
Chair: Dan Mittleman

THz Near-Field Imaging And Micro-Spectroscopy 286
Paul Planken
Delft University of Technology, The Netherlands

The THz frequency range has proven to be a very interesting frequency range for imaging and spectroscopy. The smallest spatial feature that can theoretically be resolved is limited by diffraction to values of about half of a wavelength, which corresponds to 150 μm for a frequency of 1 THz. To overcome this diffraction limit, terahertz near-field techniques have been developed. This talk describes techniques to overcome the diffraction limit in the THz frequency range. These techniques have been used for micro-spectroscopy and for imaging of the EM field in the neighbourhood of small antenna-like structures.

Tu1 **11:00 - 12:30** **High-Power Sources 4** **Gutenberg 1**
Chair: Georg Neil

Tu1-1 11:00 **New Results On The Physics Of THz Gyrotrons 290**
Stefano Alberti[1]; Falk Braunmueller[1]; Trach-Minh Tran[1]; Jeremy Genoud[1]; Quentin Vuillemin[1]; Jean-Philippe Hogge[1]; Minh-Quang Tran[1]; Jean-Philippe Ansermet[2]; Alessandro Macor[2]; Emile de Rijk[2]
[1]CRPP/EPFL, Switzerland; [2]IPMC/EPFL, Switzerland
Basic wave-particle interaction dynamics from linear to chaotic regimes is studied in detail both experimentally and theoretically on a frequency tunable gyrotron developed for DNP-NMR spectroscopy applications and generating THz radiation in continuous mode (150 W) at 260 GHz. The non-linear dynamics associated to the wave-particle interaction is dominated by self-consistent effects on the longitudinal profile of a given single transverse cavity-mode $TE_{m,p}$. This study covers a wide range of control parameters from traveling wave tube (gyro-TWT) to gyro-backward wave oscillator (gyro-BWO) like interactions. The route to chaos via a period doubling cascade dynamics is experimentally observed and is supported by numerical simulations. In presence of phase-locked side-bands a novel regime characterized by the generation of nano second pulses has been experimentally identified. This novel regime is consistent with numerical simulations and may open up new applications for gyrotrons.

Tu1-3 11:30 **Long Pulse Operation Of A Dual Frequency Gyrotron For JT-60SA 293**
Takayuki Kobayashi; Masayuki Sawahata; Masayuki Terakado; Shinichi Hiranai; Kenji Wada; Yoshikatsu Sato; Jun Hinata; Kenji Yokokura; Katsumichi Hoshino; Ken

Kajiwara; Yasuhisa Oda; Koji Takahashi; Ryosuke Ikeda; Shinichi Moriyama; Keishi Sakamoto
Japan Atomic Energy Agency, Japan
Long pulse operation of a dual frequency gyrotron for JT-60SA, which can oscillate both 110 GHz and 138 GHz waves, was started. Oscillations at ~ 0.4 MW for 2 s (both frequencies) and 0.7 MW for 1 s (110 GHz) were obtained, so far. Temperature increase in the cavity, the output window and some components, which absorb stray radiation in the gyrotron, were measured and cavity loss power and the dielectric loss tangent of the output window were evaluated. Heat loads in the gyrotron measured so far were acceptable for long pulse operation at an output power of 1 MW.

Tu1-4 11:45 **New Results of Megawatt Power Gyrotrons Development 295**
Alexander Litvak; Gregory Denisov
Institute of Applied Physics of RAS, Russian Federation
During last year several new steps in gyrotrons development have been done at IAP/GYCOM. The main ITER requirements to a gyrotron have been demonstrated: 170 GHz frequency, 1MW power, 1000 seconds pulse duration, 53 % efficiency. The operation regime of 1.2 MW was found for 100 second pulses. For a multi-frequency gyrotron a novel scheme for a tuneable window was developed. at running plasma installations.

Tu1-5 12:00 **Power Improvement On Gyrotron FU CW GIII 297**
Yoshinori Tatematsu; Tatsuru Kawase; Ryoichi Ichioka; Yuusuke Yamaguchi; Isamu Ogawa; Ryosuke Ikeda; Toshitaka Idehara; Teruo Saito
FIR, University of Fukui, Japan
Gyrotron FU CW GIII has been developed as an improved version of Gyrotron FU CW GII. A new electron gun has been designed to improve the quality of an electron beam. After careful set up of FU CW GIII, the maximum oscillation power of 420 W was obtained, which is more than 5 times larger than that obtained on Gyrotron FU CW GII.

Tu1-6 12:15 **Progress Of 1.5-1.7 MW/170 GHz Gyrotron Development 299**
Vadim Myasnikov[1]; Marina Agapova[1]; Andrey Kuftin[2]; Vladimir Zapevalov[2]; Gregory Denisov[2]; Vladimir Ilin[3]; Ludmila Belnova[1]; Aleksey Chirkov[2]; Aleksander Gnedenkov[1]; Aleksander Litvak[2]; Vladimir Malygin[2]; Vadim Nichiporenko[1]; Vladimir Novikov[3]; Leonid Popov[1]; Igor Roy[3]; Vera Rukavishnikova[1]; Evgeniy Tay[1]; Evgeniy Sokolov[1]; Elena Soluyanova[1]; Sergey Usachev[1]
[1]GYCOM Ltd., Russian Federation; [2]IAP RAS, Russian Federation; [3]Tokamak Physics Institute, NRC "Kurchatov Institute", Russian Federation
Recent test results of newly designed 1.5-1.7 MW / 170 GHz gyrotron which is considered as a possible RF source for the ITER program are presented. As yet the gyrotron test has been carried out with evacuated transmission line at 0.1 s pulse length. The maximal output power of 1.75 MW was attained at beam voltage of 98.6 kV and current of 58.4 A. Long-pulse gyrotron test is planned to start in autumn.

Tu2 11:00 - 12:30 Photoconductive Antennas 1 Gutenberg 2
Chair: Thorsten Göbel

Tu2-1 11:00 **Enhancing The Amplitude Stability Of A Photomixer-based Terahertz System By Photocurrent Normalization 301**
Axel Roggenbuck[1]; Malte Langenbach[2]; Komalavalli Thirunavukkuarasu[2]; Holger Schmitz[2]; Anselm Deninger[1]; Joachim Hemberger[2]; Markus Grüninger[2]
[1]TOPTICA Photonics AG, Germany; [2]Universität zu Köln, Germany
We present a method to improve the stability of continuous-wave photomixer-based terahertz spectroscopy systems by monitoring the DC photocurrents in both the transmitter and the receiver. We introduce the theoretical concept, describe our implementation, and show experimental results validating the approach.

Tu2-2 11:15 **Terahertz Detection Sensitivity Enhancement By Incorporating Plasmonic Gratings In Photoconductive Detectors 303**
Mona Jarrahi; Ning Wang; Christopher W. Berry; Mohammad R. Hashemi
University of Michigan, United States
We present a design of plasmonic photoconductive detectors, which mitigates the low detection sensitivity limitation of conventional photoconductive terahertz detectors. By incorporating plasmonic contact electrode gratings in the photoconductive detector, average carrier transport path length to the contact electrodes is reduced, enhancing photoconductor responsivity significantly. Experimental results show that a 30-fold terahertz detection sensitivity enhancement can be achieved over 0.1 THz to 1.5 THz frequency range by using the presented plasmonic photoconductive detector.

Tu2-3 11:30 **A travelling-wave type p-i-n photomixer with a thin absorption layer. 305**
Sang-Pil Han; Jeong Woo Park; Namje Kim; Hyunsung Ko; Kiwon Moon; Kyung Hyun Park; Namje Kim; Hyunsung Ko; Kiwon Moon; Kyung Hyun Park
ETRI, Korea, Republic of
A travelling-wave photomixer was realized. The responsivity was 0.42 A/W for 15 μm length device. It showed a 3 dB bandwidth of more than 200 GHz, limited by transit-time of photo-generated carriers. Also, it showed a successful THz wave generation up to frequency range of more than 500 GHz.

Tu2-4 11:45 **Carbon Ion Irradiated SI-GaAs Based Efficient Photoconductive THz Emitters Using Low Electrical Power 307**
Abhishek Singh; Sanjoy Pal; Harshad Surdi; S. S. Prabhu; Vandana Nanal; R. G. Pillay
TIFR, India
We demonstrate here an efficient THz source with low electrical power consumption. We have overcome the saturation problem in THz sources at higher applied bias voltages by implanting the SI-GaAs source substrate crystals with Carbon-ion irradiation at 33.5 MeV energy. Photoconductive Emitter (PCE) source fabricated on an un-annealed Carbon irradiated SI-GaAs has shown linear increase in emitted THz Electric field amplitude with increasing applied electric field even up to 8 kV/cm. The emitted THz power at higher applied bias voltages is more than a factor of 4 in comparison to the PCEs fabricated on normal un-irradiated SI-GaAs under identical conditions.

Tu2-5 12:00 **Photoconductive CW THz Receiver With 20-fold Increased THz Conversion Efficiency By Buried Interdigital Electrodes 309**
Dennis Stanze; Thorsten Göbel; Roman Dietz; Björn Globisch; Martin Schell
Fraunhofer HHI, Germany
Photoconductive cw THz receivers with buried interdigital finger contacts feature a 20-fold higher conversion efficiency than their planar counterpart. Applied to a 1.5 μm cw THz photomixing system, a SNR up to 95 dB @ 100GHz was achieved.

Tu2-6 12:15 **The Effect Of Er Fraction On THz Power Generated By Extrinsic-photoconductive ErAs:GaAs Switches Driven At 1550 nm 311**
John Middendorf; Elliott Brown
Wright State University, United States
Two Er-doped-GaAs photoconductive (PC) switches have been studied in extrinsic mode with different Er fractions of 1 % and 2 %. The PC switches were driven with a 1550 nm ultrafast laser ($h\nu = 0.56\ U_G$, U_G=1.42 eV for GaAs) and exhibited different THz bandwidths and photoelectric responsivities. These experiments are aimed at optimizing the new extrinsic mode of generating THz radiation in ErAs:GaAs photoconductive devices. This is the first ever demonstration of generating THz power with extrinsic photoconductivity with a 2 % Er ErAs:GaAs PC switch. We find that the PC switch with 2 % Er concentration produced more THz power and the bandwidth was marginally better.

Tu3	11:00 - 12:30	THz Communications 2 Chair: Thomas Kleine-Ostmann	Gutenberg 3

Tu3-1 11:00 **Enhanced THz Generation For Wireless Communications Using Short Optical Pulses 313**

Lothar Moeller[1]; Alexandre Shen[2]
[1]Alcatel-Lucent, United States; [2]Alcatel-lUCENT, France

We measure the duty cycle impact of pulsed signals at 1.5 µm wavelength used for optical THz generation. Our results suggest pulse coding for wireless transmitters can maximize emitted THz power.

Tu3-3 11:30 **0.2 THz Wireless Communication Using Plasma-wave Transistor Detector 316**

Stéphane Blin[1]; Lucie Tohme[1]; Guillaume Ducournau[2]; Dominique Coquillat[3]; Philippe Nouvel[1]; Annick Pénarier[1]; Wojciech Knap[1]; Jean-François Lampin[4]
[1]IES Univ. Montpellier 2, France; [2]IEMN, France; [3]L2C, France; [4]IES, Université de Montpellier 2, France

Transistors are possible THz detectors using rectification in the channel that can be applied for detection of high data-rate wireless communications, based on THz-frequency carrier. For the first time, we present the transmission of pseudo-random bit sequence at 0.2 THz using a commercial GaAs transistor and demonstrate open eye patterns up to 0.250 Gbps.

Tu3-4 11:45 **Coherent Terahertz Communication Based On DSP-Aided Radio-over-Fiber Technology 317**

Atsushi Kanno[1]; Toshiaki Kuri[1]; Isao Morohashi[1]; Iwao Hosako[1]; Tetsuya Kawanishi[1]; Yuki Yoshida[2]; Yoshihiro Yasumura[2]; Ken'ichi Kitayama[2]
[1]National Institute of Information and Communications Technology, Japan; [2]Osaka University, Japan

Coherent terahertz-signal transmission using an optical frequency comb and a high-speed digital signal processing (DSP) technology is successfully demonstrated. The DSP-aided radio-over-fiber technology can enhance the resilience of networks to disasters.

Tu3-5 12:00 **A 16QAM Modulation Based 3Gbps Wireless Communication Demonstration System At 0.34 THz Band 319**

Wei Huang; Changxin Lin; Cheng Wang; Bin Lu
China Academy Engineering Physics, China

This article describes a 16 QAM modulation based 3 Gbps wireless communication demonstration system at 0.34 THz band, which consists of a 0.34 THz wireless communication transceiver front end based on solid-state semiconductor, an IF updown converter, and a digital signal process unit. The transmitted signal carrier of this demonstration system is centered at 0.34 THz, the output power is -20 dBm, the gain of antenna is 25 dBi. The demonstration system succeedes in error free transmission of 3 Gbps data rate signal over 30 cm distance.

Tu3-6 12:15 **Substrate Integrated Waveguide Antenna For 60 GHz Radio-over-Fiber Transmitter 321**

Ivan Flammia; Besher Khani; Andreas Stöhr
University of Duisburg-Essen, Germany

We present a substrate integrated waveguide (SIW) antenna designed for 60 GHz indoor Radio-over-Fiber photonic transmitters. For broad-band applications (57-64 GHz) a return loss (RL) higher than 7 dB and a front-to-back ratio (FTBR) of 17 dB are achieved. Alternative resonant solutions are also introduced to achieve RL > 10 dB and FTBR = 21 dB.

Tu4	**11:00 - 12:30**	**QCLs Applications** **Chair: Miriam Vitiello**	**Gutenberg 4**

Tu4-1 11:00 **THz Quantum Cascade Laser-based Quartz Enhanced Photo-acoustic Sensor 323**

Vincenzo Spagnolo[1]; Pietro Patimisco[2]; Angelo Sampaolo[2]; Simone Borri[3]; Harvey H. Beere[4]; David A. Ritchie[4]; Miriam S. Vitiello[5]; Gaetano Scamarcio[2]; Paolo P. Calabrese[6]

[1]Physics Dept. Politecnico di Bari, Italy; [2]Physics Dept. University of Bari, Italy; [3]IFN-CNR UOS BARI, Italy; [4]University of Cambridge, United Kingdom; [5]NEST-CNR and Scuola Normale Superiore, Italy; [6]CNR-IFN UOS BARI, Italy

We report on the first demonstration of a quartz enhanced photo-acoustic (QEPAS) sensor in the Terahertz (THz) range. The sensor is based on a QCL emitting at 3.93 THz and a customized quartz tuning fork. For methanol detection we reached a normalized noise-equivalent absorption of 2×10^{-10} cm^{-1} $W/Hz^{½}$ comparable with the best result of mid-IR QEPAS.

Tu4-3 11:30 **Fast Terahertz Computed-Tomography Imaging With A Quantum-Cascade Laser And A Scanning Mirror 326**

Nick Rothbart[1]; Heiko Richter[1]; Martin Wienold[2]; Lutz Schrottke[2]; H. T. Grahn[2]; H.-W. Hübers[1]

[1]German Aerospace Center (DLR), Germany; [2]Paul-Drude-Institut für Festkörperelektronik, Germany

A terahertz transmission imaging system based on a quantum-cascade laser (QCL), a fast scanning mirror, and a sensitive Ge:Ga detector is demonstrated. In order to reduce artifacts, special care was taken on the optics and the conversion of the measured data into the image. Images with a diameter of approximately 40 mm and a signal-to-noise ratio of up to 28 dB were obtained within 1.1 s. The system was used to record three dimensional images of objects in an ellipsoidal volume with axes of approximately 40 mm by computed tomography within 87s. In addition to the Ge:Ga detector, a more compact pyroelectric device was also used for detection.

Tu4-4 11:45 **Coherent Imaging With Mid-IR And THz Quantum Cascade Lasers through Optical Feedback Interferometry 328**

Francesco Mezzapesa[1]; Maurangelo Petruzzella[2]; Maurizio Dabbicco[1]; Miriam Serena Vitiello[3]; H.E. Beere[4]; D. A. Ritchie[4]; Gaetano Scamarcio[1]

[1]Dipartimento Interateneo di Fisica, Università degli Studi di Bari, and IFN-CNR UOS Bari, Italy; [2]Dipartimento Interateneo di Fisica, Università degli Studi di Bari, Italy; [3]NEST, CNR - Istituto Nanoscienze and Scuola Normale Superiore, Pisa, Italy; [4]Cavendish Laboratory, University of Cambridge, United Kingdom

We retrieve the phase signature in coherent imaging based on a quantum cascade laser (QCL) subjected to optical feedback. In the self-mixing scheme, a single QCL acting as a source and detector of THz radiation, is used to obtain the reflection image of a sample as well as the phase profile without ambiguity. We study the phase sensitivity against optical feedback and assess the limit of the phase signal detection.

Tu4-5 12:00 **Spectroscopic Analysis Of Powders Through Diffuse-reflectance Imaging Using A Frequency-switchable Terahertz Quantum Cascade Laser 332**

Alex Valavanis; Paul Dean; Siddhant Chowdhury; Andrew Burnett; Suraj Khanna; Giles Davies; Edmund Linfield

University of Leeds, United Kingdom

A heterogeneous THz-QCL is used for diffuse-reflectance imaging of powdered solids at 4 frequencies in the range 3.05−3.35 THz. An effective-optical-path-length model reproduces TDS absorption spectra accurately and discriminates between admixtures of materials with differing concentrations.

Tu4-6 12:15 **High Order Optical Sideband Generation With Terahertz Quantum Cascade Lasers** **334**

Pierrick Cavalie[1]; Julien Madéo[1]; Joshua Freeman[1]; Jean Maysonnave[1]; Elodie Strupiechonski[2]; Gangyi Xu[2]; Raffaele Colombelli[2]; Harvey Beere[3]; Dave Ritchie[3]; Lianhe Li[4]; Edmund Linfield[4]; Giles Davies[4]; Carlo Sirtori[5]; Jerome Tignon[1]; Sukhdeep Dhillon[1]

[1]CNRS/Ecole Normale Superieure, France; [2]University Paris Sud, France; [3]University of Cambridge, United Kingdom; [4]University of Leeds, United Kingdom; [5]University Paris 7, France

Optical sidebands are generated by difference frequency mixing between a resonant bandgap near-infrared beam and a terahertz (THz) wave. This is realized within the cavity of a THz quantum cascade laser using resonantly enhanced non-linearities. Multiple order optical sidebands and conversion efficiencies up to 0.1 % are shown.

Tu5 **14:00 - 15:30** **Free-Electron Lasers** **Gutenberg 1**
Chair: Harald Schneider

Tu5-1 14:00 **FELIX Facility: Free Electron Laser Light Sources From 0.2 To 75 THz** **335**

Wim J van der Zande[1]; Britta Redlich[1]; Rienk T Jongma[2]; Lex van der Meer[2]

[1]Radboud University, Institute for Molecules and Materials, Netherlands; [2]Radboud University Nijmegen, Netherlands

The user FELIX Facility Nijmegen offers four FEL beam lines, FLARE from 0.2 to 3 THz, FELIX-2 from 12 to 75 THz, FELIX-1 from 2 to 12 THz and FELICE, a special beam line for intra-cavity experiments from 3 -75 THz

Tu5-3 14:30 **The TeraFERMI Beamline At The FERMI Free-Electron-Laser** **337**

Andrea Perucchi[1]; Simone Di Mitri[1]; Giuseppe Penco[1]; Enrico Allaria[1]; Stefano Lupi[2]

[1]Elettra - Sincrotrone Trieste S.C.p.A., Italy; [2]Universita di Roma "Sapienza", Italy

We describe the project for the construction of a Terahertz (THz) beamline to be called TeraFERMI at the seeded FERMI Free Electron Laser (FEL) facility in Trieste, Italy. We discuss topics as the underlying scientific case, the choice of the source, the expected performance, and THz beam propagation.

Tu5-4 14:45 **Terahertz Pump-Probe Experiment At The Synchrotron Light Source MLS** **339**

Andreas Pohl[1]; Arne Hoehl[2]; Ralph Müller[2]; Gerhard Ulm[2]; Markus Ries[3]; Godehard Wüstefeld[3]; Sergey Pavlov[4]; Heinz-Wilhelm Hübers[4]

[1]TU Berlin, Germany; [2]PTB, Germany; [3]HZB, Germany; [4]DLR, Germany

We have developed a pump-probe experiment utilizing broad-band coherent terahertz synchrotron radiation provided by the Metrology Light Source (MLS). The design, performance and first results obtained with the setup are presented.

Tu5-5 15:00 **Ultrafast High-resolution Spectroscopy Of Separate NovoFEL Pulses** **341**

Vitaly Kubarev

BINP, Russian Federation

One-pulse spectroscopy is used for the first time for a direct diagnostics of separate free-electron laser pulses. Full pulse coherency in a stabilized NovoFEL regime was demonstrated. Generation at different side-band modes in different pulses was observed when stabilizing detuning between electron and light pulses was decreased.

Tu5-6 15:15 **Terahertz Circular Dichroism Polarimeter With An Attenuated Total Reflection Module At Novosibirsk Free Electron Laser** **343**

Yulia Choporova[1]; Valery Cherkassky[2]; Elvira Grigorieva[3]; Boris Knyazev[2]; Ludmila Mostovich[3]; Dmitry Rodionov[4]

[1]Budker institute of nuclear physics SB RAS, Russian Federation; [2]novosibirsk state university, Russian Federation; [3]Institute of Molecular Biology and Biophysics SD RAMS, Russian Federation; [4]Budker Institute of Nuclear Physics SB RAS, Novosibirsk, Russian Federation

A circular dichroism polarimeter (CDP) with an attenuated total reflection element for study of strongly absorbing substances and NovoFEL as a monochromatic source of THz radiation has been developed. Polarimetric characteristics of polysaccharide enantiomers have been studied for checking the performance of the CDP.

Tu6	**14:00 - 15:30**	**Photoconductive Antennas 2** **Chair: Frank Ospald**	**Gutenberg 2**

Tu6-1 14:00 **Generation And Detection Of THz Radiation Up To 4.5 THz Using LTG-GaAs PCAs Illuminated At 1560 nm 345**

Jan-Martin Rämer[1,2]; Frank Ospald[1,2]; Georg von Freymann[1,2]; René Beigang[1,2]
[1]Fraunhofer Institute for Physical Measurement Techniques IPM, Germany;
[2]Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, Germany

We demonstrate generation and detection of terahertz radiation using low-temperature grown GaAs photoconductive switches excited at 1560 nm. The dependence of the DC photocurrent and the terahertz amplitude on the input power of the detector and emitter is evaluated.

Tu6-2 14:15 **Highly Efficient Terahertz Photoconductive Switch At 1060nm Excitation Wavelength For Multichannel THz System 347**

Carsten Gerth[1]; Roman J.B. Dietz[2]; Thorsten Göbel[2]; Martin Schell[2]; Anika Brahm[3]; Gunther Notni[1]; Andreas Tuennermann[1]
[1]Fraunhofer IOF, Germany; [2]Fraunhofer HHI, Germany; [3]Friedrich Schiller University, Germany

A new algorithm for the processing of THz absorption spectra is developed. It grants further applications of the THz radiation in the field of security control or chemical substance identification. The algorithm processes the whole spectra with small information content by means of continuous wavelet transformation (CWT).

Tu6-3 14:30 **Plasmonic Photoconductive Terahertz Emitters Based On Logarithmic Spiral Antenna Arrays 349**

Christopher Berry; Mohammed Reza Hashemi; Mona Jarrahi
University of Michigan, United States

We present an efficient photoconductive terahertz emitter based on a logarithmic spiral antenna array that incorporates plasmonic contact electrodes on a LT-GaAs substrate. Under a 400 mW optical pump power, the emitter generates 1.9 mW of terahertz radiation in the 0.1 – 2 THz range.

Tu6-4 14:45 **Investigation Into The Role Of The Metal Mask And Pump Laser Illumination Parameters For Lateral Photo-Dember Emitters 351**

Mark Barnes[1]; Duncan McBryde[1]; Paul C. Gow; Sam Berry[1]; Geoff Daniell[1]; Harvey Beere[2]; David Ritchie[2]; Vasilis Apostolopoulos[1]
[1]University of Southampton, United Kingdom; [2]University of Cambridge, United Kingdom

In lateral photo-Dember emitters pulses of coherent terahertz radiation can be generated by ultrafast above bandgap laser illumination of the surface of a partially metallic masked semiconductor. We investigate the role of the metallic mask and how the emission depends on spot size and fluence.

Tu6-5 15:00 **Bandwidth Improvement Of Cw THz Receivers By Be Doping Of Low Temperature Grown InGaAs/InAlAs Heterostructures 353**

Björn Globisch; Dennis Stanze; Roman J. B. Dietz; Thorsten Göbel; Martin Schell
Fraunhofer Heinrich Hertz Institute, Germany

LTG InGaAs/InAlAs based cw THz receivers can be fine-tuned by Be doping, which is an advantage towards their LTG GaAs counterparts. By increasing Be doping we reduce carrier trapping time, resulting in larger bandwidth. As a tradeoff, the current response

is reduced.

Tu6-6 15:15 **High-speed Near-field Imaging System Based On Photoconductive Terahertz Microprobes 355**

Christopher Matheisen[1]; Michael Nagel[1]; Simon Sawallich[1]; Heinrich Kurz[1]; Giorgos Georgiou[2]; Jaime Gomez-Rivas[2]
[1]AMO GmbH, Germany; [2]FOM Institute AMOLF, Netherlands

Photoconductive Terahertz microprobes have been crystalized as powerful measurement tools for high-resolution conductivity imaging, chip inspection and near-field imaging applications. In this work we demonstrate their integration into a high-speed system with 250 pixels/s data acquisition rate.

Tu7 14:00 - 15:30 THz Plasmonics 1 Gutenberg 3
Chair: Jean-Louis Coutaz

Tu7-1 14:00 **THz Spectroscopy Of Semiconducting Plasmonic Resonators 357**

Giorgos Georgiou[1]; Audrey Berrier[1]; Martijn Schaafsma[1]; Michael Nagel[2]; Jaime Gomez-Rivas[1]; Hemant Tyagi[1]
[1]FOM Institute AMOLF, Netherlands; [2]AMO GmbH, Germany

We investigate the photo-excitation of localized surface plasmon polaritons (LSPPs) in semiconductor structures at THz frequencies by the optical pumping of electrons across the semiconductor energy bandgap. This excitation can be actuated in picosecond time scales, enabling ultrafast THz plasmonics. The concept of active plasmonics can be extended to a full spatial and temporal optical control of plasmonic resonances using the structured illumination of flat semiconductors. This control has lead to the observation of strong capacitive coupling and charge transfer plasmons in dimers with very small gaps. Furthermore, we show that LSPPs can enhance THz local fields in subwavelength volumes by several orders of magnitude. This field enhancement is used to probe very thin organic layers.

Tu7-3 14:30 **Plasmonic focusing on metal and semiconductor disks under radially polarized terahertz illumination 360**

Jan Hodapp[1]; Korbinian Kaltenecker[2]; Stefan Waselikowski[1]; Christian Fischer[1]; Bernd M. Fischer[3]; Markus Walther[1]; Jan Wallauer[1]
[1]Freiburg Materials Research Center, Germany; [2]French-German Research Institute of Saint-Louis, Freiburg Materials Research Center, Germany; [3]French-German Research Institute of Saint-Louis, Germany

Optimal focusing of surface plasmon polaritons in the center of a metal disc illuminated by radially polarized terahertz pulses is demonstrated. Due to the cylinder symmetrical structure surface plasmons can be excited along the entire circumference, which interfere constructively in the center of the disk forming a sharp frequency-depended focal spot. We map the field distribution on the disk by THz near-field microscopy and compare our result to numerical simulations. For comparison, behavior under linearly polarized THz illumination is characterized. Furthermore, first results of semiconducting plasmonic lenses are presented.

Tu7-5 15:00 **Surface Plasmon Propagation Along Plane Metal-dielectric Interfaces With Air Gaps 363**

Guerman Zhizhin[1]; Valery Cherkassky[2]; Alexey Nikitin[1]; Vasily Gerasimov[3]; Boris Knyazev[3]; Igor Kotelnikov[3]; Gennady Kulipanov[3]
[1]Scientific and Technological Center for Unique Instrumentation of RAS, Russian Federation; [2]Department of General Physics, Novosibirsk State University, Russian Federation; [3]Budker Institute of Nuclear Physics SB RAS, Russian Federation

Propagation of terahertz surface plasmon polaritons along plane metal-dielectric interfaces and their jumps across air gaps have been studied using monochromatic radiation of Novosibirsk free electron laser.

Tu7-6 15:15 **Mid-infrared Plasmonic Antennas Made Of Electron-doped Epitaxial Germanium-on-Silicon 365**

Marco Finazzi[1]; Michele Ortolani[2]; Leonetta Baldassarre[3]; Alessandro Nucara[2]; Paolo Biagioni[1]; Jacopo Frigerio[4]; Giovanni Isella[1]; Antonio Samarelli[5]; Douglas Paul[5]
[1]Politecnico di Milano, Italy; [2]Sapienza University of Rome, Italy; [3]Istituto Italiano di Tecnologia, Italy; [4]politecnico di Milano, Italy; [5]University of Glasgow, United Kingdom

We are developing an all-semiconductor plasmonic platform for mid-infrared sensing which includes growth of epitaxial n-doped germanium films, spectroscopic test and electromagnetic design of plasmonic antennas.

Tu8 14:00 - 15:30 Detectors 3 Gutenberg 4
Chair: Francois Lampin

Tu8-1 14:00 **1/f-Noise Prediction In Millimeter Wave Detectors Based On Quasi Vertical Schottky Diodes 367**

Matthias Hoefle[1]; Andreas Penirschke[1]; Oleg Cojocari[2]; Andreas Amrhein[2]; Thibaut Decoopman[3]; Petri Piironen[4]; Rolf Jakoby[1]
[1]TU Darmstadt, Germany; [2]ACST GmbH, Germany; [3]Astrium SAS France, France; [4]ESA-ESTEC, Netherlands

A modeling concept for accurate prediction of 1/f-noise in millimeter wave Schottky detectors is presented. The concept is based on DC bias current measurements with precise knowledge of the diode structure. Key aspect is the distinction between DC and RF current distribution at the Schottky contact, specifically investigated on a quasi-vertical diode structure.

Tu8-3 14:30 **Polarization-Sensitive Broadband Sub-Terahertz-Wave Detector Implementing Planar-Antenna-Integrated Schottky Barrier Diode 370**

Hiroshi Ito[1]; Toshihide Yoshimatsu[2]; Hiroshi Yamamoto[1]; Tadao Ishibashi[3]
[1]Kitasato University, Japan; [2]NTT Photonics Laboratories, Japan; [3]NTT Electronics Corporation, Japan

A polarization-sensitive sub-THz-wave detector module implementing an InP-based Schottky barrier diode that integrates an extended bowtie antenna has been developed. The fabricated module could detect signals at frequencies from 30 GHz to 1 THz. The measured sensitivities were 1080 V/W at 250 GHz, 250 V/W at 400 GHz, and 86 V/W at 600 GHz for a zero-bias condition. The principal polarization axis angle was confirmed to be stable at frequencies from 80 to 600 GHz while the degree of polarization was more than 95 %.

Tu8-4 14:45 **Terahertz Imaging Using InGaAs Schottky Barrier Diode Array Detectors 372**

Sang-Pil Han[1,4], Jeong-Woo Park[1,4], Hyunsung Ko[1], Namje Kim[1], Kiwon Moon[1], Young-Jong Yoon[1,4],Wang-Joo Lee[2], Won-Hee Lee[2], Min Yong Jeon[3], and Kyung Hyun Park[1,4]
[1]THz Photonics Creative Research Center, ETRI, Daejeon, 305-700, Korea
[2]Radio Technology Research Department, ETRI, Daejeon, 305-700, Korea
[3]Department of Physics, Chungnam National University, Daejeon, 305-764, Korea
[4]School of Advanced device Technology, UST, Daejeon 305-350, Korea

We characterize InGaAs Schottky barrier diodes (SBDs) with a variation in the anode size. High-efficiency terahertz (THz) pulse detection of the InGaAs SBDs is performed in the cases of anode diameters of 2 μm and 3 μm. The uniformity of the fabricated 1×20 InGaAs SBD array is measured to be fine. The THz imaging results using the 1×20 InGaAs SBD array are presented.

Tu8-5 15:00 **Quasi Optical Schottky Diode Detectors For Fast Ultra-Wideband Detection 374**

H. Hübers[1]; Arne Hoehl[2]; Alvydas Lisauskas[3]; Nikolay Sobornytskyy[3]; Oleg Cojocari[3]; Cristian Weickhmann[4]; R. Jakobi[4]
[1]Institute of Planetary Research, German Aerospace Center (DLR), Germany;
[2]Physicalisch-Technische Bundesanstalt, Germany; [3]ACST GmbH, Germany; [4]TU

Darmstadt, Germany
We present ultra-wideband zero-bias Schottky diode detector modules with monolithically integrated log-spiral antenna. Detectors exhibit a broad-band response with a stronger roll-off above 800 GHz and the minimum noise-equivalent power of 10 pW/√Hz. The intrinsic diode response time to a short THz radiation has been measured to be less than 25ps.

Tu8-6 15:15 **Analysis Of CMOS 0.13 µm Test Structures For 0.6 To 1.5 THz Imaging 376**
Suzana Domingues[1]; Matteo Perenzoni[1]; David Stoppa[1]; Daniele Perenzoni[1]; Valeria Giliberti[2]; Alessandra Di Gaspare[3]; Michele Ortolani[2]
[1]Fondazione Bruno Kessler, Italy; [2]Institute for Photonics and Nanotechnology/Sapienza University of Rome, Italy; [3]Institute for Photonics and Nanotechnology, Italy
Test structures comprehending several combinations of FET detector sizes and bow-tie antennas were designed and fabricated in a 0.13 µm standard CMOS technology. Measurement results from these stuctures provide a quantitative comparison basis for the design of a future real-time high-frame rate THz camera, providing an insight on the optimization of the FET size.

Tu9 14:00 - 15:30 Waveguiding Structures Congress Hall
Chair: Michael Nagel

Tu9-1 14:00 **Long-range Guided THz Radiation Coupled In Thin Layers Of Water - A Study Of The Propagation Length Characteristics 378**
Robert Sczech; Peter Haring Bolívar
University of Siegen, Germany
We demonstrate end-fire excited THz radiation coupled in thin layers of water propagating a distance of 4 cm. As the propagation lengths are critically dependent from the permittivity, we experimentally demonstrate this propagation length dependency by stepwise exchanging the material layer from deionized water to pure ethanol.

Tu9-2 14:15 **Plasmonic Two Wire Terahertz Fibers With Porous Dielectric Support 379**
Andrey Markov; Maksim Skorobogatiy
Ecole Polytechnique de Montreal, Canada
A practical plasmonic THz fiber is described that features two metallic wires held together by the porous dielectric cladding. High porosity is required in order to guarantee low loss and low dispersion of guided modes.

Tu9-3 14:30 **Confinement And Losses Of THz Planar Goubau Lines Fabricated On A Thin Silicon Substrate 381**
Abdallah Chahadih; Abbas Ghaddar; Serkan Kaya; Ibrahim Türer; Gabriel Moreno; Yohann Zapart; Tahsin Akalin
IEMN, Lille 1 University, France
Low loss broad band transmission lines are of great interest for terahertz applications. To overcome high losses, Planar Goubau Lines (PGL) have been designed and fabricated on high resistivity silicon substrate. The measured loss level is typically 1 dB/mm around 250 GHz. The transitions are also extremely efficient for CPW-to-PGL conversion. The loss level depends on certain parameters such as length and width of the rectangular cross section or the thickness of the silicon substrate. The confinement of the electromagnetic wave will be also discussed particularly for different values of the strip's width.

Tu9-4 14:45 **Optimization And Application Of On-chip Terahertz Goubau Lines 383**
Christopher Russell; Christopher Wood; Andrew Burnett; Lianhe Li; Edmund Linfield; Giles Davies; John Cunningham
University of Leeds, United Kingdom
We demonstrate optimization of planar terahertz (THz) frequency Goubau lines to

achieve a ~ 2 THz bandwidth. This has allowed high resolution, on-chip THz spectra of polycrystalline materials to be recorded over temperatures ranging from 4–292 K.

Tu9-5 15:00 **Terahertz Filters Based On Planar Goubau Transmission Lines With Multi Split Rings Resonators 385**

Tahsin Akalin; Abdallah Chahadih; Serkan Kaya; Ibrahim Turer; Yohann Zapart; Abbas Ghaddar; Mokhtar Zehar; Gabriel Moreno
IEMN, Lille 1 University, France

The electromagnetic field around Planar Goubau transmission Line (PGL) offers the possibility of tailoring the response of metamaterials components such as single or multi-micro resonators type. In this paper, we suggest a novel design of filter based on PGL coupled with micro split rings resonators (SRR). The frequency selectivity of resonant-type metamaterial transmission lines suggests their application in filter design.

Tu9-6 15:15 **In-situ Real-time Characterization Of Spurious Modes In HE_{11} Transmission Lines With A Mitrebend Hole Coupler 387**

Burkhard Plaum[1]; Walter Kasparek[2]; Carsten Lechte[1]; Hiroshi Idei[3]; Zana Popovic[1]
[1]Universität Stuttgart, Germany; [2]Unisersität Stuttgart, Germany; [3]Kyushu University, Japan

A method for the in-situ characterization of spurious modes in high power microwave transmission lines is presented. It uses hole couplers, which are integrated into a mitre-bend. The signals are proportional to the field strength at the mirror and allow to partly reconstruct the mode spectrum in the waveguide. The theoretical background is presented as well as results from measurements on prototypes.

Tu10 16:00 - 17:30 Graphene 1 Gutenberg 1
Chair: Chao Zhang

Tu10-1 16:00 **Magnetic Quantum Ratchet Effect In Graphene 389**

Sergey Ganichev
University of Regensburg, Germany

We report on the observation of magnetic quantum ratchet (MQR) effect induced by electric field of terahertz radiation in single-layer graphene samples subjected to an in-plane magnetic field. We show that the dc electric current stems from the orbital asymmetry of the Dirac fermions induced by an in-plane magnetic field, while the periodic driving comes from terahertz radiation. A microscopic theory of the observed effect is developed being in a good qualitative agreement with the experiment. The observation of the ratchet transport in the purest possible two-dimensional system indicates that the orbital effects may appear and be substantial in other 2D crystals, such as boron nitride, molybdenum dichalcogenides, and related heterostructures. The measurable orbital effects in the presence of an in-plane magnetic field give strong evidence for the existence of structure inversion asymmetry in graphene.

Tu10-3 16:30 **Nonlinear Terahertz Conductivity In Graphene 392**

Zoltan Mics[1]; Mischa Bonn[1]; Klaas-Jan Tielrooij[2]; Dmitry Turchinovich[1]
[1]Max Planck Institute for Polymer Research, Germany; [2]Institut de Ciéncies Fotóniques, Spain

Graphene is a unique conductor, where charge is transported by massless carriers. Remarkably, the THz response of carriers strongly depends on the driving field.

Tu10-5 17:00 **Amplification Of Terahertz Radiation By Stimulated Emission Of Plasmons In Graphene 394**

Olga Polischuk[1]; Taiichi Otsuji[2]; Michael Shur[3]; Viacheslav Popov[1]; Arthur Davoyan[1]; Victor Ryzhii[2]
[1]Kotelnikov Institute of Radio Engineering and Electronics, Russian Federation; [2]RIEC, Tohoku University, Japan; [3]ECSE, Rensselaer Polytechnic Institute, United States

We predict strong amplification of terahertz radiation by the stimulated generation of

plasmons in a planar array of graphene micro/nanocavities. Amplification drastically enhances due to lateral and vertical confinement of the plasmons in graphene micro/nanocavities and superradiant nature of electromagnetic radiation from the array.

Tu10-6 17:15 **Reststrahlen Band Assisted Photocurrents In Graphene 396**

Christoph Drexler[1]; Leonid Golub[2]; Sergey Danilov[1]; Vadim Shalygin[3]; Peter Olbrich[1]; Rupert Huber[1]; Rositza Yakimova[4]; Samuel Lara-Avila[5]; Sergey Kubatkin[5]; Britta Redlich[6]; Sergey Ganichev[1]
[1]University of Regensburg, Germany; [2]A.F. Ioffe Institute, Russian Federation; [3]St. Petersburg Polytechnic University, Russian Federation; [4]Linköping University, Sweden; [5]Chalmers University, Sweden; [6]FOM Institute for Plasma Physics Rijnhuizen, Netherlands

We report on the experimental and theoretical study of the Reststrahlen Band assisted photocurrents in epitaxial grown graphene on SiC. We show that excitation of graphene with infrared radiation results in a dc current. We demonstrate that photocurrent in response to linearly polarized radiation exhibit a resonance enhancement in the frequency range of the Reststrahlen Band of the SiC substrate. By contrast the photocurrent excited by circularly polarized radiation is suppressed in the same spectral range. The developed theory is in agreement with the data and reveals a strong influence of the Reststrahlen Band on the high frequency transport in graphene.

Tu11 16:00 - 17:30 THz Spectroscopy: Proteins Gutenberg 2
Chair: Axel Zeitler

Tu11-1 16:00 **Temperature And Hydration Dependence Of Low-frequency Dynamics Of A Small Globular Protein Studied By Terahertz Time-domain Spectroscopy 397**

Naoki Yamamoto; Atsuo Tamura; Keisuke Tominaga
Kobe University, Japan

Temperature- and hydration-dependent terahertz spectra of hen egg white lysozyme were obtained by using terahertz time-domain spectroscopy. Analysis of the complex dielectric spectra indicated hydration-water dynamics at around 2 picoseconds were thermally activated above 230 K upon hydration.

Tu11-2 16:15 **Can Terahertz Time-domain Spectroscopy Detect An Extended Hydration Layer Around Peptides? 399**

Robert Falconer[1]; Anton Middelberg[2]; Tao Ding[3]; Jordan Bye[1]
[1]University of Sheffield, United Kingdom; [2]University of Queensland, Australia; [3]National University of Singapore, Singapore

A peptide was added to a KF solution and the absorbance measured by Terahertz time-domain spectroscopy (THz-TDS). The absorbance dropped then plateaued at ~25 mM. This is consistent with a hydration layer around 11-17 Å thick with lower absorbance than bulk water. Terahertz spectroscopy using synchrotron light performed on a solution containing the protein bovine serum albumin (BSA) confirmed the rise in absorbance observed using p-germanium spectroscopy and the plateauing observed by THz-TDS in aqueous peptide samples. Using the inflection in the decline of the absorbance, the thickness of the hydration layer around BSA can be estimated at 15 Å thick.

Tu11-3 16:30 **Kinetic Terahertz Absorption Spectroscopy Of Protein Solutions 401**

Jessica Dielmann[1]; Valeria Conti Nibali[1]; Benjamin Born[2]; Erik Bründermann[1]; Martina Havenith[1]
[1]Ruhr-Universität Bochum, Germany ;[2]Weizmann Institute of Science, Israel

Recently we used kinetic terahertz absorption (KITA) spectroscopy to investigate hydration dynamics during enzymatic hydrolysis. In order to extend KITA studies by phase and frequency information, we set up a dual-mode THz time domain spectrometer (TDS) that can be run either in asynchronous optical sampling (ASOPS) or conventional TDS mode.

Tu11-4 16:45 **Effects Of Saline On Terahertz Absorption Of Aqueous Glucose At Physiological Concentrations Probed By THz Spectroscopy 402**
Seongsin Margaret Kim; Michael Bolus; Soner Balci; David Wilbert; Patrick Kung
University Of Alabama, United States
Terahertz time domain spectroscopy in the range 0.3-1.5 THz has been conducted for D-glucose at physiological concentrations from 25-200 mg/dL in pure water and in 0.9 % saline by mass. The results show that the ions do not uniformly affect absorption of aqueous glucose, so NaCl ions should not be modeled simply as transparent holes in the water framework.

Tu11-5 17:00 **Probing Label Free Antibody Interactions With HA Protein Using Terahertz Pulsed Spectroscopy 404**
Yiwen Sun[1]; Jian Zuo[2]; Zhenwei Zhang[2]; Cunlin Zhang[2]; Zexuan Zhu[3]
[1]Department of Biomedical Engineering, School of Medicine, Shenzhen University, China; [2]Department of Physics, Capital Normal University, Beijing, 100037, China, China; [3]Shenzhen University, China
In this paper we use terahertz spectroscopy to study the concentration dependence non-linear absorption behaviors of the influenza virus hemagglutinin (HA) protein and effects of HA protein interacting with the neutralization antibody in the solutions. The thickness of the hydration shell around the HA protein was determined based on two and three components model. The absorption coefficient was measured over the frequency range 0.1-1.5 THz. The terahertz properties of HA was strongly affected by the presence of a specific antibody.

Tu11-6 17:15 **Structural Hierarchy Of Short Peptides Observed In The Terahertz Frequency Region 406**
Ohki Kambara[1]; Tetsuo Sasaki[1]; Jun-ichi Nishizawa[2]
[1]RIE, Shizuoka University, Japan; [2]SRI, Sophia University, Japan
Terahertz (THz) spectra of amino acids: glycine and L-alanine and these polypeptides are measured by THz spectroscopy. For both amino acids, the spectral features are more complicated with increasing the number of the chain length. This structural hierarchy is studied by DFT calculation results.

Tu12 16:00 - 17:30 THz Plasmonics 2 Gutenberg 3
Chair: Dai-Sik Kim

Tu12-1 16:00 **Active THz Plasmonic Waveguides And Circuits 408**
Giorgos Georgiou; Jaime Gómez Rivas; Hemant Kumar Tyagi
FOM Institute AMOLF, Netherlands
We propose a novel way to actively control the propagation of THz Surface Plasmon Polariton (SPPs) in plasmonic waveguides structured on semiconductors. The SPP characteristics (field confinement and mode propagation length) can be precisely tuned by optically pumping charge carriers to the conduction band of the semiconductor. This approach can be used to generate active and integrated THz components and circuits.

Tu12-2 16:15 **THz Plasmonic Waveguides With Low-loss And Low-group Velocity Dispersion Using Flexible Thin Substrate 410**
Djamal Gacemi[1]; Fanqi Meng[2]; Paul Crozat[2]; Juliette Mangeney[1]
[1]Ecole Normale Superieure Paris, France; [2]Institut d'électronique fondamentale, France
We demonstrate a reduction of loss and group velocity dispersion (GVD) of THz plasmonic waveguides by using a low-loss thin flexible substrate. We present a numerical calculation of the effect of the substrate thickness on the GVD. We show experimentally low absorption and weak distortion of the propagated THz pulses along a THz plasmonic waveguide on a flexible 58 μm-thick polyimide substrate.

Tu12-3 16:30 **Characterization Of Highly Doped Si With Surface Plasmon 411**
Maxim Nazarov[1]; Alexander Shkurinov[2]; Frederic Garet[3]; Jean-Louis Coutaz[3]
[1]ILIT RAS, Russian Federation; [2]M.V.Lomonosov Moscow State University, Russian Federation; [3]IMEP-LAHC, University of Savoie, France
We propose to measure the THz surface plasmon signal transmitted after a long distance propagation over a conductive sample in view of determining the THz properties of the sample material. We demonstrate this very sensitive method on a highly-doped silicon samples. The surface permittivity differs from the Drude model prediction.

Tu12-4 16:45 **Semiconductor Plasmonic Crystals: Active Control Of THz Extinction 413**
Martijn Schaafsma; Jaime Gomez Rivas
FOM Institute AMOLF, c/o Philips Research Laboratories, Netherlands
We study the scattering, absorption and extinction of THz radiation by 2D plasmonic crystals formed by periodic arrays of semiconductor particles. The particles sustain localized surface plasmon resonances that can couple to diffracted orders of the array giving rise to hybrid plasmonic-photonic modes. These modes exhibit extraordinary extinction and narrow line widths. The coupling strength and, consequently, the extinction can be actively tuned by changing the carrier concentration in the semiconductor, which is achieved by optical pumping.

Tu12-5 17:00 **Plasmonic Excitations In Bi_2Se_3 Topological Insulator 415**
Paola Di Pietro[1]; Michele Ortolani[2]; Odeta Limaj[3]; Alessandra Di Gaspare[4]; Valeria Giliberti[2]; Flavio Giorgianni[3]; Matthew Brahlek[5]; Namrata Bansal[5]; Nikesh Koirala[5]; Seongshik Oh[5]; Paolo Calvani[6]; Stefano Lupi[3]
[1]INSTM UdR Trieste-ST Area Science Park, Trieste, Italy, Italy; [2]CNR-IFN and Dipartimento di Fisica, Università di Roma "La Sapienza", Piazzale A. Moro 2, I-00185 Ro, Italy; [3]Dipartimento di Fisica, Università di Roma "La Sapienza" and INFN, Piazzale A. Moro 2, I-00185 Roma,, Italy; [4]CNR-IFN, Via Cineto Romano, 00100 Roma, Italy; [5]Department of Physics and Astronomy Rutgers, The State University of New Jersey 136 Frelinghuysen Ro, United States; [6]CNR-SPIN and Dipartimento di Fisica, Università di Roma "La Sapienza", Piazzale A. Moro 2, I-00185 R, Italy
We first report evidence by using terahertz (THz) spectroscopy of plasmonic excitations in a topological insulator (TI) that was engineered in thin micro-ribbon arrays. Plasmons are due to Dirac quasi-particles of the two-dimensional electron gas which forms at the surface of TIs.

Tu12-6 17:15 **Electromagnetic Generation By Combining Electronics And Photonics: Surface Plasmon Polariton Cherenkov Light Source 417**
Shenggang Liu; Min Hu; Ping Zhang; Sen Gong; Tao Zhao; Renbin Zhong; Xiaoxing Chen
University of Electronic Science and Technology of China, China
A novel physical phenomenon is reported which may combine electronics and photonics to generate electromagnetic radiation. Surface plasmon polaritons (SPPs) are excited by a uniformly moving electron beam in a structure of nano-scale metal film with dielectric medium loading, and then are transformed into Cherenkov radiation with intensity enhancement. Surface Polariton Cherenkov Light Source (SPCLS) is proposed and explored. The results show that SPCLS can generate radiation from visible light to ultraviolet frequency regime and the radiation power density can reach 10^8 W/cm^2 or even higher depending on the beam energy and current density.

Tu13 16:00 - 17:30 Detectors 4 Gutenberg 4
Chair: Viktor Krozer

Tu13-1 16:00 **Optimized Tera-FET Detector Performance Based On an Analytical Device Model Verified Up To 9 THz 419**
Sebastian Boppel[1]; Alvydas Lisauskas[1]; Maris Bauer[1]; Martin Mundt[1]; Rimvydas Venckevičius[2]; Linas Minkevičius[2]; Dalius Seliuta[2]; Irmantas Kašalynas[2]; Bassam

Khamaisi[3]; Eran Socher[3]; Gintaras Valušis[2]; Viktor Krozer[1]; Hartmut G. Roskos[1]
[1]Physikalisches Institut, Johann Wolfgang Goethe-Universität Frankfurt, D-60438 Frankfurt, Germany, Germany; [2]Semiconductor Physics Institute of Center for Physical Science and Technology, LT-01108 Vilnius, Lit, Lithuania; [3]School of Electrical Engineering, Tel-Aviv University, IL-69978 Tel-Aviv, Israel, Israel
We report on an order-of-magnitude enhancement of sensitivity of CMOS-transistor-based THz detectors. At 2.54 THz, 3.13 THz and 4.25 THz, responsivity values of 336 V/W, 308 V/W, and 230 V/W and optimum noise-equivalent-power values of 63 pW/√Hz, 85 pW/√Hz, and 110 pW/√Hz are obtained.

Tu13-3 16:30 **Contribution Of The Gate Leakage Current To Terahertz Detection By Asymmetric Dual-Grating Gate HEMT Structures 420**

Dominique Coquillat[1]; Yuki Kurita[2]; Kengo Kobayashi[2]; Frederic Teppe[1]; Nina Dyakonova[1]; Christophe Consejo[1]; Dmytro But[1]; Lucie Tohme[3]; Philippe Nouvel[3]; Stephane Blin[1]; Jeremie Torres[1]; Annick Pénarier[1]; Taiichi Otsuji[4]; Wojciech Knap[1]
[1]Laboratoire Charles Coulomb UMR 5221, France; [2]Research Institute of Electrical Communication, Tohoku Univ., Japan; [3]Institut d'Electronique du Sud UMR 5214 CNRS-Univerty of Montpellier, France; [4]Research Institute of Electrical Communication, Tohoku Univ, Japan
We present experimental study of terahertz detection by asymmetric dual-grating gate HEMT structures. The separate contributions of the gate leakage current and the loading effect to the rectification signal in the sub-threshold region was investigated versus temperature and frequency range.

Tu13-4 16:45 **Serially Connected MOS Terahertz Sensor Array 422**

Domonkos Gergelyi[1]; Péter Földesy[1]; Zoltán Kárász[1]; Csaba Füzy[2]
[1]Pázmány Péter Catholic University, Hungary; [2]MTA-SZTAKI, Hungary
In this paper we present a coherent detector array architecture that efficiently utilizes the available chip area to enhance signal to noise ratio. For this goal the configuration can consists multiple serially connected individual detectors that are coupled to a regularly arranged antenna matrix. The solution is scalable and can be easily customized to application specific needs e.g. microscopic imaging. In the followings we present the measurement results of a fully functional prototype chip that were fabricated at 350 nm Bi CMOS technology.

Tu13-5 17:00 **Fabrication And Characterization Of InAs/GaSb Strained Layer Superlattice Infrared Focal Plane Array Detectors 424**

Jianxin Chen[1]; Li Quan[2]; zhicheng xu[2]; Yi Zhou[2]; Jiajia Xu[2]; Ruijun Ding[2]; Li He[2]
[1]Shanghai Institute of Technical Physics Chinese Academy of Sciences, China; [2]Shanghai Institute of Technical Physics, Chinese Academy of Sciences, China
We report the fabrication and characterization of high performance superlattice infrared photodetectors. The single-element detectors have 50 % cutoff wavelengths of 5.2 μm and 8.0 μm with related R_0A of 7.5×10^4 Ωcm^2 and 110 Ωcm^2, respectively at 77 K. The focal plane arrays with cutoff wavelength of 5.2 μm and format of 128×128, showed a noise equivalent differential temperature 33.4 mK at 80 K. Fabrication of long wavelength FPA is under way.

Tu13-6 17:15 **Theoretical Characterization And Measurements Of Lens-Coupled LEKIDs 426**

Beatriz Blazquez; Nuria Llombart; Andrea Neto
Delft University of Technology, Netherlands
Lumped Element Kinetic Inductance Detectors (LEKID), when coupled with a silicon lens, have very high absorption efficiencies (70 %) over more than one octave frequency band. In this contribution we introduce a theoretical derivation of the power received by these detectors by modeling them as an infinite array of dipoles. The theoretical model has been validated by measurements on a prototype working in the microwave band.

Tu14	16:00 - 17:30	THz Spectroscopy 1 Chair: Koichiro Tanaka	Congress Hall

Tu14-1 16:00 **Study On Weak Hydrogen Bond By Terahertz And Mid-IR Spectroscopy 428**

Kohji Yamamoto; Kazutoshi Fukui; Kazuko Kazuko Mizuno; Masahiko Tani
University of Fukui, Japan

We have investigated molecular aggregates of dimethylsulfoxide (DMSO) in cyclohexane to study the weak hydrogen bond between S=O and H-C using terahertz time-domain spectroscopy and FT-IR absorption spectroscopy. It is suggested that formation of different types of DMSO aggregates are observed in mid-IR and THz absorption.

Tu14-3 16:30 **Relation Between Anisotropic Relative Permittivity And Density Of Wood Evaluated Using THz Time Domain Transmission Spectroscopy 430**

Soichi Tanaka[1]; Yoshihisa Fujii[2]; Keiichiro Shiraga[3]; Yuichi Ogawa[3]
[1]Materials Research Institute for Sustainable Development, National Institute of Advanced Industrial, Japan; [2]Division of Forest and Biomaterials Science, Graduate School of Agriculture, Kyoto University, Japan; [3]Division of Environmental Science and Technology, Graduate School of Agriculture, Kyoto University, Japan

To confirm the feasibility of applying THz time domain spectroscopy (TDS) technique to nondestructive evaluation (NDE) of wood, the relation of relative permittivity to density for specimens of 12 wood species was investigated using THz-TDS transmission measurement system. The dielectric anisotropy, the difference in the relative permittivity in the fiber and transverse direction of wood, was also examined. The findings of our investigations indicate that THz-TDS technique can be applied to NDE of wood density and grain direction.

Tu14-4 16:45 **Terahertz Frequency Optical Constants Of Montmorillonite 432**

Ingrid Wilke
Rensselaer Polytechnic Institute, United States

The real and imaginary parts of the complex index of refraction of montmorillonite between 0.2 THz and 1.4 THz at room temperature are reported. The optical properties of montmorillonite in this frequency range were experimentally determined using time-domain THz spectroscopy. Distinct frequency dependencies of the index of refraction and the extinction coefficient are not observed within the uncertainties of the measurements. The index of refraction of montmorillonite is modeled using effective medium theory.

Tu14-5 17:00 **Hydration Water In Protein-Salt Aqueous Solutions Observed By THz-TDS 434**

Katsuyoshi Aoki; Kentaro Shiraki; Toshiaki Hattori
University of Tsukuba, Japan

We studied salt effects on hydration water of protein using terahertz time-domain spectroscopy (THz-TDS). The number of hydration water molecules at the protein surface was observed to decrease by addition of ammonium sulfate, while ammonium thiocyanate increases it.

Tu14-6 17:15 **Role Of Growth Morphology On The Terahertz Response Of Vertically Aligned Carbon Nanotubes 436**

Wissem Zouaghi[1]; Mark D. Thomson[1]; Kaneez Rabia[1]; Hartmut G. Roskos[1]; Thorsten Heinlein[2]; Jörg Engstler[2]; Jörg J. Schneider[2]
[1]Johann Wolfgang Goethe-Universität Frankfurt am Main, Germany; [2]Technische Universität Darmstadt, Germany

We study the terahertz response of vertically aligned carbon nanotubes (VA-CNT) using THz time-domain spectroscopy, in order to determine optimal conditions for their use as THz-based gas sensors. The morphology of such films must be considered to reconcile the reflected signals and extract the complex conductivity spectra.

Wednesday	**Congress Hall**
	Plenary Session
08:55 – 09:50	Plenary session We-Pl1 **Exploring Frontiers Between Optics And Electronics - 1950 To The Present: A Prominent Period -** Kiyomi Sakai *NICT, Japan* **In this plenary session Kiyomi Sakai will be awarded the Kenneth J. Button Prize 2013 for his outstanding contributions to the development of a wide range of far-infrared and spectroscopic techniques, with special emphasis on terahertz time-domain spectroscopy.**
09:50 – 10:35	Plenary session We-Pl2 **Electromagnetic Metamaterials: A New Paradigm For The 21st Century** Christophe Caloz *École Polytechnique de Montréal, Canada*
10:35 – 11:00	**Coffee Break (Rhein Foyer)**

Wednesday	Gutenberg 1	Gutenberg 2
	We1 High Power Sources 5	**We2 Photomixers**
11:00 – 11:15	We1-1 (invited talk) **A 263 GHz 10 Watt Pulsed Extended Interaction Klystron Amplifier** *Peter Horoyski; Brian Steer; Albert Roitman; Henry Deng; Mark Hyttinen; Ross MacHattie* *CPI Canada, Canada*	We2-1 (invited talk) **1.5 µm Cw THz Photomixing System With 105 dB Signal-To-Noise Ratio** *Thorsten Göbel; Dennis Stanze; Roman J. B. Dietz; Björn Globisch; Helmut Roehle; Martin Schell* *Fraunhofer Heinrich-Hertz-Institute, Germany*
11:15 – 11:30		
11:30 – 11:45	We1-3 **Latest Experiments Of W-Band Gyro-BWO Using Helically Corrugated Waveguides** *Alan Phelps; Wenlong He; Craig Donaldson; Liang Zhang; Paul McElhinney; Kevin Ronald; Adrian Cross* *University of Strathclyde, United Kingdom*	We2-3 **Broadband Continuous-Wave THz Spectroscopy At Low Temperature And High Magnetic Field** *Malte Langenbach[1]; Komalavalli Thirunavukkuarasu[1]; Iván Cámara Mayorga[2]; Axel Roggenbuck[3]; Anselm Deninger[3] et al.* *[1]Universität zu Köln, Germany; [2]MPI für Radioastronomie, Germany; [3]TOPTICA photonics AG, Germany*

Gutenberg 3	Gutenberg 4	Congress Hall
We3 THz Metamaterials	**We4 Detectors 5**	
We3-1 (invited talk) **Metamaterial-Mediated Terahertz Surface Waves With Strong Confinement** *Tassilo Fip; Benjamin Reinhard; Jens Neu; Marco Rahm* *University of Kaiserslautern, Germany*	We4-1 (invited talk) **Semiconducting Y-Ba-Cu-O Thermal Detectors: Low Noise And Fast Pyroelectric IR Response - Development For Future THz Imagers** *Alain Kreisler; Xavier Galiano; Annick Degardin; Vishal Jagtap* *SUPELEC – LGEP; CNRS UMR 8507; UPMC Université Paris 06; Université Paris Sud 11, France*	
We3-3 **Broadband And High-Efficient Terahertz Wave Deflection Based On C-Shaped Complex Metamaterials With Phase Discontinuities** *Zhen Tian* *Tianjin University, China*	We4-3 **A Terahertz Plasma Oscillations In Nanometer Field Effect Transistors For Terahertz Radiation Rectification** *Wojciech Knap; Dominique Coquillat; Frederic Teppe; Dmitry But* *Montpellier University & CNRS, France*	

Wednesday	Gutenberg 1	Gutenberg 2
	We1 High Power Sources 5	**We2 Photomixers**
11:45 – 12:00	We1-4 **A Novel Laser Based High-Power Terahertz Source** *Amrutha Gopal[1]; Torsten May[2]* *[1]Friedrich-Schiller University,Jena, Germany;* *[2]Institute of Photonic Technologies, Germany*	We2-4 **Graphene LTG-GaAs Photomixer For Reliable Continuous Wave Terahertz Generation** *Shihab Al-Daffaie; Oktay Yilmazoglu; Franko Küppers; Hans Hartnagel* *TU Darmstadt, Germany*
12:00 – 12:15	We1-5 **Numerical Simulation Of Processes At The Cavities Of High-Power 300 GHz Gyrotrons** *Vladimir Zapevalov; Mark Moiseev; Nikolay Zavolsky* *Institute of Applied Physics, Russian Academy of Sciences, Russian Federation*	We2-5 **Continuous THz Wave Generation By Photodiodes Up To 2.5 THz** *Tadao Ishibashi[1]; Yoshifumi Muramoto[1]; Toshihide Yoshimatsu[1]; Hiroshi Ito[2]* *[1]NTT Photonics Laboratories, Japan; [2]Kitasato University, Japan*
12:15 – 12:30	We1-6 **Near-Field Imaging And Nano-Fourier Transform Infrared Spectroscopy By Using A Broadband Synchrotron Radiation Source** *Peter Hermann[1]; Arne Hoehl[1]; Piotr Patoka[1]; Florian Huth[2]; Eckart Rühl[3]; Gerhard Ulm[1]* *[1]PTB, Germany; [2]Neaspec GmbH, Germany; [3]FU Berlin, Germany*	We2-6 (invited talk, 12:15 – 12:45) **Milliwatt Output Power Generated In The J-Band By A GaAs Photomixer** *Emilien Peytavit[1]; Philipp Latzel[1]; Fabio Pavanello[1]; Guillaume Ducournau[2]; Jean-François Lampin[1]* *[1]IEMN / CNRS, France; [2]IEMN / Lille University, France*
12:30 – 14:00	**Lunch (on your own)**	

Gutenberg 3	Gutenberg 4	Congress Hall
We3 THz Metamaterials	**We4 Detectors 5**	
We3-4 **Eutectic Terahertz Metamaterials** *Maria Massaouti[1]; Alexey Basharin[1]; Maria Kafesaki[1,2]; Maria Fernanda Acosta[3]; Rosa–Isabel Merino[3]; Victor Manuel Orera[3]; Eleftherios Nikolaos Economou[1]; Costas Soukoulis[1] et al.* *[1]Foundation for Research and Technology-Hellas (FORTH), Greece; [2]University of Crete, Greece; [3]CSIC-Universidad de Zaragoza, Spain*	We4-4 **Nonlinear Photoresponse Of FET THz Broadband Detectors At High Power Irradiation** *Dmytro But[1]; Christoph Drexler[2]; Oleksiy Drachenko[3]; Nina Dyakonova[1]; Sergey D. Ganichev[2]; Wojciech Knap[1]* *[1]University of Montpellier 2, France; [2]University of Regensburg, Germany; [3]Helmholtz Zentrum Dresden Rossendorf, Germany*	
We3-5 **Asymmetric Transmission Of Planar Chiral THz Metamaterials For Circularly Polarized Light** *Boyoung Kang; Keisuke Takano; Masanori Hangyo* *Institute of Laser Engineering, Osaka University, Japan*	We4-5 **Mechanism Of Weakly Ionized Plasma Terahertz Wave Detector** *Lei Hou; Wei Shi; Yu Wu; Hong Liu; Yi Ding* *Xi'an University of Technology, China*	
We3-6 **Transient Terahertz Conductivity Spectra Of Semiconductor Nanostructures With Complex Percolation Pathways** *Hynek Nemec; Petr Kuzel; Ivan Rychetsky* *Institute of Physics, Academy of Sciences of the Czech Republic, Czech Republic*	We4-6 **Novel Broadband THz-Detector** *Christian Monte[1]; Ralf Müller[1]; Andreas Steiger[1]; Mathias Kehrt[1]; Werner Bohmeyer[2]; Karsten Lange[2]* *[1]PTB, Germany; [2]SLT, Germany*	
Lunch (on your own)		

Wednesday	Gutenberg 1	Gutenberg 2
	We5 High Power Sources 6	**We6 Waveguides 1**
14:00 – 14:15	We5-1 (invited talk) **The SPARC_LAB High Peak Power THz Source: Different Methods Of Generation And Characterization** *Enrica Chiadroni[1]; Michele Castellano[1]; Alessandro Cianchi[2]; Domenico Di Giovenale[1]; Giampiero Di Pirro[1]; Massimo Ferrario[1]; Giancarlo Gatti[1]; Flavio Giorgianni[3]; Andrea Mostacci[4]; Riccardo Pompili[5]; Concetta Ronsivalle[6]; Cristina Vaccarezza[1]; Fabio Villa[1]; Stefano Lupi[3]; Marco Bellaveglia[1]* *[1]INFN-LNF, Italy; [2]University Rome Tor Vergata and INFN Tor Vergata, Italy; [3]University Rome La Sapienza and INFN Romal, Italy; [4]SBAI Dept. University Rome La Sapienza and INFN Romal, Italy; [5]University Rome Tor Vergata and INFN-LNF, Italy; [6]ENEA C.R. Frascati, Italy*	We6-1 **Evanescent Wave Coupling In Terahertz Waveguide Arrays** *Kimberly Reichel[1]; Naokazu Sakoda[2]; Rajind Mendis[1]; Daniel Mittleman[1]* *[1]Rice University, United States; [2]Kobe Steel, Republic of Korea*
14:15 – 14:30		We6-2 **Compact High-Q Photonic Resonator Inside A Metallic Ridge Terahertz Waveguide** *Marko Gerhard; René Beigang; Marco Rahm* *University of Kaiserslautern, Germany*
14:30 – 14:45	We5-3 **2 MW, 170 GHz Coaxial-Cavity Short-Pulse Gyrotron - Investigations On Electron Beam Instabilities And Parasitic Oscillations –** *Tomasz Rzesnicki; Gerd Gantenbein; Stefan Illy; John Jelonnek; Jianbo Jin; Ioannis Pagonakis; Bernhard Piosczyk; Andreas Schlaich; Manfred Thumm* *Karlsruhe Institute of Technology (KIT), Germany*	We6-3 **Understanding The Dispersion Of THz Pulses In Tapered Parallel Plate Waveguides: Role Of The Multimode Propagation And Radiation Leakage** *Miguel Navarro-Cia[1]; Raimund Mueckstein[2]; Oleg Mitrofanov[2]* *[1]Imperial College London, United Kingdom; [2]University College London, United Kingdom*

Gutenberg 3	Gutenberg 4	Congress Hall
We7 Metamaterial Symp. 1	**We8 THz Spectr. Systems 2**	**We9 Remote Detec. & Imag.**
We7-1 (invited talk) **Broadband Terahertz Modulation Through Reconfigurable Meta-Surfaces With Diamagnetic Switching Capability** *Mona Jarrahi; Mehmet Unlu; Mohammad R. Hashemi; Christopher W. Berry; Shenglin Li; Shang-Hua Yang* *University of Michigan, United States*	We8-1 (invited talk) **Ultrabroadband Terahertz Time Domain Spectroscopic Ellipsometry** *Masatsugu Yamashita; Chiko Otani* *Terahertz Sensing and Imaging Laboratory, RIKEN RAP, Japan*	We9-1 (invited talk) **The Concept Of Remote Detection Of Concealed Radioactive Materials By Using High-Power THz Radiation** *Gregory Nusinovich[1]; Michael Glyavin[2]; Alexey Luchinin[2]* *[1]University of Maryland, United States; [2]Institute of Applied Physics, Russian Federation*
We7-3 (invited talk) **Terahertz Metasurfaces: Fabrication And Characterization Of Flat Lenses And Antennas** *Tahsin Akalin* *IEMN, UMR CNRS 8520, Lille 1 University, France*	We8-3 **Coherent Detection Of Ultrabroadband Coherent Infrared Pulses Up To 150 THz Using Air** *Eiichi Matsubara; Masaya Nagai; Masaaki Ashida* *Osaka University, Japan*	We9-3 **Passive Stand-Off THz Imaging Using Lock-In Phase Information** *Alexey Semenov[1]; Heinz-Wilhelm Hübers[2]; Roy Bretfeld[3]; Ute Böttger[1]; Heiko Richter[1]; Sven Augustin[2]; Helmut Hirsch[3]* *[1]German Aerospace Center, Germany; [2]TU Berlin/German Aerospace Center, Germany; [3]Astro-und Feinwerktechnik Adlershof GmbH, Germany*

Wednesday	Gutenberg 1	Gutenberg 2
	We5 High Power Sources 6	**We6 Waveguides 1**
14:45 – 15:00	We5-4 **Zones Of Locked Oscillations In A MW-Power Gyrotron Driven By External Microwave Signal** *Grigory Denisov; Vladimir Bakunin; Yulia Novozhilova* *Institute of Applied Physics RAS, Russian Federation*	We6-4 **Influence Of Metal Surface Roughness On The Phase Velocity Of Terahertz Waves Propagating In Parallel Plate Waveguides** *Daiki Takeshima[1]; Tomoya Sakon[1]; Satoshi Tsuzuki[1]; Futoshi Matsui[2]; Yuji Kusuda[3]; Takashi Furuya[1]; Seizi Nishizawa[1] et al.* *[1]University of Fukui, Japan; [2]Fukui Industrial Support Center, Japan; [3]Fukuoka Rashi Co. Ltd., Japan*
15:00 – 15:15	We5-5 **Effect Of The Tilt On The Gyrotron Operation** *Olgerts Dumbrajs* *Institute of Solid State Physics, University of Latvia, Latvia*	We6-5 **Minimization Of Reflection At The Boundaries Of A Finite-Size Coupled Terahertz Cavity In A Metal Air-Gap Waveguide** *Chul-Sik Kee[1]; Sun-Goo Lee[1]; Chul Kang[1]; Tae-In Jeon[2]; Eui Su Lee[2]* *[1]Advanced Photonics Research Institute, GIST, Republic of Korea; [2]Korea Maritime University, Republic of Korea*
15:15 – 15:30	We5-6 **Remote-Steering Launchers For The ECRH System On The Stellarator W7-X** *C. Lechte[1]; B. Plaum[1]; W. Kasparek[2]; A. Zeitler[2]; V. Erckmann[3]; H. Laqua[3]; M. Weißgerber[3]; A. Bechtold[4] et al.* *[1]University of Stuttgart, Germany; [2]IGVP, Germany; [3]MPI für Plasmaphysik, EURATOM-IPP, Germany; [4]NTG Neue Technologie GmbH & Co KG, Germany*	We6-6 **Modular Set Of Corrugated Wave-Guiding Components For Applications From 500 To 750 GHz** *Emile de Rijk[1]; Alessandro Macor[1]; Arndt von Bieren[1]; Jean-Philippe Ansermet[2]; Bruno Maffei[3]; Pisano Giampaolo[3]; Jeffrey Hesler[4]* *[1]SWISSto12 SA, Switzerland; [2]EPFL, Switzerland; [3]University of Manchester, United Kingdom; [4]Virginia Diodes Inc., United States*
15:30 – 16:00	**Coffee Break (Rhein Foyer)**	

Gutenberg 3	Gutenberg 4	Congress Hall
We7 Metamaterial Symp. 1	**We8 THz Spectr. Systems 2**	**We9 Remote Detec. & Imag.**
	We8-4 **On-Chip THz Spectroscopy Of Polyhydroxybutyrate (PHB) Powder** *Martin Muthee; Sigfrid Yngvesson* *ECE Department, University of Massachusetts, United States*	We9-4 **Study Of Aperture Synthesized Imaging Method In Terahertz Fan-Beam Scanning System** *Chao Li* *Institute of Electronics, Chinese Academy of Sciences, China*
We7-5 (invited talk) **Reconfigurable Plasmonic And Metamaterial Devices Using Liquid Metals** *Jinqi Wang; Shuchang Liu; Ajay Nahata* *University of Utah, United States*	We8-5 **Self-Referenced Spectral Domain Interferometry For Terahertz Detection** *Akram Ibrahim; Gargi Sharma; K. P Singh; Tsuneyki(John) Ozaki; Ibraheem Al-Naib; Roberto Morandotti* *Institut National de la Recherche Scientifique, Énergie, Matériaux et Télécommunications (INRS)., Canada*	We9-5 **Impact Damage Analysis Of Composite Materials With A mm-Wave Synthetic Aperture Radar** *Martin Nezadal; Jan Schür; Lorenz-Peter Schmidt* *Friedrich-Alexander Universität Erlangen-Nürnberg, Germany*
	We8-6 **Low-Cost Delay Line For Fast Terahertz Imaging** *Bastian Reitemeier[1]; Stefan Busch[1]; Thorsten Probst[1]; Maik Scheller[2]; Martin Koch[1]* *[1]Faculty of Physics and Material Sciences Center, Philipps-Universität Marburg, Germany; [2]Optical Sciences Center, University of Arizona, Tucson, USA, United States*	We9-6 **A Passive Submillimeter Video Camera For Security Applications** *Gabriel Zieger; Detlef Born; Solveig Anders; Erik Heinz; Katja Peiselt; Anika Brömel; Vyacheslav Zakosarenko; Torsten May; Hans-Georg Meyer* *IPHT JENA, Germany*
Coffee Break (Rhein Foyer)		

Wednesday	Gutenberg 1	Gutenberg 2
	We10 THz Metrology	**We11 Waveguides 2**
16:00 – 16:15	We10-1 **On The Necessity Of Standardization For Power And Sensitivity Measurements Of Terahertz Sources And Cameras** *Naoki Oda[1]; Iwao Hosako[2]; Tsutomu Ishi[1]; Hiroaki Minamide[3]; Chiko Otani[3]; Norihiko Sekine[2]* *[1]NEC, Japan; [2]NICT, Japan; [3]RIKEN, Japan*	We11-1 (invited talk) **Ultra-Thin Terahertz Waveguides On Periodic Dielectric Multilayers** *Vincent Paeder; Juraj Darmo; Karl Unterrainer* *Vienna University of Technology, Austria*
16:15 – 16:30	We10-2 **Calibration Of mm-Wave Power Meters Using A Broadband Calorimeter in The Frequency Range From 110 GHz To 170 GHz** *Kazuhiro Shimaoka[1]; Moto Kinoshita[1]; Katsumi Fujii[2]; Toshihide Tosaka[2]* *[1]AIST, Japan; [2]NICT, Japan*	
16:30 – 16:45	We10-3 **High Precision THz Radiometry** *Andreas Steiger; Ralf Müller* *PTB, Germany*	We11-3 **Dispersion And Attenuation In Flexible Dielectric-Lined Hollow Metallic THz Waveguides** *Miguel Navarro-Cia[1]; Carlos M. Bledt[2]; Miriam S. Vitiello[3]; Harvey E. Beere[4]; David A. Ritchie[4]; James A. Harrington[2] et al.* *[1]Imperial College London, United Kingdom; [2]Rutgers University, United States; [3]NEST, CNR, Italy; [4]Cavendish Laboratory, United Kingdom*

Gutenberg 3	Gutenberg 4	Congress Hall
We12 Metamaterial Symp. 2	**We13 THz Spectr. Systems 3**	**We14 Near Field Imaging**
We12-1 (invited talk) **Broadband And High-Efficiency Terahertz Metamaterial Linear Polarization Converters** *Hou-Tong Chen; Nathaniel Grady; Jane Heyes; Dibakar Roy Chowdhury; Yong Zeng; Matthew Reiten; Abul Azad; Antoinette Taylor; Diego Dalvit* *Los Alamos National Laboratory, United States*	We13-1 **Extending Spectral Focusing Techniques Into The THz Regime** *Stefan Funkner[1]; Katsuya Saito[1]; Takashi Furuya[1]; Kohji Yamamoto[1]; Mariko Yamaguchi[2]; Masanori Hangyo[3]; Masahiko Tani[1]* *[1]University of Fukui, Japan; [2]Nara Institute of Science and Technology, Japan; [3]Osaka University, Japan*	We14-1 (invited talk) **Nano-FTIR -The Chemical Nanoscope** *Fritz Keilmann* *Ludwig-Maximilians-Universität, Germany*
	We13-2 **Molecular Spectroscopy With A Compact 557 GHz Heterodyne Receiver** *Philipp Neumaier[1]; Heiko Richter[1]; Heinz-Wilhelm Hübers[1]; Jan Stake[2]; Huan Zhao[2]; Aik-Yean Tang[2]; Vladimir Drakinskiy[2]; Peter Sobis[3]; Tony Pellikka[3]; Anders Emrich[3] et al.* *[1]DLR, Germany; [2]Chalmers University of Technology, Sweden; [3]Omnisys Instruments AB, Sweden*	
We12-3 (invited talk) **THz Imaging With Metamaterials** Claire Watts; Willie Padilla; David Shrekenhamer Boston College, United States	We13-3 **THz Spectroscopy Of Radicals By Means Of Photomixing Experiment** *Gael Mouret; Arnaud Cuisset; Francis Hindle; Marie-Aline Martin-Drumel* *Université du Littoral Côte d'Opale, Laboratoire de Physico Chimie de l'Atmosphère, France*	We14-3 **Terahertz Transceiver Microprobe For Chip-Inspection Applications Using Optoelectronic Time-Domain Reflectometry** *Michael Nagel[1]; Christopher Matheisen[1]; Simon Sawallich[1]; Heinrich Kurz[1]; Stephan Dobritz[2]* *[1]AMO GmbH, Germany; [2]Fraunhofer IZM ASSID, Germany*

Wednesday	Gutenberg 1	Gutenberg 2
	We10 THz Metrology	**We11 Waveguides 2**
16:45 – 17:00	We10-4 **Precise Frequency Measurement Of Continuous-Wave Terahertz Radiation Based On THz Comb** *Kenta Hayashi[1]; Shuko Yokoyama[2]; Hajime Inaba[3]; Kaoru Minoshima[3]; Takeshi Yasui[1]* *[1]The University of Tokushima, Japan; [2]Micro-Optics Co. Ltd, Japan; [3]AIST, Japan*	We11-4 **Tunable THz Single Resonance With TEM Mode** *Tae-In Jeon; Eui Su Lee* *Korea Maritime University, Republic of Korea*
17:00 – 17:15	We10-5 **THz Spectroscopy With An Absolute Frequency Scale By A QCL Phase-Locked To A THz Frequency Comb** *Luigi Consolino[1,2]; Saverio Bartalini[1,2]; Andrea Taschin[2]; Paolo Bartolini[2]; Pablo Cancio[1,2]; Marco De Pas[2]; Harvey Beere[3]; David Ritchie[3]; Miriam Vitiello[1,4] et al.* *[1]CNR-INO, Italy; [2]LENS, Italy; [3]Cavendish Laboratory, United Kingdom; [4]Scuola Normale Superiore, Italy*	We11-5 **Extreme Confinement Of THz Surface Waves By Subwavelength Metallic Waveguides** *Juliette Mangeney; Djamal Gacemi; Raffaele Colombelli; Aloyse Degiron* *Institut d'Electronique Fondamentale, Université Paris-Sud, UMR CNRS 8622, France*
17:15 – 17:30	We10-6 **Methods For Determining The Exposure To THz Radiation Utilizing CMOS-Based Detectors** *Richard Al Hadi[1]; Volkert Hansen[2]; Oliver Spathmann[2]; Konstantin Statnikov[1]; Ullrich Pfeiffer[1]; Markus Clemens[2]; Joachim Streckert[2] et al.* *[1]Institute for High Frequency and Communication Technology, Germany; [2]Chair for Electromagnetic Theory, Germany*	We11-6 **Practical Plasmonic Terahertz Fibers For Sensing Applications** *Andrey Markov; Maksim Skorobogatiy* *Ecole Polytechnique de Montreal, Canada*
17:30 – 19:00	**Poster session P2 (Rhein Foyer West)**	

Gutenberg 3	Gutenberg 4	Congress Hall
We12 Metamaterial Symp. 2	**We13 THz Spectr. Systems 3**	**We14 Near Field Imaging**
	We13-4 **Variable Temperature, Continuous-Wave Terahertz Magneto-spectrometer** *David Daughton[1]; Richard Higgins[1]; Scott Yano[1]; Joseph Demers[2]* *[1]Lake Shore Cryotronics, United States; [2]EMCORE Corporation, United States*	We14-4 **Extremely Low-Jitter And Ultra-Broadband Electrooptic Sampling System For Near Field Sensing Of Active And Passive Sub-THz Electronic Devices** *Mehran Jamshidifar* *University of Siegen, Germany*
We12-5 (invited talk) **Ultrafast Refractive Index Control Of THz Graphene Metamaterials** *Bumki Min* *Department of Mechanical Engineering, Korea Advanced Institute of Science and Technology (KAIST), Republic of Korea*	We13-5 **Demonstration Of THz Wave Generation Up To 700 GHz Using Mach-Zehnder-Modulator-Based Flat Comb Generator** *Isao Morohashi; Yoshihisa Irimajiri; Takahide Sakamoto; Tetsuya Kawanishi; Norihiko Sekine; Motoaki Yasui; Iwao Hosako* *NICT, Japan*	We14-5 **Optimization Of THz Microscopy Imaging** *Andrea Markelz; Katherine Niessen* *University at Buffalo, SUNY, United States*
	We13-6 **Tunable Narrowband THz Source (1--20 THz) Based On Organic Crystals DSTMS And OH1** *Mojca Jazbinsek[1]; Tobias Bach[1]; Marko Zgonik[2]; Roger Cudney[3]; Blanca Ruiz[1]; Carolina Medrano[1]; Peter Günter[1]* *[1]Rainbow Photonics AG, Switzerland; [2]University of Ljubljana, Slovenia; [3]CICESE, Mexico*	We14-6 **The ANKA-IR2 Nanoscope And Micro- And Nanospectroscopy Applications** *Erik Bründermann[1]; Diedrich A. Schmidt[2]; Biliana Gasharova[3]; Yves-Laurent Mathis[3]; David Moss[3]; Johannes Steinmann[3] Eugen Edengeiser[1]; Meike Mischo[1]; Martina Havenith[1]* *[1]Ruhr-Universität Bochum, Germany; [2]North Carolina A&T United States; [3]KIT, Germany*
Poster session P2 (Rhein Foyer West)		

Wednesday, September 4th

We Pl1 **08:55 - 09:50** **Wednesday Plenary 1 / K. J. Button Award Ceremony** **Congress Hall**
Chair: Terry Parker

Exploring Frontiers Between Optics And Electronics - 1950 To The Present: A Prominent Period - 438
Kiyomi Sakai
NICT, Japan

Progress in far-infrared (FIR) and terahertz (THz) techniques are described. There are three ways of approach to this frontier region; optic, electronic and quantum electronic approach. This paper describes optic, *i.e.,* grating and Fourier-transform spectroscopy, and quantum electronic, *i.e.* far-infrared lasers and terahertz time-domain spectroscopy/imaging (THz-TDS). Applications by use of each method are shown.

We Pl2 **09:50 - 10:35** **Wednesday Plenary 2** **Congress Hall**
Chair: Marco Rahm

Electromagnetic Metamaterials: A New Paradigm For The 21st Century 442
Christophe Caloz
École Polytechnique de Montréal, Canada

An overview of electromagnetic metamaterials and their future prospects is presented from the perspective of the author. A number of selected references are provided for each of the discussed topics.

We1 **11:00 - 12:30** **High-Power Sources 5** **Gutenberg 1**
Chair: Toshitaka Idehara

We1-1 11:00 **A 263 GHz 10 Watt Pulsed Extended Interaction Klystron Amplifier 444**
Peter Horoyski; Brian Steer; Albert Roitman; Henry Deng; Mark Hyttinen; Ross MacHattie
CPI Canada, Canada
A new model of vacuum tube amplifier, designed to produce over 10 Watts at 263 GHz is in development at CPI Canada. This device uses CPI's Extended Interaction Klystron technology, which has previously demonstrated good results from 17 to 220 GHz. With recent completion of a 264 GHz CW tunable oscillator, the amplifier development will extend the demonstrated envelope for EIKs to a frequency and power useful in DNP and other mm-wave applications.

We1-3 11:30 **Latest Experiments Of W-band Gyro-BWO Using Helically Corrugated Waveguides 446**
Alan Phelps; Wenlong He; Craig Donaldson; Liang Zhang; Paul McElhinney; Kevin Ronald; Adrian Cross
University of Strathclyde, United Kingdom
Latest experimental developments of W-band gyro-devices with helically corrugated waveguides and a cusp electron gun are presented. The cusp generated a 40 keV, 1.5 A axis-encircling electron beam. Helical corrugated waveguides have ideal dispersive properties which improve the frequency tuning range of a gyrotron backward wave oscillator (gyro-BWO) whilst maintaining the already good efficiency of operation. The output power of the gyro-BWO was measured to be 12 kW with a frequency tuning range of 88-103 GHz.

We1-4 11:45 **A Novel Laser Based High-power Terahertz Source 448**

Amrutha Gopal[1]; Torsten May[2]
[1]Friedrich-Schiller University,Jena, Germany; [2]Institute of Photonic Technologies, Germany

We report the experimental realization of a gigawatt (GW) class T-rays from a laser-driven particle accelerator. The space time integrated energy was measured using a calibrated thermal detector, recording T-ray pulses with peak energy no less than 700 μJ. A conversion efficiency higher than 10^{-3} and a peak power above a GW makes our source the most efficient, compact and powerful THz source known today. The THz source has been characterized in detail. The spatial-temporal properties of the THz pulse were carried out by an angular scan and a single-shot electro-optic method.

We1-5 12:00 **Numerical Simulation Of Processes At The Cavities Of High-power 300 GHz Gyrotrons 449**

Vladimir Zapevalov; Mark Moiseev; Nikolay Zavolsky
Institute of Applied Physics, Russian Academy of Sciences, Russian Federation

For some advanced fusion experiments and promising technological applications RF sources with CW power near 200-1000 kW and frequency 300 GHz and more are requested. In the framework of this project, investigation of processes of interaction of helical electron beam with RF field at the cavities of several design versions of a 300 GHz gyrotron with output power of 200-1000 kW for operation in the continuous regime was implemented at IAP RAS.

We1-6 12:15 **Near-field Imaging And Nano-Fourier Transform Infrared Spectroscopy By Using A Broadband Synchrotron Radiation Source 452**

Peter Hermann[1]; Arne Hoehl[1]; Piotr Patoka[1]; Florian Huth[2]; Eckart Rühl[3]; Gerhard Ulm[1]
[1]Physikalisch-Technische Bundesanstalt, Germany; [2]Neaspec GmbH, Germany; [3]Physikalische und Theoretische Chemie, Institut für Chemie und Biochemie, Freie Universität Berlin, Germany

We demonstrate scanning near-field optical microscopy with a spatial resolution below 100 nm by using broadband synchrotron radiation in the infrared range provided by the Metrology Light Source. This approach opens up the possibility to perform Fourier transform infrared spectroscopy on a nanoscale.

We2 11:00 - 12:30 Photomixers Gutenberg 2
Chair: Mona Jarrahi

We2-1 11:00 **1.5 μm cw THz Photomixing System With 105 dB Signal-to-noise Ratio 454**

Thorsten Göbel; Dennis Stanze; Roman J. B. Dietz; Björn Globisch; Helmut Roehle; Martin Schell
Fraunhofer Heinrich-Hertz-Institute, Germany

A new receiver drastically increases the signal-to-noise ratio of 1.5 μm cw THz photomixing systems. The obtained SNR of 105 dB at 100 GHz and 45 dB at 2 THz are the highest values reported in literature and superior to 800 nm setups. This is a milestone in the evolution of cw THz photomixing systems.

We2-3 11:30 **Broadband Continuous-wave THz Spectroscopy At Low Temperature And High Magnetic Field 456**

Malte Langenbach[1]; Komalavalli Thirunavukkuarasu[1]; Iván Cámara Mayorga[2]; Axel Roggenbuck[3]; Anselm Deninger[3]; Joachim Hemberger[1]; Markus Grüninger[1]
[1]Universität zu Köln, Germany; [2]Max-Planck-Institut für Radioastronomie, Germany; [3]TOPTICA photonics AG, Germany

We report on the implementation of a continuous-wave terahertz spectrometer into a magneto-cryostat. The integrated setup for THz investigations down to 3 K and in magnetic fields up to 8 T overcomes the drawbacks of windows or additional focusing

components and allows for a stable determination of transmittance and phase.

We2-4 11:45 **Graphene LTG-GaAs Photomixer For Reliable Continuous Wave Terahertz Generation 458**
Shihab Al-Daffaie; Oktay Yilmazoglu; Franko Küppers; Hans Hartnagel
TU Darmstadt, Germany
A new type of continuous-wave (CW) terahertz (THz) emitter was fabricated using multilayer graphene (MLG) electrodes on LTG-GaAs photomixer instead of metal electrodes. Unique graphene properties allow high optical power illumination for high photocurrent generation and show the potential for reliable CW THz emission.

We2-5 12:00 **Continuous THz Wave Generation By Photodiodes Up To 2.5 THz 460**
Tadao Ishibashi[1]; Yoshifumi Muramoto[1]; Toshihide Yoshimatsu[1]; Hiroshi Ito[2]
[1]NTT Photonics Laboratories, Japan; [2]Kitasato University, Japan
Antenna-integrated diode photomixers packaged with silicon lenses were characterized. Continuous THz wave generation at frequencies up to 2.5 THz is demonstrated. A strong bias dependent output level, which is more remarkable at higher frequency, is observed resulting from the ballistic nature of electron transport.

We2-6 12:15 **Milliwatt Output Power Generated In The J-Band By A GaAs Photomixer 462**
Emilien Peytavit[1]; Philipp Latzel[1]; Fabio Pavanello[1]; Guillaume Ducournau[2]; Jean-François Lampin[1]
[1]IEMN / CNRS, France; [2]IEMN / Lille University, France
It is shown that a continuous wave output power reaching 1.8 mW at 252 GHz can be generated by photomixing in a low-temperature-grown GaAs photoconductor using a metallic mirror-based Fabry-Pérot cavity thanks to an impedance matching circuit.

We3 11:00 - 12:30 THz Metamaterials Gutenberg 3
Chair: Willie Padilla

We3-1 11:00 **Metamaterial-mediated Terahertz Surface Waves With Strong Confinement 465**
Tassilo Fip; Benjamin Reinhard; Jens Neu; Marco Rahm
University of Kaiserslautern, Germany
We present experimental und numerical investigations on the excitation, optimization and propagation of terahertz surface waves on silicon substrates. A single metamaterial layer is used to enhance the spatial confinement of the surface wave at the interface between air and silicon. The electric terahertz field of the surface wave is measured by a 2D near field scan.

We3-3 11:30 **Broadband And High-efficient Terahertz Wave Deflection Based On C-shaped Complex Metamaterials With Phase Discontinuities 467**
Zhen Tian
Tianjin University, China
A terahertz metamaterial comprised of C-shaped SRRs was experimentally devised and demonstrated to exhibit high-efficient and broadband anomalous refraction with strong phase discontinuities. The generalized refraction properties of the proposed metamaterial, including the effect of various incident angles and polarizations were investigated at broad terahertz frequencies. By employing such metasurface, we demonstrated a simple method to tailor transmission and phase of terahertz wave.

We3-4 11:45 **Eutectic Terahertz Metamaterials 469**
Maria Massaouti[1]; Alexey Basharin[1]; Maria Kafesaki[1,2]; Maria Fernanda Acosta[3]; Rosa–Isabel Merino[3]; Victor Manuel Orera[3]; Eleftherios Nikolaos Economou[1]; Costas Soukoulis[1]; Stelios Tzortzakis[1,2]
[1]Foundation for Research and Technology-Hellas (FORTH), Greece; [2]University of Crete, Greece; [3]Instituto de Ciencia de Materiales de Aragón, CSIC-Universidad de Zaragoza, Spain

We present unique phenomena of enhanced transmission of terahertz (THz) waves through a self-organized eutectic metamaterial. Our experimental results in combination with theoretical calculations show that the experimentally observed enhanced transmission is associated with sub-wavelength waveguiding within the dielectric rods lattice embedded in an epsilon-near zero polaritonic host.

We3-5 12:00 **Asymmetric Transmission Of Planar Chiral THz Metamaterials For Circularly Polarized Light 471**

Boyoung Kang; Keisuke Takano; Masanori Hangyo
Institute of Laser Engineering, Osaka University, Japan

We demonstrated a reciprocal planar chiral metamaterials in the THz spectral regime exhibiting asymmetric electromagnetic transmission in opposite propagation directions for circular polarization. We also measured dichroism for counter propagating linear polarized light, which is identical with measured dichroism from its mirror image.

We3-6 12:15 **Transient Terahertz Conductivity Spectra Of Semiconductor Nanostructures With Complex Percolation Pathways 473**

Hynek Nemec; Petr Kuzel; Ivan Rychetsky
Institute of Physics, Academy of Sciences of the Czech Republic, Czech Republic

Depolarization fields are evaluated in several model structures with varying percolation degree. On this basis we propose a simple relation between the *microscopic* photoconductive response of semiconductor nanostructures and their *effective* response measured in a time-resolved THz experiment.

We4 11:00 - 12:30 Detectors 5 Gutenberg 4
Chair: Sergey Ganichev

We4-1 11:00 **Semiconducting Y-Ba-Cu-O Thermal Detectors: Low Noise And Fast Pyroelectric IR Response - Development For Future THz Imagers 474**

Alain Kreisler; Xavier Galiano; Annick Degardin; Vishal Jagtap
SUPELEC – LGEP; CNRS UMR 8507; UPMC Université Paris 06; Université Paris Sud 11, France

$YBa_2Cu_3O_{6+x}$ (YBCO) oxides are semiconductors (SC) at low oxygen content. IR detectors were processed with amorphous SC films, either planar or metal/YBCO/metal trilayers. The response at 850 nm exhibited a low noise and fast pyroelectric behavior. THz detectors with planar antennas are considered.

We4-3 11:30 **A Terahertz Plasma Oscillations In Nanometer Field Effect Transistors For Terahertz Radiation Rectification 477**

Wojciech Knap; Dominique Coquillat; Frederic Teppe; Dmitry But
Montpellier University & CNRS, France

Two-dimensional electron plasma in nanometer size field effect transistors can oscillate in Terahertz (THz) frequencies, far beyond transistors fundamental cut-of frequencies. We propose an overview of some important and recent results concerning THz detection by nanometer field effect transistors. The subjects were selected in a way to stress some new aspects of the physics of nanometer scale field effect transistors.

We4-4 11:45 **Nonlinear Photoresponse Of FET THz Broadband Detectors At High Power Irradiation 479**

Dmytro But[1]; Christoph Drexler[2]; Oleksiy Drachenko[3]; Nina Dyakonova[4]; Sergey D. Ganichev[2]; Wojciech Knap[5]
[1]University of Montpellier 2, France; [2]Terahertz Center, University of Regensburg, Germany; [3]Helmholtz Zentrum Dresden Rossendorf, Germany; [4] Universite Montpellier 2, France; [5]Universite Montpellier 2, France

The goal of our work was to study the capability of field effect transistors to measure high power THz radiation at frequencies from 0.1 up to 3 THz and to determine the linear detection limits. We observed different types of the photoresponse dependence on

the incident radiation power. We qualitatively explain the unusual sub-linear behavior observed in high intensities.

We4-5 12:00 **Mechanism Of Weakly Ionized Plasma Terahertz Wave Detector 481**

Lei Hou; Wei Shi; Yu Wu; Hong Liu; Yi Ding
Xi'an University of Technology, China

Plasma generated in discharged noble gases has been successfully used for terahertz (THz) wave detection. We theoretically analysed the detection mechanism, and found the electrons in the weakly ionized plasma can obtain energy from the incident THz radiation and convert excitation collisions of electrons with excited neutral atoms into ionization collisions, so the ionization current increases. An experiment was designed and testified the mechanism.

We4-6 12:15 **Novel Broadband THz-Detector 483**

Christian Monte[1]; Ralf Müller[1]; Andreas Steiger[1]; Mathias Kehrt[1]; Werner Bohmeyer[2]; Karsten Lange[2]
[1]PTB, Germany; [2]SLT, Germany

Novel broadband THz detectors have been developed within a cooperation project. A carbon nanotube based black coating on a thin pyroelectric foil together with a patented 3D radiation trap design result in a spectrally flat power responsivity in a broad THz spectral range. A second promising approach to an even wider spectral range will be feasible by using thin film metal absorber on the pyroelectric foil.

We5 14:00 - 15:30 High-Power Sources 6 Gutenberg 1
Chair: Gian Piero Gallerano

We5-1 14:00 **The SPARC_LAB High Peak Power THz Source: Different Methods Of Generation And Characterization 485**

Enrica Chiadroni[1]; Michele Castellano[1]; Alessandro Cianchi[2]; Domenico Di Giovenale[1]; Giampiero Di Pirro[1]; Massimo Ferrario[1]; Giancarlo Gatti[1]; Flavio Giorgianni[3]; Andrea Mostacci[4]; Riccardo Pompili[5]; Concetta Ronsivalle[6]; Cristina Vaccarezza[1]; Fabio Villa[1]; Stefano Lupi[3]; Marco Bellaveglia[1]
[1]INFN-LNF, Italy; [2]University Rome Tor Vergata and INFN Tor Vergata, Italy; [3]University Rome La Sapienza and INFN RomaI, Italy; [4]SBAI Dept. University Rome La Sapienza and INFN RomaI, Italy; [5]University Rome Tor Vergata and INFN-LNF, Italy; [6]ENEA C.R. Frascati, Italy

High peak power THz radiation with tunable spectral bandwidth is produced at SPARC_LAB as coherent radiation (CR) from relativistic, short (100 fs) electron bunches. The CR spectrum is characterized through frequency-resolved techniques.

We5-3 14:30 **2 MW, 170 GHz Coaxial-Cavity Short-Pulse Gyrotron - Investigations On Electron Beam Instabilities And Parasitic Oscillations - 488**

Tomasz Rzesnicki; Gerd Gantenbein; Stefan Illy; John Jelonnek; Jianbo Jin; Ioannis Pagonakis; Bernhard Piosczyk; Andreas Schlaich; Manfred Thumm
Karlsruhe Institute of Technology (KIT), Germany

The development of a 2 MW, 170 GHz short-pulse coaxial-cavity gyrotron pre-prototype for electron cyclotron heating and current drive (ECRH&CD) of magnetically confined plasmas in upcoming fusion devices is in progress at Karlsruhe Institute of Technology (KIT). Significant design modifications have been done recently. First experimental tests of a modified setup show two important unwanted effects. The gyrotron operation is limited by problems, which are occurring in the electron beam. In addition, an excitation of low frequency parasitic oscillations has been observed. The origin for those effects is under study.

We5-4 14:45 **Zones Of Locked Oscillations In A MW-Power Gyrotron Driven By External Microwave Signal 490**

Grigory Denisov; Vladimir Bakunin; Yulia Novozhilova
Institute of Applied Physics RAS, Russian Federation

A multimode MW-power gyrotron can be driven to the maximal orbital efficiency point through startup scenario with the frequency- and phase-locking effect by external signal of quite moderate power. Zones of stable single-mode generation of such a gyrotron are analyzed in the plane of parameters «magnetic field – beam current».

We5-5 15:00 **Effect Of The Tilt On The Gyrotron Operation 492**

Olgerts Dumbrajs
Institute of Solid State Physics, University of Latvia, Latvia

The effect of the tilt of the electron beam axis on the gyrotron operation is investigated. It is commonly accepted that the tilt deteriorates the efficiency of cylindrical cavity gyrotrons. Our study showed that this deterioration can be mitigated by a proper displacement of the electron beam axis at the entrance. Also, in some cases, when the aftercavity interaction lowers the gyrotron efficiency, the tilt can reduce this interaction and, therefore, slightly increase the efficiency.

We5-6 15:15 **Remote-Steering Launchers For The ECRH System On The Stellarator W7-X 494**

C. Lechte[1]; B. Plaum[1]; W. Kasparek[2]; A. Zeitler[2]; V. Erckmann[3]; H. Laqua[3]; M. Weißgerber[3]; A. Bechtold[4]; M. Busch[5]; B. Szczepaniak[5]
[1]Institut für Grenzflächenverfahrenstechnik und Plasmatechnologie, University of Stuttgart, Germany; [2]Institute of Interfacial Process Engineering and Plasma Technology (IGVP), Germany; [3]Max-Planck-Institut für Plasmaphysik, EURATOM-IPP, Germany; [4]NTG Neue Technologie GmbH & Co KG, Germany; [5]Galvano-T electroplating-electroforming GmbH, Germany

For electron cyclotron resonance heating of the stellarator W7-X at IPP Greifswald, a 140 GHz/10 MW cw millimeter wave system is in construction. Two out of 12 launchers will employ a remote-steering design. This paper describes design issues like input coupling structures, manufacturing of corrugated waveguides, optimization of the steering range, integration of vacuum windows, mitrebends and vacuum valves into the launchers, as well as tests of prototype parts.

We6 14:00 - 15:30 Waveguides1 Gutenberg 2
Chair: Peter Haring Bolivar

We6-1 14:00 **Evanescent Wave Coupling In Terahertz Waveguide Arrays 496**

Kimberly Reichel[1]; Naokazu Sakoda[2]; Rajind Mendis[1]; Daniel Mittleman[1]
[1]Rice University, United States; [2]Kobe Steel, Korea, Republic of

We experimentally study THz evanescent wave coupling in an array of parallel-plate waveguides in close proximity. We observe stronger coupling with larger plate separations and longer propagation paths.

We6-2 14:15 **Compact High-Q Photonic Resonator Inside A Metallic Ridge Terahertz Waveguide 498**

Marko Gerhard; René Beigang; Marco Rahm
University of Kaiserslautern, Germany

We present a compact high-Q photonic crystal resonator for 1 THz based on a micro-structured metallic ridge waveguide. The simulated Q-factor of 150 is compared to broadband transmission measurements of a fabricated prototype.

We6-3 14:30 **Understanding The Dispersion Of THz Pulses In Tapered Parallel Plate Waveguides: Role Of The Multimode Propagation And Radiation Leakage 500**

Miguel Navarro-Cia[1]; Raimund Mueckstein[2]; Oleg Mitrofanov[2]
[1]Imperial College London, United Kingdom; [2]University College London, United Kingdom

A systematic analysis within a combined experimental and computational approach is used to understand the propagation, radiation leakage and dispersion of THz pulses travelling along a tapered parallel plate waveguide. We demonstrate that one should consider transverse electric TE_{mn} modes to understand the unexpected dispersion of the output TEM-field-distribution-like pulse.

We6-4 14:45 **Influence Of Metal Surface Roughness On The Phase Velocity Of Terahertz Waves Propagating In Parallel Plate Waveguides 502**

Daiki Takeshima[1]; Tomoya Sakon[1]; Satoshi Tsuzuki[1]; Futoshi Matsui[2]; Yuji Kusuda[3]; Takashi Furuya[1]; Seizi Nishizawa[1]; Kazuyoshi Kurihara[1]; Fumiyoshi Kuwashima[4]; Elmer Estacio[5]; Kohji Yamamoto[1]; Masahiko Tani[1]
[1]University of Fukui, Japan; [2]Fukui Industrial Support Center, Japan; [3]Fukuoka Rashi Co. Ltd., Japan; [4]Fukui University of Technology, Japan; [5]University of Philippines Diliman, Philippines

This work presents evidence of phase velocity dependence on metal surface roughness for terahertz (THz) waves propagating in a parallel plate metal waveguide having a sub-wavelength gap. This suggests a possibility to control the phase velocity and the propagation direction of guided THz waves by varying the surface roughness of the parallel plates.

We6-5 15:00 **Minimization Of Reflection At The Boundaries Of A Finite-size Coupled Terahertz Cavity In A Metal Air-gap Waveguide 504**

Chul-Sik Kee[1]; Sun-Goo Lee[1]; Chul Kang[1]; Tae-In Jeon[2]; Eui Su Lee[2]
[1]Advanced Photonics Research Institute, GIST, Korea, Republic of; [2]Division of Electrical and Electronics Engineering/Korea Maritime University, Korea, Republic of

Introducing antireflection slits at the boundaries of a finite-size coupled terahertz cavity in a metal air-gap waveguide can minimize reflections at the boundaries. The optimal design parameters for the minimal reflection were obtained using the one-dimensional antireflection coating theory and finite-difference time-domain simulations. We experimentally demonstrated that the optimized antireflection slits significantly reduce the finite-size effects such as the strong Fabry-Perot oscillations in the transmission spectrum and the variations in the group velocity curve.

We6-6 15:15 **Modular Set Of Corrugated Wave-guiding Components For Applications From 500 To 750 GHz 506**

Emile de Rijk[1]; Alessandro Macor[1]; Arndt von Bieren[1]; Jean-Philippe Ansermet[2]; Bruno Maffei[3]; Pisano Giampaolo[3]; Jeffrey Hesler[4]
[1]SWISSto12 SA, Switzerland; [2]Institute of Condensed Matter Physics, EPFL, Switzerland; [3]JBCA, University of Manchester, United Kingdom; [4]Virginia Diodes Inc., United States

A modular set of compact corrugated wave-guiding components is presented as an alternative to rectangular waveguides in the WR-1.5 band (500 to 750 GHz). The components presented are designed to enable broadband and low loss operation. A high performance connection system between the components allows for modular path building and efficient power coupling to solid-state devices. The manufacturing is based on the "stacked rings" technology.

We7 14:00 - 15:30 Metamaterial Symposium 1 Gutenberg 3
Chair: Marco Rahm

We7-1 14:00 **Broadband Terahertz Modulation Through Reconfigurable Meta-Surfaces With Diamagnetic Switching Capability 508**

Mona Jarrahi; Mehmet Unlu; Mohammad R. Hashemi; Christopher W. Berry; Shenglin Li; Shang-Hua Yang
University of Michigan, United States

We present high-performance terahertz intensity modulators based on a new class of reconfigurable meta-surfaces that offer extreme diamagnetic switching capability over a

broad frequency band. We experimentally demonstrate record high modulation depths (> 70 %) and modulation bandwidths (> 1.5 THz) through a fully integrated platform at room temperature.

We7-3 14:30 **Terahertz Metasurfaces: Fabrication And Characterization Of Flat Lenses And Antennas 510**
Tahsin Akalin
IEMN, UMR CNRS 8520, Lille 1 University, France
The control of electromagnetic waves at terahertz frequencies is possible with bulky or voluminous structures like planar antennas with Silicon lenses or classical horn antennas. In this work, we present the development of Metasurfaces in order to achieve flat or low profile devices such as flat lenses with V-shape cells and also antennas with corrugations. The lenses, with a single or a multilayer metallization, and antennas with straight and circular corrugations are designed and characterized at terahertz frequencies.

We7-5 15:00 **Reconfigurable Plasmonic And Metamaterial Devices Using Liquid Metals 513**
Jinqi Wang; Shuchang Liu; Ajay Nahata
University of Utah, United States
We demonstrate an approach for creating reconfigurable plasmonic and metamaterial devices. As an example, this allows for dramatic changes in the transmission properties through subwavelength apertures and split ring resonators. We accomplish this by using a liquid metal that can be injected into or withdrawn from channels in an elastomeric mold.

We8 14:00 - 15:30 THz Spectroscopy Systems 2 Gutenberg 4
Chair: Roger Lewis

We8-1 14:00 **Ultrabroadband Terahertz Time Domain Spectroscopic Ellipsometry 515**
Masatsugu Yamashita; Chiko Otani
Terahertz Sensing and Imaging Laboratory, RIKEN RAP, Japan
We have developed an ultrabroadband terahertz time domain ellipsometry (TDSE) which covers the frequency range from 0.2 to 30 THz except for the phonon absorption band of the low temperature grown photoconductive antenna detector around 8.1 THz. The THz emitter of the system can be changed between GaP crystal from 0.1 to 7.5 THz and GaSe crystal from 9 to 30 THz. The carrier transport property of ITO thin film was characterized and well agreed with the result obtained by the measurement of the resistivity and Hall coefficient.

We8-3 14:30 **Coherent Detection Of Ultrabroadband Coherent Infrared Pulses Up To 150 THz Using Air 518**
Eiichi Matsubara; Masaya Nagai; Masaaki Ashida
Osaka University, Japan
We coherently detected the ultrabroadband infrared pulse generated from air plasma in the spectral range of 1−150 THz through field-induced second harmonic generation in air. Pump and probe pulses with duration of 10 fs were produced with hollow fiber compression. This result proves the advantage of using air for coherent detection over conventional electro-optic sampling in terms of wide spectral range as well as high sensitivity. We are integrating this system in a pump and probe measurement system, which will be a powerful tool for studying optical property of materials.

We8-4 14:45 **On-Chip THz Spectroscopy Of Polyhydroxybutyrate (PHB) Powder 520**
Martin Muthee; Sigfrid Yngvesson
ECE Department, University of Massachusetts, United States
We recently demonstrated terahertz radiation from joule-heated Single Wall Carbon Nanotubes (SWCNTs) whose main defining feature was a broad frequency spectrum mediated by an antenna. In this work, we use such a source in an integrated THz circuit

to demonstrate the feasibility of an on-chip spectroscopy system through measurements on Polyhydroxybutyrate (PHB) powder.

We8-5 15:00 **Self-Referenced Spectral Domain Interferometry For Terahertz Detection 522**
Akram Ibrahim; Gargi Sharma; K. P Singh; Tsuneyki(John) Ozaki; Ibraheem Al-Naib; Roberto Morandotti
Institut National de la Recherche Scientifique, Énergie, Matériaux et Télécommunications (INRS), Canada
We demonstrate a novel technique for improving the signal-to-noise ratio of terahertz detection, based on self-referencing spectral-domain interferometry. We test and compare the terahertz electric field measured using this method with standard electro-optic sampling technique**.**

We8-6 15:15 **Low-Cost Delay Line For Fast Terahertz Imaging 524**
Bastian Reitemeier[1]; Stefan Busch[1]; Thorsten Probst[1]; Maik Scheller[2]; Martin Koch[1]
[1]Faculty of Physics and Material Sciences Center, Philipps-Universität Marburg, Germany; [2]Optical Sciences Center, University of Arizona, Tucson, USA, United States
In this work we present a novel concept for fast and low-cost terahertz imaging. A fast and stable source for time delay is created by inserting a rotating piece of high-density polyethylene into the THz path of a terahertz time domain spectrometer. We will present the specifications of a first implementation of this device as well as imaging examples.

We9 14:00 - 15:30 Remote Detection and Imaging Congress Hall
Chair: Heiko Richter

We9-1 14:00 **The Concept Of Remote Detection Of Concealed Radioactive Materials By Using High-power THz Radiation 526**
Gregory Nusinovich[1]; Michael Glyavin[2]; Alexey Luchinin[2]
[1]University of Maryland, United States; [2]Institute of Applied Physics, Russian Federation
This paper describes the progress in developing a high-power, sub-THz gyrotron with a pulsed solenoid and new results in elaborating the concept of THz gyrotron radiation for remote detection of concealed radioactive materials. The 0.67 THz gyrotron delivers more than 200 kW in 20-30 microsecond pulses and operates with the efficiency about 20 %. New contributions to the development of the concept include: a) analysis of the propagation of gamma rays and production of free electrons in air, b) estimating the mass of radioactive material which can be detectable at a certain distance from the source, c) characterization of the breakdown-prone volume as the function of the THz power and polarization, crossing angles (in the case of crossing wave beams) and the atmospheric turbulence.

We9-3 14:30 **Passive Stand-off THz Imaging Using Lock-in Phase Information 529**
Alexey Semenov[1]; Heinz-Wilhelm Hübers[2]; Roy Bretfeld[3]; Ute Böttger[1]; Heiko Richter[1]; Sven Augustin[2]; Helmut Hirsch[3]
[1]German Aerospace Center, Germany; [2]TU Berlin/German Aerospace Center, Germany; [3]Astro-und Feinwerktechnik Adlershof GmbH, Germany
A method for directly detecting edges in images which are obtained with a passive stand-off terahertz (THz) imaging system is presented. This novel method can improve the signal-to-noise ratio of THz images as well as it may contribute to solving the privacy problem of body scanners. In addition the proposed method when used with a suitable Spatial Light Modulator (SLM) allows imaging in the lock-in phase space where the trade-off between detection robustness and temperature resolution can be adapted to the situation at hand.

We9-4 14:45 **Study Of Aperture Synthesized Imaging Method In Terahertz Fan-Beam Scanning System 531**

Chao Li
Institute of Electronics, Chinese Academy of Sciences, China

Aperture synthesized focusing technique was extended for terahertz imaging with fan-beam scanning. Appropriate algorithms were developed both for the single-frequency two-dimensional case and wide-band three-dimensional case. Proof-of-concept experiments were performed at 0.2 THz band.

We9-5 15:00 **Impact Damage Analysis Of Composite Materials With A mm-Wave Synthetic Aperture Radar 533**

Martin Nezadal; Jan Schür; Lorenz-Peter Schmidt
Friedrich-Alexander Universität Erlangen-Nürnberg, Germany

This paper presents investigations on impact damages on carbon and glass fibre reinforced plastics with a synthetic aperture radar in the frequency range of the W-Band (75 to 110 GHz) and J-Band (220 to 325 GHz). It was possible to detect the high energy impacts in the carbon fibre samples due to their phase delay in both bands. With the glass fibre samples it was also possible to detect changes in magnitude besides the phase delay. The three dimensional image reconstruction also revealed the damages beneath the surface.

We9-6 15:15 **A passive submillimeter video camera for security applications 535**

Gabriel Zieger; Detlef Born; Solveig Anders; Erik Heinz; Katja Peiselt; Anika Brömel; Vyacheslav Zakosarenko; Torsten May; Hans-Georg Meyer
IPHT JENA, Germany

Submillimeter waves have unique optical properties that allow for applications in the security domain. Especially the high transmission through clothing combined with low transmission through many materials that can be used to build harmful objects enables applications in security screenings. We already showed that it is possible to acquire passive images at 350 GHz with a cooled system based on superconducting detectors working at 500 mK. Now we present recent results of our current development of a new prototype of a passive submillimeter video camera for security applications. Compared to its predecessor, it has a larger field of view and can take images at frame rates up to 25 Hz.

We10 16:00 - 17:30 THz Metrology Gutenberg 1
Chair: Andreas Steiger

We10-1 16:00 **On The Necessity Of Standardization For Power And Sensitivity Measurements Of Terahertz Sources And Cameras 537**

Naoki Oda[1]; Iwao Hosako[2]; Tsutomu Ishi[1]; Hiroaki Minamide[3]; Chiko Otani[3]; Norihiko Sekine[2]
[1]NEC Guidance and Electro-Optics Division, Japan; [2]National Institute of Information and Communications Technology, Japan; [3]RIKEN, Japan

Strong THz sources, good power meters and real-time THz cameras are being developed and produced. Authors make discussions on necessity of standardization for power measurements, non-uniformity correction and sensitivity measurements, using these components. For example, it is found that NEP (Noise Equivalent Power) values can change with measurement methods.

We10-2 16:15 **Calibration Of mm-Wave Power Meters Using A Broadband Calorimeter in The Frequency Range From 110 GHz To 170 GHz 540**

Kazuhiro Shimaoka[1]; Moto Kinoshita[1]; Katsumi Fujii[2]; Toshihide Tosaka[2]
[1]National Institute of Advanced Industrial Science and Technology, Japan; [2]National Institute of Information and Communications Technology, Japan

A broadband rectangular waveguide calorimeter is fabricated to establish a reliable mm-wave power standard in the frequency range from 110 GHz to 170 GHz. Two types of

mm-wave power meter are calibrated using this calorimeter and their calibration factors are reported with their uncertainties. Uncertainty calculations are based on the Monte Carlo method.

We10-3 16:30 **High Precision THz Radiometry 542**
Andreas Steiger ; Ralf Müller
PTB, Germany
The accuracy of THz detector calibration traceable to the International System of Units has been improved to a standard uncertainty below 2 % in the range from 1 THz to 5 THz. This enables PTB to offer such high precision measurements as part of its unique THz calibration services.

We10-4 16:45 **Precise Frequency Measurement Of Continuous-Wave Terahertz Radiation Based On THz Comb 544**
Kenta Hayashi[1]; Shuko Yokoyama[2]; Hajime Inaba[3]; Kaoru Minoshima[3]; Takeshi Yasui[1]
[1]The University of Tokushima, Japan; [2]Micro-Optics Co. Ltd, Japan; [3]National Institute of Advanced Industrial Science and Technology, Japan
We demonstrated a frequency measurement of CW-THz wave referring to THz frequency comb. Effectiveness of the proposed method is demonstrated by measurement of sub-THz test sources. The achieved precision of frequency measurement was 2.0×10^{-11}.

We10-5 17:00 **THz Spectroscopy With An Absolute Frequency Scale By A QCL Phase-locked To A THz Frequency Comb 546**
Luigi Consolino[1,2]; Saverio Bartalini[1,2]; Andrea Taschin[2]; Paolo Bartolini[2]; Pablo Cancio[1,2]; Marco De Pas[2]; Harvey Beere[3]; David Ritchie[3]; Miriam Vitiello[1,4]; Renato Torre[2,5]; Paolo De Natale[1,2]
[1]CNR-INO, Italy; [2]LENS, Italy; [3]Cavendish Laboratory, United Kingdom; [4]Scuola Normale Superiore, Italy; [5]Università di Firenze, Italy
The exploitation of a THz frequency comb for absolutely-referenced THz spectroscopy is presented. The frequency of a 2.5-THz QCL, phase-locked to the comb, is swept across a methanol line, providing the spectroscopy with and absolute-frequency scale.

We10-6 17:15 **Methods For Determining The Exposure To THz Radiation Utilizing CMOS-Based Detectors 548**
Richard Al Hadi[1]; Volkert Hansen[2]; Oliver Spathmann[2]; Konstantin Statnikov[1]; Ullrich Pfeiffer[1]; Markus Clemens[2]; Joachim Streckert[2]; Martin Zang[2]
[1]Institute for High Frequency and Communication Technology, Germany; [2]Chair for Electromagnetic Theory, Germany
This paper presents methods enabling the examination of a THz system for its compliance with legal exposure limits. The test process is divided into two steps: first, THz hotspot localization using a lens-coupled THz CMOS camera, followed by lateral power density measurement employing a CMOS detector with a 87 µm × 100 µm on-chip patch antenna. At the hotspot location, the measured power density distribution of a focused beam at 0.655 THz is presented.

We11 **16:00 - 17:30** **Waveguides 2** **Gutenberg 2**
Chair: Vincent Wallace

We11-1 16:00 **Ultra-thin Terahertz Waveguides On Periodic Dielectric Multilayers 550**
Vincent Paeder; Juraj Darmo; Karl Unterrainer
Vienna University of Technology, Austria
We study theoretically, numerically and experimentally deeply sub-wavelength dielectric ridge terahertz waveguides on the surface of finite size photonic bandgap structures. We show that their dispersion relation can be described in a numerically stable closed form. We present the fundamental properties of surface modes on multilayers made of silicon and cyclo-olefin copolymer and study them experimentally.

Several schemes for guiding terahertz light with surface modes in dielectric structures are illustrated.

We11-3 16:30 **Dispersion And Attenuation In Flexible Dielectric-lined Hollow Metallic THz Waveguides 552**

Miguel Navarro-Cia[1]; Carlos M. Bledt[2]; Miriam S. Vitiello[3]; Harvey E. Beere[4]; David A. Ritchie[4]; James A. Harrington[2]; Oleg Mitrofanov[5]; Jeffrey E. Melzer[2]
[1]Imperial College London, United Kingdom; [2]Rutgers University, United States; [3]NEST, CNR—Istituto Nanoscienze and Scuola Normale Superiore, Italy; [4]Cavendish Laboratory, United Kingdom; [5]University College London, United Kingdom

Mode profiles, transmission attenuation and dispersion in flexible dielectric-lined hollow metallic cylindrical waveguides are analyzed experimentally and numerically. Using dielectric coatings made of different materials and different thicknesses, we show the crossover between the fundamental TE_{11} and TM_11 modes and the hybrid HE_{11} mode.

We11-4 16:45 **Tunable THz Single Resonance With TEM Mode 554**

Tae-In Jeon; Eui Su Lee
Korea Maritime University, Korea, Republic of

According to an air gap variation in a parallel-plate waveguide (PPWG), a tunable terahertz (THz) single resonance with a transverse-electromagnetic (TEM) mode can be demonstrated. When the air gap between the metal plates of the PPWG is controlled from 60 to 240 μm using a piezo-actuator, the resonant frequency is changed from 1.75 up to 0.62 THz, respectively. We also demonstrate the tunable THz single resonance by using a piezo-actuator and a finite difference time-domain (FDTD) simulation.

We11-5 17:00 **Extreme Confinement Of THz Surface Waves By Subwavelength Metallic Waveguides 556**

Juliette Mangeney; Djamal Gacemi; Raffaele Colombelli; Aloyse Degiron
Institut d'Electronique Fondamentale, Université Paris-Sud, UMR CNRS 8622, France

We show that shrinking the transverse size of metallic waveguides always leads to solutions with extreme field confinement at THz frequencies, regardless of the materials used and of the system geometry. We provide a unified framework to understand such universal behaviors, which will benefit future developments in THz science and technology**.**

We11-6 17:15 **Practical Plasmonic Terahertz Fibers For Sensing Applications 557**

Andrey Markov; Maksim Skorobogatiy
Ecole Polytechnique de Montreal, Canada

A novel plasmonic THz fiber featuring two metallic wires in a porous dielectric cladding is studied for resonant sensing applications. In our design, introduction of even lossless analytes into the porous fiber core leads to significant changes in the modal losses, which is used as a transduction mechanism.

We12 16:00 - 17:30 Metamaterial Symposium 2 Gutenberg 3
Chair: Ajay Nahata

We12-1 16:00 **Broadband And High-Efficiency Terahertz Metamaterial Linear Polarization Converters 559**

Hou-Tong Chen; Nathaniel Grady; Jane Heyes; Dibakar Roy Chowdhury; Yong Zeng; Matthew Reiten; Abul Azad; Antoinette Taylor; Diego Dalvit
Los Alamos National Laboratory, United States

We demonstrate ultrathin THz metamaterials capable of high-efficiency and broadband linear polarization conversion in reflection or transmission. Through the creation of a linear phase gradient, they are further employed in the demonstration of near-perfect anomalous reflection/refraction.

We12-3 16:30 **THz Imaging With Metamaterials 562**

Claire Watts; Willie Padilla; David Shrekenhamer
Boston College, United States

Metamaterials have demonstrated the ability to efficiently alter electromagnetic radiation in the terahertz range. The use of semiconductors as substrates, or as part of the metamaterial itself, has enabled real-time dynamic control providing spatial and frequency modulation of THz waves. We utilize metamaterial / semiconducting spatial light modulators to enable single pixel time-multiplexed THz imaging. Various encoding schemes are explored and we experimentally demonstrate high fidelity THz images using several orders of magnitude less power than conventional imaging techniques.

We12-5 17:00 **Ultrafast Refractive Index Control Of THz Graphene Metamaterials 564**

1. *Bumki Min*
Department of Mechanical Engineering, Korea Advanced Institute of Science and Technology (KAIST), Republic of Korea

We present an ultrafast dynamics of THz graphene-metamaterial hybrid devices, where the refractive index and the conductivity are largely modulated by electrical and optical methods. Unprecedentedly large modulation of refractive index and the pump-induced effective negative conductivity are investigated by an ultrafast time-resolved optical-pump THz-probe spectroscopy with varying gate voltage.

We13 16:00 - 17:30 THz Spectroscopy Systems 3 Gutenberg 4
Chair: Peter Jepsen

We13-1 16:00 **Extending Spectral Focusing Techniques Into The THz Regime 566**

Stefan Funkner[1]; Katsuya Saito[1]; Takashi Furuya[1]; Kohji Yamamoto[1]; Mariko Yamaguchi[2]; Masanori Hangyo[3]; Masahiko Tani[1]
[1]Research Center for Development of Far-Infrared Region, University of Fukui, Japan; [2]Graduate School of Materials Science, Nara Institute of Science and Technology, Japan; [3]Institute of Laser Engineering, Osaka University, Japan

We present the status of our coherent Raman experiment, which uses spectral focusing techniques to observe the spectral THz response of samples to two incident laser pulses in four-wave mixing process. To gauge and test our setup, we investigate solid samples and organic liquids with well-known Raman bands.

We13-2 16:15 **Molecular Spectroscopy With A Compact 557 GHz Heterodyne Receiver 568**

Philipp Neumaier[1]; Heiko Richter[1]; Heinz-Wilhelm Hübers[1]; Jan Stake[2]; Huan Zhao[2]; Aik-Yean Tang[2]; Vladimir Drakinskiy[2]; Peter Sobis[3]; Tony Pellikka[3]; Anders Emrich[3]; Axel Hülsmann[4]; Ingmar Kallfass[5]; Axel Tessmann[4]; Arnulf Leuther[4]; Tom Johansen[6]; Tomas Bryllert[7]; Johanna Hanning[7]; Lei Yan[7]; Viktor Krozer[8]
[1]German Aerospace Center (DLR), Germany; [2]Chalmers University of Technology, Sweden; [3]Omnisys Instruments AB, Sweden; [4]Fraunhofer Institute for Applied Solid State Physics, Germany; [5]University Stuttgart, Germany; [6]Technical University of Denmark, Denmark; [7]Wasa Millimeter Wave AB, Sweden; [8]Goethe-University Frankfurt, Germany

In this work the results of spectroscopic and performance measurements with a compact heterodyne receiver in the frequency range between 520 and 590 GHz are presented.

We13-3 16:30 **THz Spectroscopy Of Radicals By Means Of Photomixing Experiment 570**

Gael Mouret; Arnaud Cuisset; Francis Hindle; Marie-Aline Martin-Drumel
Université du Littoral Côte d'Opale, Laboratoire de Physico Chimie de l'Atmosphère, France

A THz spectrometer based onto the photomixing technique associated with a femtosecond frequency comb is a perfect tool for the study of radicals, which usually required a very large tunability. The spectra of OH, SH and SO have been revisited and updated data have been obtained.

We13-4 16:45 **Variable Temperature, Continuous-wave Terahertz Magneto-spectrometer 572**

David Daughton[1]; Richard Higgins[1]; Scott Yano[1]; Joseph Demers[2]
[1]Lake Shore Cryotronics, United States; [2]EMCORE Corporation, United States

We present a coherent, continuous-wave terahertz materials characterization platform enabling THz spectroscopy and characterization of chemical, electronic and magnetic samples from 5 K to 300 K and in fields up to 9 T.

We13-5 17:00 **Demonstration Of THz Wave Generation Up To 700 GHz Using Mach-Zehnder-modulator-based Flat Comb Generator 574**

Isao Morohashi; Yoshihisa Irimajiri; Takahide Sakamoto; Tetsuya Kawanishi; Norihiko Sekine; Motoaki Yasui; Iwao Hosako
National Institute of Information and Communications Technology, Japan

By photomixing of optical two-tone signals, which was extracted from an optical comb signal generated by a Mach-Zehnder-modulator-based flat comb generator (MZ-FCG), generation of cw-THz signal up to 700 GHz was demonstrated. In this system, the frequency accuracy of the THz signal is decided by that of the rf signal driving the MZ-FCG, so that it is expected that the generated THz signal has extremely high frequency accuracy.

We13-6 17:15 **Tunable Narrowband THz Source (1--20 THz) Based On Organic Crystals DSTMS And OH1 576**

Mojca Jazbinsek[1]; Tobias Bach[1]; Marko Zgonik[2]; Roger Cudney[3]; Blanca Ruiz[1]; Carolina Medrano[1]; Peter Günter[1]
[1]Rainbow Photonics AG, Switzerland; [2]University of Ljubljana, Slovenia; [3]CICESE, Mexico

We demonstrate efficient generation of narrowband (< 100 GHz) THz pulses in the nanosecond range by using difference frequency generation in organic electro-optic crystals DSTMS and OH1. The terahertz output is tunable in the range of 1–20 THz and can be used for THz imaging and spectroscopy.

We14 16:00 - 17:30 Near Field Imaging Congress Hall
Chair: Paul Planken

We14-1 16:00 **Nano-FTIR--the Chemical Nanoscope 578**

Fritz Keilmann
Ludwig-Maximilians-Universität, Germany

Identification of chemical compounds and their mapping at a 20 nm scale are enabled, by combining FTIR with near-field microscopy. A first application is demonstrated with biominerals and human bone sections. Generally, nano-FTIR yields broad quantitative fingerprint spectra which can directly rely on common IR databases for chemical recognition.

We14-3 16:30 **Terahertz Transceiver Microprobe For Chip-inspection Applications Using Optoelectronic Time-domain Reflectometry 580**

Michael Nagel[1]; Christopher Matheisen[1]; Simon Sawallich[1]; Heinrich Kurz[1]; Stephan Dobritz[2]
[1]AMO GmbH, Germany; [2]Fraunhofer IZM ASSID, Germany

In this work a compact microprobe for advanced chip-inspection applications is introduced. The probe features integrated photoconductive switches for Terahertz pulse generation and detection. Device application is demonstrated for contact-free high-resolution time-domain reflectometry measurements at silicon-chip test structures.

We14-4 16:45 **Extremely Low-Jitter And Ultra-Broadband Electrooptic Sampling System For Near Field Sensing Of Active And Passive Sub-THz Electronic Devices 582**

Mehran Jamshidifar
University of Siegen, Germany

In this paper we present an ultra-broadband measurement electrooptic sampling (EOS) system for characterization of active mm-wave and sub-THz electronic devices. We also introduce a novel solution for the challenge of relative jitter in EOS of CW exited circuits that extremely recovers the measurement bandwidth of the system.

We14-5 17:00 **Optimization Of THz Microscopy Imaging N/A**

Andrea Markelz; Katherine Niessen
University at Buffalo, SUNY, United States

THz near field microscopy opens a new frontier in material science. High spatial resolution requires the detection crystal to have uniform and reproducible response. We present the THz near field spatial and temporal response of ZnTe and GaP and examine possible properties that give rise to the ZnTe degraded signal.

We14-6 17:15 **The ANKA-IR2 Nanoscope And Micro- And Nanospectroscopy Applications 584**

Erik Bründermann[1]; Diedrich A. Schmidt[2]; Biliana Gasharova[3]; Yves-Laurent Mathis[4]; David Moss[4]; Johannes Steinmann[5]; Eugen Edengeiser[1]; Meike Mischo[1]; Martina Havenith[1]
[1]Ruhr-Universität Bochum, Physikalische Chemie II, Germany; [2]North Carolina A&T State Univ., Dept. of Physics & JS of Nanoscience, United States; [3]KIT, Institute for Photon Science and Synchrotron Radiation (IPS), Germany; [4]KIT, ANKA Synchrotron Radiation Facility, Germany; [5]KIT, Laboratory for Applications of Synchrotron radiation (LAS), Germany

We report on a newly developed and integrated microscopy and nanoscopy station at the ANKA-IR2 beamline. We further elucidate how vibrational near-field and microspectroscopy can give new insights in medical applications.

We P2 17:30 - 18:45 Poster 2 Rhein Foyer West

We P2-01 WITHDRAWN

We P2-02 **Receiving Properties Of Thin-Film Spiral Antenna On Si_3N_4 Membrane At 200 GHz Band 586**

Akihito Matsushita; Son Le; Takashi Tachiki; Takashi Uchida
National Defense Academy, Japan

A thin-film spiral antenna coupled with Bi microbolometer operating at 200 GHz band was fabricated on Si_3N_4/SiO_2 membrane. The experimental antenna patterns agreed well with theoretical ones, and wide band characteristic of the antenna ranging from 140 to 220 GHz was obtained.

We P2-03 **Multifrequency Notch Filter For Sub-THz Applications based On Photonic Bandgaps In Corrugated Circular Waveguides 588**

Dietmar Wagner[1]; Waldo Bongers[2]; Walter Kasparek[3]; Fritz Leuterer[1]; Francesco Monaco[1]; Max Münich[1]; Harald Schütz[1]; Jörg Stober[1]; Manfred Thumm[4]; Hugo van den Brand[5]
[1]Max-Planck-Institut für Plasmaphysik, Germany; [2]Differ, Netherlands; [3]IGVP Stuttgart, Germany; [4]Karlsruhe Institute of Technology, Germany; [5]DIFFER, Netherlands

Sensitive millimeter wave diagnostics need often to be protected against unwanted radiation like, for example, stray radiation from high power Electron Cyclotron Resonance Heating applied in nuclear fusion. A notch filter based on a waveguide Bragg reflector (photonic bandgap) can provide several stop bands of defined width within up to two standard waveguide frequency bands.

We P2-04 **THz Plasmonic Devices Based On An Array Of Metallic Posts In A Parallel-Plate Waveguide 590**

Mehdi Ahmadi-Boroujeni[1]; Mahmoud Shahabadi[2]; Kristian Altmann[3]
[1]Sharif University of Technology, Iran; [2]University of Tehran, Iran; [3]Philipps-Universität Marburg, Germany

An array of metallic posts sandwiched between two parallel metal plates supports highly-confined surface waves that can be regarded as spoof surface plasmons. This structure which is called the parallel-plate ladder waveguide (PPLWG) can be used for implementing THz guided-wave devices. In this paper, the effect of post shapes on waveguiding characteristics of PPLWG is analyzed and realization of certain devices such as couplers using the proposed structure is investigated.

We P2-05 **The Evaluation Methodology Of THz-VIS Fused Images 592**

Marcin Kowalski; Norbert Palka; Marek Piszczek; Mieczyslaw Szustakowski
Military University of Technology, Poland

A growing interest in terahertz technology finds support in a large number of applications. One of the most interesting applications of terahertz waves is imaging. The terahertz range of electromagnetic radiation has large potential in the field of hidden objects detection because it is not harmful to humans. However, the main difficulty in the THz imaging systems is low image quality due to low sensitivity and a small number of pixels in detecting modules of cameras Considering the fact that even THz images with low pixel resolution still provide valuable information, it is justified to combine them with the high-resolution images from a visible camera. Image fusion can be used in a wide range of security applications for example detection and identification of hidden objects. Our goal is to build a system harmless to humans for screening and detection of hidden objects using a THz camera. A very important aspect of applying various processing techniques to images is proper assessment of image quality. We propose a combination of two image quality assessment methods (IQA) as a methodology of assessing quality of the fused images and a method to compare image fusion algorithms.

We P2-06 **Evaluation Of Effect Of Wall On Wave Propagation At 300 GHz 594**

Toshihide Tosaka; Katsumi Fujii; Kaori Fukunaga; Akifumi Kasamatsu
NICT, Japan

To evaluate wave propagation at 300 GHz using a simulator, we constructed an accurate measurement system for wave propagation. In this study, we used simple propagation models and evaluated the system by comparing the results of simulation with those of measurement. From the results, measurement using the system had the same accuracy as measurement in free-space. Then, we added a wall and compared the results of simulation and measurement. The difference was within 1.5 dB at 300 GHz; thus, we concluded that our system can measure wave propagation accurately and that evaluation using the simulator was valid. Finally, we measured actual data dispersions by measuring some wall materials using our system.

We P2-07 **Resolving Sub-Phonon Wavelength Super Lattices Using Coherent Acoustic Phonon Spectroscopy 596**

Jeremy Curtis[1]; Andrew Steigerwald[2]; John Reno[3]; Norman Tolk[2]; David Hilton[1]
[1]The University of Alabama at Birmingham, United States; [2]Vanderbilt University, United States; [3]Sandia National Lab, United States

We demonstrate that various features of a complex GaAs/AlGaAs heterostructure superlattice can be resolved using coherent acoustic phonon spectroscopy (CAP) and that CAP is a viable non-destructive metrological tool in the study of stratified media.

We P2-08 **Analysis Of Intermolecular Interactions In Progesterone And 17α-hydroxyprogesterone Crystals 597**

Olga Cherkasova
Institute of Laser Physics SB RAS, Russian Federation

The total energy of intermolecular hydrogen bonds in 17α-hydroxyprogesterone crystal (17HP) estimated on the basis of the DFT/B3LYP calculations is significantly higher than that in progesterone crystal.

We P2-09 **THz-VIS Passive Imaging System For Visualization Of Hidden Threats 598**

Marcin Kowalski; Norbert Palka; Marek Piszczek; Mieczyslaw Szustakowski
Military University of Technology, Poland

Terahertz imaging is the latest entry into the crowded field of imaging technologies. Many applications are emerging for the relatively new technology. THz radiation penetrates deep into nonpolar and nonmetallic materials such as paper, plastic, clothes, wood, and ceramics that are usually opaque at optical wavelengths. In contrast to X-rays, the T-rays have large potential in the field of hidden objects detection because it is not harmful to humans. The main difficulty in the THz imaging systems is low image quality thus it is justified to combine THz images with the high-resolution images from a vision camera. An imaging system is usually composed of various subsystems. Many of the imaging systems use imaging devices working in various spectral ranges. Our goal is to build a system harmless to humans for screening and detection of hidden objects using a THz and VIS cameras. In this paper we present the multispectral passive imaging system for hidden threats visualization based on THz and VIS cameras.

We P2-10 **Graphene Based Ultrafast All-Optical Terahertz Modulator 600**

Qi-Ye Wen; Dan-Dan Sun; Zhi Chen; Huai-Wu Zhang; Kai Dong; Yu-Lan Jing
University of Electronic Science & Technology of China, China

In this presentation, we proposed an all-optical broadband THz modulator based on single-layer graphene (SLG) on silicon. By illuminating the film with CW laser, the THz transmission decreased significantly. The modulation speed was measured at 340 GHz to be as high as 0.5 MHz. This modulator has huge potential for real application.

We P2-11 **Quantum Dot Terahertz Emission -- A Study Of The Structures And Growth Conditions 601**

Chun Yong, Andrew Ngo[1]; Thiam Khee Tan[2]; Soon Fatt Yoon[2]; Satrio Wicaksono[2]; Jing Hua Teng[1]; Qing Yang Steve Wu[1]
[1]IMRE, Singapore; [2]NTU, Singapore

Terahertz (THz) emission by difference frequency generation (DFG) technique has attracted vast interests recently. Quantum dot (QD) system is proposed to be the best candidate for THz emission by DFG technique due to its large optical nonlinearity. For efficient QD THz emission, the QD transition energies must lie within the THz range (0.4–41 meV). However, QD transition energies generally fall outside the critical energy difference, i.e. more than 41 meV. In this work, we investigated the effects of QD structures and growth conditions on the energy states. Consequently, we determined the required QD structures and growth conditions needed to obtain energy difference in the THz range.

We P2-12 **MM-wave Cylindrical, Periodic-Surface-Lattice Cavities For Cherenkov Sources 603**

Alan Phelps[1]; Amy MacLachlan[1]; Alan Phipps[1]; Craig Robertson[1]; Ivan Konoplev[2]; Adrian Cross[1]
[1]University of Strathclyde, United Kingdom; [2]University of Oxford, United Kingdom

Cavities based on a periodic-surface-lattice (PSL) of cylindrical topology have been studied. The lattice perturbations have an amplitude much smaller than the operating wavelength of the structure, allowing the PSL to be described as an effective metadielectric or high impedance surface. Dispersive plots describing the electromagnetic (EM) properties of the PSL are presented and the potential for novel sources of coherent high power radiation and Cherenkov devices is established.

We P2-13 **Measurement Of The Glass Fiber Orientation Of Single And Double Layers By Polarized THz Radiation 605**

Michael Pfleger[1]; Stefan Katletz[1]; Harald Pühringer[1]; Oliver Focke[2]; Karin Wiesauer[1]
[1]RECENDT GmbH, Austria; [2]Faserinstitut Bremen e.V., Germany

We determine the orientation of glass fibers in samples consisting of single and double layers of oriented fibers by sensing the polarization of the transmitted THz-beam. Four different types of samples are investigated and the results are compared.

We P2-14 **Terahertz Multiparameter Sensors Based On Frequency Selective Surfaces Coupled To Subwavelength Fibers 607**

Martin Girard; Maksim Skorobogatiy; Andrey Markov
École Polytechnique de Montréal, Canada

We propose using frequency selective surfaces as resonant sensors for simultaneous measurement of several optical properties of thick films placed in contact with a flat part of the device. Changes in refractive index, losses and thickness of a film can be measured by detecting changes in the spectral position, and amplitude of the transmission peaks in the THz fiber spectrum. As an example, our simulations show 0.16 GHz / μm sensitivity to changes in the film thickness.

We P2-15 **Continuous Wave Terahertz Generation From Photomixer With Single Walled Carbon Nanotubes Film 609**

Qing Yang Steve Wu[1]; Hendrix Tanoto[1]; Jinghua Teng[1]; Enina Nasir[2]; Qing Zhang[2]; Soo Jin Chua[3]
[1]Institute of Materials Research and Engineering, ASTAR, Singapore; [2]Nanyang Technological University, Singapore; [3]National University of Singapore, Singapore

Photomixer with single walled carbon nanotubes utilizing a dual dipole antenna is fabricated. The output spectrum of the continuous-wave Terahertz photomixer with SWCNTs is presented. DC biased voltage dependent characteristic of CW photomixer with SWCNTs is demonstrated.

We P2-16 **Studying Pharmaceutical Tablet Coating Process With Real-time THz In-line Sensing 611**

Hungyen Lin[1]; Robert May[2]; Axel Zeitler[1]
[1]University of Cambridge, United Kingdom; [2]Teraview, United Kingdom

Terahertz in-line sensing was successfully demonstrated previously for measuring the coating thickness of individual pharmaceutical tablets during a production scale film coating process. This paper investigates how this technology can be used to evaluate the impact of changes in the process conditions on the inter-tablet coating thickness distribution. The process changes that were investigated in this study were the removal of the mixing baffles from the coating pan, blockage of one of the spray guns and the addition of uncoated tablet cores to a bed of partially coated tablets. Using the terahertz sensor the coating thickness of more than 20 individual tablets was sampled per minute in situ throughout the coating process. By analysing the resulting variation in coating thickness distribution it was possible to resolve the effect of all these process changes on the coating thickness homogeneity within the batch.

We P2-17 **Design And Characterization Of 4x4-Phased-Array Patch Antennas at 77 GHz And 94 GHz 613**

Thorsten Schrader; Thomas Kleine-Ostmann; Mohammed Salhi
Physikalisch-Technische Bundesanstalt (PTB), Germany

We have designed 4x4-phased-array patch antennas at 77 and 94 GHz using simulations based on the finite integration technique in the time-domain. The antennas are designed for communications and for the development of antenna measuring techniques. They have been fabricated and characterized with regard to input impedance and antenna diagrams.

We P2-18 **Calibration Of Standard Gain Horn Antennas In The Frequency Range From 220 To 325 GHz 615**

Katsumi Fujii; Toshihide Tosaka; Yasushi Matsumoto; Akifumi Kasamatsu
National Institute of Information and Communications Technology, Japan

The actual gains of standard gain horn antennas with an operating frequency range from 220 to 325 GHz were calibrated experimentally by the three-antenna method. To determine the actual gain precisely, the required distance between the transmitting and receiving antennas was clarified by evaluating the propagation loss in terms of the distance between the antennas. In addition, to ensure the validity of the experimental results, the actual gain was also calculated using an electromagnetic simulator.

We P2-19 **Terahertz Waveguide Using Triangle Bundle Structure Of Polymer Tubes 617**

Yoh Imai[1]; Satoshi Yamauchi[1]; Hirohisa Yokota[1]; Masayoshi Tonouchi[2]
[1]Ibaraki University, Japan; [2]Osaka University, Japan

A new terahertz fiber using polymer tube bundle with triangular structure is proposed and analyzed. An optimum tube parameters in bundle structure for low loss waveguide is clarified.

We P2-20 **CARM: A THz Source For Plasma Heating 619**

Silvio Ceccuzzi[1]; Andrea Doria[2]; Giuseppe Dattoli[2]; Emanuele Di Palma[2]; Gian Piero Gallerano[2]; Francesco Mirizzi[1]; Ivan Spassovky[3]; Gianluca Ravera[1]; Vincenzo Surrenti[3]; Angelo Tuccillo[1]; Emilio Giovenale[2]
[1]ENEA - FUS, Italy; [2]ENEA - UTAPRAD SOR, Italy; [3]ENEA - UTAPRAD MAT, Italy

Heating and Current Drive systems are of outstanding relevance in fusion plasmas, magnetically confined in tokamak devices, as they provide the tools to reach, sustain and control burning conditions. DEMO, and the future reactor will require higher frequency for ECH. Therefore, high power (≥1MW) RF sources with output frequency in the 200 – 300 GHz range would be necessary.

We P2-21 **Low-voltage Planar Cyclotron Resonance Maser Based On A Confocal Cavity 621**

Sergey Kishko[1]; Sergey Ponomarenko[2]; Alexey Kuleshov[2]; Boris Yefimov[2]; Mikhail Glyavin[3]; Irina Zotova[3]; Ilya Zheleznov[3]; Naum Ginzburg[4]; Vladimir Manuilov[4]; Vladislav Zaslavsky[4]
[1]Institute for Radiophysics and Electronics of NAS of Ukraine, Ukraine; [2]IRE of NAS of Ukraine, Ukraine; [3]Institute of Applied Physics, Russian Federation; [4]Lobachevsky Nizhegorodsky State University, Russian Federation

The results of simulation of both electron-optical and the cavity of low-voltage planar cyclotron resonance maser (CRM) have been presented. The electron-optical system (EOS), which forms a sheet helical electron beam (HEB) with the value of the pitch factor ≥ 1 was obtained. Electron beam energy characteristics were obtained as the result of trajectory analysis for EOS. Also the CRM cavity mode structure and its dispersion characteristics were simulated and analyzed.

We P2-22 **Photoconductive Photonic Crystal Switch 623**

William Otter; Stephen Hanham; Elpida Episkopou; Yun Zhou; Norbert Klein; Andrew Holmes; Stepan Lucyszyn
Imperial College London, United Kingdom

We demonstrate a single-pole single-throw switch in W-band based on the optical illumination of a defect waveguide in a photonic crystal. Simulations show that an extinction ratio of greater than 40 dB between 89 and 101 GHz is possible. Measurements at 99 GHz confirm this extinction ratio.

We P2-23 **Time-domain Characterization Of THz Power Detectors 625**

Jean-Louis Coutaz[1]; Gwenael Gaborit[1]; Jonathan Oden[1]; Jean-Francois Roux[1]; Chiko Otani[2]
[1]IMEP-LAHC, France; [2]RIKEN Sendai, Japan

We propose and demonstrate the large-band characterization of THz powermeters with a THz time-domain spectroscopy set up including a Michelson interferometer.

We P2-24 **High-field Domains In Terahertz Quantum Cascade Laser Structures Based On Resonant-phonon Depopulation Scheme 627**

Hiroaki Yasuda[1]; Iwao Hosako[1]; Kazuhiko Hirakawa[2]
[1]NICT, Japan; [2]Univ. of Tokyo, Japan

We fabricated a few periods of THz-QCL structures with small areas to investigate the formation of high-field domains that may prevent laser oscillations. The current–voltage characteristics for a two-well THz-QCL structure did not show any signs of the formation of high-field domains.

We P2-25 **Terahertz Surface Plasmon Resonance Sensor And Bull's Eye Structure For Material Sensing 629**

Daniel Hailu[1]; Sondos Alqarni[2]; Bo Cui[2]; Daryoosh Saeedkia[1]
[1]TeTechS Inc., Canada; [2]University of Waterloo, Canada

This paper presents the use of Terahertz (THz) SPR near-field sensor based on array of sub-wavelength metallic holes and Bull's eye structure to characterize materials such as PMMA and those used in organic light emitting diode (OLED). The measurement results confirmed the theoretical SPR frequencies for metal-silicon mode and demonstrate a shift to0.9211 THz from 0.9375 THz due to 2 μm of PMMA layer on the surface.

We P2-26 **Terahertz Imaging For Nondestructive Inspection Of Materials Including Conductive Microparticles 631**

Toru Kurabayashi; Shinichi Yodokawa; Satoshi Kosaka
Akita University, Japan

THz imaging for nondestructive inspection of the materials including conductive microparticles has been studied by use of FDTD analysis and THz spectroscopy. The allocated conductive particles causes the scattering for THz-wave. Though the scattering factor depends on the frequency, a frequency selected wave would be suitable for nondestructive inspection.

We P2-27 **Enhancements For The DIII-D ECH System 633**

John Lohr[1]; Mirela Cengher[1]; Yuri Gorelov[1]; Egemen Kolemen[2]; Charles Moeller[1]; Sirivong Noraky[1]; Dan Ponce[1]; Ron Prater[1]; Robert Ellis[2]
[1]General Atomics, United States; [2]Princeton Plasma Physics Laboratory, United States

The expansion and upgrading of the electron cyclotron heating and current drive (ECH/ECCD) gyrotron complex on the DIII-D tokamak are continuing with the addition of the first of a series of depressed collector tubes in the 1 MW class. The ultimate goal is a 10 gyrotron system with rapid steering of the rf beams and full integration into the DIII-D Plasma Control System using the real time EFIT equilibrium calculation to determine the ECH/ECCD deposition locations to guide requirements for both steering and injected power.

We P2-28 **THz Electroluminescence In Natural Superlattice Of SiC Polytypes Induced By Bloch Oscillations And By The Features Of Miniband Spectra 635**

Vladimir Sankin; Alexandr Andrianov; Alexey Zachar'in; Alexey Petrov; Pavel Shkrebiy; Alla Lepneva; Alexandr Bobylev
Ioffe Physical Technical Institute, Russian Federation

Studies of strong terahertz (THz) electroluminescence in several SiC natural superlattices allowed us to reveal changes in the emission spectra, which are in well consistency with the theory of electron Bloch oscillations, and to discover new channels of intensive THz electroluminescence.

We P2-29 **Signature Of Aromatic Carbons In Terahertz Spectroscopy Of Bio-chars 637**

Lucia Lepodise[1]; Roger A. Lewis[2]; Joseph Horvat[2]
[1]University of Wollongong, Australia; [2]Institute for Superconducting and Electric Materials & Physics School, Australia

The potential of terahertz spectroscopy in distinguishing aromatic carbon compounds in bio-chars is demonstrated. Several types of biochar samples were measured and compared with the THz spectra of pure aromatic compounds. Infrared spectra were modeled with B3LYP and mP2PLYP methods. Modeling could not identify accurately each of the absorption lines. However modeling shows that one of the lines close to 500 cm^{-1} is due to vibrations of carbon rings, which can be used for identification of aromatic carbons in biochars.

We P2-30 **Tailoring Extraordinary Transmission By Inductance Addition With Meander-lines 639**

Víctor Torres[1]; Pablo Rodríguez-Ulibarri[1]; Rubén Ortuño[2]; Miguel Navarro-Cía[3]; Miguel Beruete[1]
[1]Universidad Pública de Navarra, Spain; [2]Universitat Politècnica de València, Spain; [3]Imperial College London, United Kingdom

In this work, we tune the frequency of the resonant peak associated to extraordinary transmission phenomenon by changing slightly the topology of typical subwavelength square apertures. By substituting the vertical lateral walls for meander-lines it is possible to move the extraordinary transmission peak downward accompanied by an unprecedented enlargement of the fractional bandwidth. This phenomenon is theoretically analysed from an equivalent circuit perspective and demonstrated experimentally at the millimeter-wave and mid-infrared band. A wide range of applications may benefit from this, since now the extraordinary transmission happens far away from the onset of higher order diffracted modes.

We P2-31 **Eigenvalue Spectrum Of Coaxial Cavities With Corrugations On The Inner And The Outer Wall 641**

Zisis Ioannidis[1]; Konstantinos Avramidis[2]; George Latsas[1]; Ioannis Tigelis[1]
[1]National and Kapodistrian University of Athens, Greece; [2]Karlsruhe Institute of Technology, Germany

The Spatial Harmonics Method (SHM) has been employed to study TE modes in a coaxial cavity with corrugations both on the inner and the outer wall. Such cavities seem to have the potential for superior mode-selectivity and could be employed for the development of multi-MW gyrotrons above 200 GHz.

We P2-32 **High Resolution Reflective Terahertz Imaging With The TEM01 Mode Laser Beam And Large Area Detector 643**

Bogdan Voisiat; Laurynas Tumonis; Dalius Seliuta; Gintaras Valušis; Gediminas Račiukaitis; Irmantas Kašalynas; Rimvydas Venckevičius
Center for Physical Science and Technology, Lithuania

Terahertz reflection imaging with the laser operating in TEM01 mode and large area detector was investigated. Imaging of high spatial resolution targets with up to diffraction limited resolution was demonstrated. Imaging system was also illustrated to be suitable to identify defects in silicon solar cells.

We P2-33 **Emissivity Measurement Of Cold Objects Down To Liquid-Nitrogen Temperature With A 4K-Cryocooled Terahertz Photoconductive Detector 645**

Norihisa Hiromoto; Makoto Aoki
Shizuoka University, Japan

We have carried out the passive measurement of cold objects down to liquid nitrogen temperature at 1.5-2.5 THz using a 4 K-cryocooled terahertz (THz) photoconductive detector. We measured output signals of THz radiation from five materials of a 2 mm-thick acrylic plate, a 0.1 mm-thick pure H_2O, a 2 mm-thick high-resistivity silicon substrate, a #2010 black velvet coated plate, and a gold plate as a function of temperature. By assuming emissivities of the #2010 black velvet coated plate and gold plate are 1 and 0 respectively, we calculated the calibration lines of THz output signal as functions of emissivity and temperature. Using the calibration lines, we have derived the temperature-dependent THz emissivity of three samples.

We P2-34 **Characterisation Of Low Temperature And Semi-insulating GaAs Lateral photo-Dember THz Emitters 647**

Duncan McBryde[1]; Mark Barnes[1]; Paul C. Gow; Sam Berry[1]; Geoff Daniell[1]; Harvey Beere[2]; David Ritchie[2]; Vasilis Apostolopoulos[1]
[1]University of Southampton, United Kingdom; [2]University of Cambridge, United Kingdom

We characterise a set of Lateral Photo Dember (LPD) terahertz emitters fabricated on annealed low temperature grown (LTG) GaAs, unannealed LTG-GaAs and SI-GaAs substrates. Our results show that unannealed LTG-GaAs is the most efficient LPD emitter of this set due to a higher saturation fluence.

We P2-35 **Angular Profile Determination Of A THz-Time Domain Spectrometer 649**

Mark Barnes[1]; Aaron Chung[1]; Sam Berry[1]; Duncan McBryde[1]; Geoff Daniell[1]; Axel Zeitler[2]; Vasilis Apostolopoulos[1]
[1]University of Southampton, United Kingdom; [2]University of Cambridge, United Kingdom

We demonstrate a parameter extraction algorithm based on a theoretical transfer function, which takes into account a converging THz beam. We use material parameter extraction as a way to determine the angular profile of the apparatus.

We P2-36 **Numerical Study Of Optically Pumped Graphene For Loss Compensated Terahertz Metamaterials 651**

Peter Weis[1]; Juan L. Garcia-Pomar[2]; Marco Rahm[1]
[1]University of Kaiserslautern, Germany; [2]Instituto de Óptica, C.S.I.C., Spain

We investigate amplification of THz radiation in optically pumped graphene and the interaction with metamaterials. The results show, that such hybrid materials offer a promising approach for loss compensated and lasing THz metamaterials.

We P2-37 **IR Thermal Emission From An Array Of Plasmonic Coated Spheres 653**

Ian Zimmerman; Min Liang; Hao Xin
University of Arizona, United States

We explore the degree to which infrared thermal emission can be tailored using an array of dielectric spheres coated with a negative permittivity material. The spheres themselves have absorption peaks in the IR. The emission spectrum is then modified using the arrangement of the spheres.

We P2-38 **Improved Efficiency Of Photoconductive THz Source By Selective Enhancement Of Electric Fields By Patterning 655**

Abhishek Singh[1]; V. V. Nikesh[1]; Harshad Surdi[1]; S. S. Prabhu[1]; G.H. Dohler[2]
[1]TIFR, India; [2]Max- Planck Institute for the Science of Light, Germany

Improving the THz emission efficiency of the THz sources has been a major research goal for several years. We present here an approach to improve the efficiency of a THz Photoconductive Antenna (PCA) fabricated on a Semi-Insulating (SI) GaAs substrate by

etching out a grating like structure on the substrate surface before contact deposition. After patterning, we have observed enhancement in THz power emission compared to the emitted THz power from the usual un-patterned regions of the PCA. This enhancement in emitted THz amplitude is attributed to the enhancement in applied electric field in the unetched volume of GaAs as well as enhanced incident exciting photon confinement in the same un-etched volume of the patterned region.

We P2-39 **Design And Fabrication Of Cyclic-olefin Copolymer Based Terahertz Hollow-core Photonic Crystal Fiber 657**

Qi Chen
Institute of Electronic Engineering, China Academy of Engineering Physics, China

In this paper a kind of hollow-core terahertz photonic crystal fiber made of Cyclic-olefin Copolymer with low absorption loss is designed. Results show these fibers are much better than metallic waveguides for their fine transmission properties in terahertz band. Along with the fine flexibility to bend, they are of great importance in application.

We P2-40 **Terahertz Response Of Carbon Nanotube/Metal Heterojunctions 659**

Yingxin Wang; Jia-Lin Sun; Guowei Zhang; Ziran Zhao; Jia-Lin Zhu; Zhiqiang Chen; Lingbo Qiao
Tsinghua University, China

Terahertz-radiation-induced photocurrents have been experimentally observed in a carbon nanotube (CNT)/nickel heterojunction. The temporal photoresponse shows a relatively fast and a slow process, corresponding to the photoelectric and thermal effects, respectively. The photoconductive properties of this junction under terahertz illumination are also explored. Our work demonstrates the possibility of using CNT/metal junctions as novel terahertz detectors.

We P2-41 **Interpretation Of THz Absorption Spectra Of Dissolved Proteins Using Molecular Dynamics Simulations 661**

Rostyslav Dubrovka; Oleksandr Sushko; Robert Donnan
University of London, United Kingdom

This study addresses the analysis of THz absorption spectra of solvated biomolecules. Simulation results of tryptophan cage (TRP-cage) protein solvation dynamics are obtained using the molecular dynamics package, Gromacs. The relative THz absorbance by the hydration shell around a protein is calculated based on the information related to the dipole autocorrelation function (ACF) and velocity ACF.

We P2-42 **Direct Modulation Characteristics Of 1.3-μm Dual-mode Laser Diode 663**

Namje Kim[1]; Sang-Pil Han[2]; Kiwon Moon[2]; Jung-Woo Park[2]; Hyunsung Ko[2]; Min Yong Jeon[3]; Kyung Hyun Park[2]
[1]Electronics and Telecommunications Research Institute, Korea, Republic of; [2]ETRI, Korea, Republic of; [3]Chungnam National University, Korea, Republic of

We have investigated the direct modulation characteristics of a phase-shifted 1.3-μm dual-mode laser diode. Stable dual-mode operation and high spectral purity are maintained under 2.5-Gbps direct modulation.

We P2-43 **The Terahertz Identification Of The Mixtures Of Amino Acids By Principle Components Analysis 665**

Jian Zuo[1]; Fei Yu[1]; Kaijun Mu[2]; Liangliang Zhang[1]; Zhenwei Zhang[1]; Qingli Zhou[1]; Cunlin Zhang[1]
[1]Department of Physics, Capital Normal University, China; [2]School of Physical Science and Engineering, Zhengzhou University, China

Terahertz time-domain spectroscopy has been used to analyze the mixed samples of different mass ratio of L-Tyrosine and L-Phenylalanine. The total dipoles of theses mixtures are given by absorption line shape function. Moreover, the statistical method of principle components analysis is employed to spectral recognition of these samples.

We P2-44 WITHDRAWN

We P2-45 **Simulation Of Input Structure For Confocal Quasi- Cylindrical Gyrotron Amplifier 666**

Zhao Chao
Chinese Academy of Sciences, China

For the researches of input structure of confocal quasi-cylindrical gyrotron amplifier with frequency at 220 GHz, the parameters of input structure are optimum with a help of CST studio. The input structure including WR4 waveguide, WR2.8 waveguide, 90° circle waveguide and confocal quasi-cylindrical waveguide are studied. The results show that the TE_{06} mode is obtained in confocal quasi-cylindrical waveguide with the optimum structure.

We P2-46 **Electromagnetic Properties Of MWCNT/PE Composites At Different Levels Of THz Peak Power 667**

Sergey Sarkisov[1]; Valentin Suslyaev[2]; Victor Zhuravlev[2]; Vladimir Kuznetsov[3]; Sergey Moseenkov[3]; Nina Semikolenova[3]; Vladimir Zakharov[3]; Grigory Dunaevsky[2]
[1]Siberian Physical and Technical Institute of Tomsk State University, Russian Federation; [2]Tomsk State University, Russian Federation; [3]Boreskov Institute of Catalysis, Russian Federation

Complex dielectric susceptibilities of MWCNT/PE composites with various contents of nanotubes were measured using THz-TDS and cw THz BWO-spectrometer in the frequency range 100 GHz – 2.2 THz and THz peak powers from microwatts to hundred kilowatts.

We P2-47 **Frequency Measurement Of Optically Generated THz Wave Based On A fs-pulse Fiber Laser 669**

Motohiro Kumagai; Shigeo Nagano; Hiroyuki Ito; Isao Morohashi; Yoshihisa Irimajiri; Yuko Hanado
National Institute of Information and Communications Technology (NICT), Japan

We have demonstrated generation of a highly accurate THz continuous wave based on a fs-pulse fiber comb. Applying ultra-narrow optical filtering based on stimulated Brillouin scattering to the fs fiber comb having a repetition rate of 100MHz enables extraction of only two optical modes of the fs fiber laser to generate a highly stable 100GHz wave.

We P2-48 **Studies On Terahertz Time Domain Spectroscopy For Hydrated State Of Ionic Molecules 671**

Shunsuke Kawabe; Kyohei Fukuda; Hitoshi Tabata
University of Tokyo, Japan

It has been found that the sensitivity of the terahertz attenuated total reflection spectroscopy was enhanced five times by using a metallic mesh. Using this method, reflectances of various ionic solutions were measured. As a result of measurement, hydrated states of ionic molecules were evaluated.

We P2-49 **Photonic Crystal Sandwiched In Parallel Plates As THz Waveguide 673**

Damien Armand[1]; Shingo Koya[2]; Yutaka Kadoya[3]
[1]Japan Science and Technology Agency, Japan; [2]Graduate School of Advanced Science of Matter, Japan; [3]Graduate School of Advanced Sciences of Matter, Japan

We consider THz waveguide made of metallic photonic crystal embedded in parallel plate. Transmitted frequency bandwidth control is allowed thanks modification of parallel plate spacing. Experiment and FDTD simulation shows a good agreement.

We P2-50 **Study Of Terahertz Zone Plates With Integrated Cross-shape Apertures 675**

Linas Minkevičius; Karolis Madeikis; Bogdan Voisiat; Algirdas Mekys; Rimvydas Venckevičius; Irmantas Kašalynas; Gediminas Račiukaitis; Gintaras Valušis; Vincas Tamošiūnas
Center for Physical Sciences and Technology, Lithuania

Zone plates with integrated band-pass filters were designed numerically via finite-difference time-domain technique and demonstrated experimentally at 0.76 THz frequency applying Fourier spectroscopy and optically pumped molecular terahertz laser.

We P2-51 **Detection Of THz Radiation By Using GaAs in Cherenkov-phase-matched Electro-optic Sampling 677**

Shinpei Ozawa[1]; Tomohiro Nagase[1]; Satoshi Tsuzuki[1]; Daiki Takeshima[1]; Furuya Takashi[1]; Seizi Nishizawa[1]; Kazuyoshi Kurihara[1]; Fumiyoshi Kuwashima[2]; Ramon de los Santos[3]; Armando Somintac[3]; Elmer Estacio[3]; Kohji Yamamoto[1]; Michael I Bakunov[4]; Tani Masahiko[1]
[1]University of Fukui, Japan; [2]Fukui University of Technology, Japan; [3]University of Philippines Diliman, Philippines; [4]University of Nizhny Novgorod,, Russian Federation

We propose and demonstrate electro-optic (EO) sampling of terahertz (THz) radiation by using GaAs in the Cherenkov phase-matching scheme. This technique can be implemented without Si-prism coupling due to a small difference between optical group and THz phase refractive indices of GaAs and its low THz absorption.

We P2-52 **Characterization Of Encapsulation And Metal Interconnects Of Solar Cells By Terahertz Techniques 679**

Linas Minkevičius; Andrzej Urbanowicz; Arūnas Krotkus; Arūnas Šetkus; Vincas Tamošiūnas
Center for Physical Sciences and Technology, Lithuania

We present our investigations of solar cell mini modules and metal interconnects using terahertz time-domain spectroscopic imaging. It was demonstrated, that time-domain data can be used to reveal the thickness variation of encapsulating layers and height difference of metal contact surfaces in a vicinity of shunts.

We P2-53 **Study On The Terahertz Coaxial Gyrotron Cavity With A Tapered Inner Rod 681**

Diwei Liu
University of Electronic Science and Technology of China, China

The resonant frequency, the diffractive quality factor in the coaxial gyrotron cavity with a tapered inner rod have been investigated. The resonant frequency and the diffractive quality factor can be adjusted by changing the tilt angle of the tapered inner rod and the ratio of the inner and outer radii. The mode competition can be improved with an appropriate design of the tilt angle of the tapered inner rod and the ratio of the inner and outer radii in a coaxial gyrotron cavity with a tapered inner rod.

We P2-54 **Intrinsic Linewidth Of The Fano Resonance In A Micrometric Metal Mesh 682**

Leonetta Baldassarre[1]; Michele Ortolani[2]; Alessandro Nucara[2]; Paola Maselli[2]; Alessandra Di Gaspare[3]; Valeria Giliberti[3]; Paolo Calvani[2]
[1]Center for Life NanoScience@Sapienza, Istituto Italiano di Tecnologia, Italy; [2]Università Sapienza di Roma, Italy; [3]CNR-Istituto di Fotonica e Nanotecnologie, Italy

The intrinsic linewidth of Surface Plasmon Polariton resonance in a micrometric metal mesh has been measured with a collimated mid-infrared beam, provided by an External-Cavity, tunable Quantum Cascade Laser. The use of a collimated beam yields a resonance linewidth of 12 cm^{-1}, much narrower than by conventional black-body sources. This opens more favorable perspectives to the use of metal meshes as sensors and detectors.

We P2-55 **Extensive Simulations Are Performed To Investigate A Ka-band Gyrotron Traveling Wave Tube Amplifier (Gyro-TWTA) With Helically Corrugated Waveguide Us 684**

Shouxi Xu
Institute of Electronics, Chinese Academy Of Sciences, China

Extensive simulations are performed to investigate a ka-band gyrotron traveling wave tube amplifier (Gyro-TWTA) with helically corrugated waveguide using three-dimensional particle-in-cell (PIC) codes. With beam energy of 80 keV, the amplifier achieved an output power of 35 kW, saturated gain of 28 dB, and an efficiency of 22 %.

We P2-56 **Numerical Simulation Of Astrophysical Cyclotron-maser Emission 685**

David Speirs; Sandra McConville; Karen Gillespie; Alan Phelps; Adrian Cross; Kevin Ronald
University of Strathclyde, United Kingdom

Numerical simulations have been conducted at the University of Strathclyde to study the spatial growth rate and emission topology of the cyclotron maser instability responsible for auroral magnetospheric radio emission from stars and planets and intense non-thermal radio emission in other astrophysical contexts. The results have significant bearing on the radiation propagation characteristics and highly debated question of escape from the source region.

We P2-57 **Comparative Study Of Water Absorption And Retention Of Nafion And Its Hybrid Polymer Electrolytic Membranes Using Terahertz Spectroscopy 687**

Shaumik Ray[1]; Jyotirmayee Dash[1]; Kathirvel Nallappan[1]; Santosh Bhat[2]; Bala Pesala[1]
[1]CSIR-CEERI, India; [2]CSIR-CECRI, India

Nafion membranes are used as proton exchange membranes in fuel cells. Water absorption and retention capacity of Nafion membranes play a key role in determining the electrochemical conversion efficiencies. Here, we use Terahertz spectroscopy to study different Nafion membranes and show that hybrid membranes have higher water absorption/retention capacity.

We P2-58 **Low Power Test Of the ITER Electron Cyclotron Equatorial Launcher Mock-up 689**

Masafumi Fukunari[1]; Koji Takahashi[2]; Yasuhisa Oda[2]; Ken Kajiwara[2]; Keishi Sakamoto[2]; Toshimichi Omori[3]; Mark Henderson[4]
[1]The University of Tokyo, Japan; [2]Japan Atomic Energy Agency, Japan; [3]ITER Organization, France; [4]ITER Organization, France

Beam propagation behavior of the ITER EC equatorial launcher mock-up was investigated at low power level. A 170 GHz, HE11 mode generator was used as a beam source. Maximum intensity at the mirror-edge was -35 dB which was almost background level and no signal was obtained on the beam-duct wall. Assuming a radiation from the waveguide nearest to the wall an intensity profile on the beam-duct wall was estimated, the maximum intensity on the beam-duct wall and at the mirror-edge were a level of -40 dB, and of -13 dB, respectively. At outlet of the EL mock-up, single peak radiation profile was confirmed and the beam center was located as designed. The peak intensity of the side lobes were about -20 dB which is reasonably small.

We P2-59 WITHDRAWN

We P2-60 **Frequency Stabilization Of A Pump 9R(8) CO_2 Laser For Simultaneously Oscillated 5.2- And 6.3-THz CH_3OD Lasers 691**

Kazuya Nakayama[1]; Shigeki Okajima[1]; Tsuyoshi Akiyama[2]; Kenji Tanaka[2]; Kazuo Kawahata[2]
[1]Chubu University, Japan; [2]NIFS, Japan

A two color far-infrared (FIR) laser interferometer and polarimeter using 5.2- and 6.3-THz CH_3OD lasers pumped by a 9R(8) CO_2 laser has been developed for future plasma diagnostics. The pump 9R(8) CO_2 laser has been stabilized by an external Stark-cell

modulation. The performances are the power stability of 108 ± 0.6 W/hour and the frequency stability of ± 230 kHz_{p-p}/hour at the line center.

We P2-61 **Active Imaging System At 0.22 THz 693**

Jian Chen
Nanjing Univ, China

An active imaging system has been constructed using a Cassegrain reflector with the diameter of 30 cm and a direct detector with the noise equivalent power of about 1.5×10^{-11} $W/Hz^{1/2}$ at room temperature and 0.22 THz. It takes about 0.5 s to get 40×40 pixels and the special resolution is about 1.41 cm.

We P2-62 **Analysis And Design Of Planar Dipole Array For Terahertz Magnetic Surface Wave Propagation 694**

Masaki Yashiro[1]; Withawat Withayachumnankul[2]; John Young[3]; Keisuke Takano[4]; Masanori Hangyo[4]; Takehito Suzuki[1]
[1]Ibaraki University/Department of Electrical and Electronic Engineering, College of Engineering, Japan; [2]The University of Adelaide/School of Electrical & Electronic Engineering, Australia; [3]University of Kentucky/Department of Electrical and Computer Engineering, College of Engineering, United States; [4]Osaka University/Institute of Laser Engineering, Japan

A planar dipole array on low-temperature (LT) growth gallium arsenide (GaAs) or cyclo olefin polymer film is analyzed for magnetic terahertz surface wave, TE wave propagation. A laser pulse excites the dipole gap in order to generate photo carriers on the surface of a LT-GaAs photoconductive substrate. A dipole array on the LT-GaAs substrate is designed for a surface wave around 0.40 THz. The analysis also derives the dispersion diagram and transmission loss. The dispersion diagram indicates that propagation of the surface wave is confined around the dipole elements. The dipole array on a cyclo olefin polymer film can be also designed at around 0.45 THz.

We P2-63 **Broadband Orthomode Transducer For The WR12-Band 696**

Amir Cenanovic; Tobias Köppel; Johannes Ringel; Lorenz-Peter Schmidt
Institute of Microwaves and Photonics, Germany

In this work a broadband waveguide orthomode transducer (OMT) operating at the entire WR12 band is presented. The compact size OMT is fabricated in split-block technique. It exhibits an insertion loss below 0.6 dB and return loss values for the horizontal polarization greater than 20 dB and for the vertical polarization greater than 17 dB at 69 - 90 GHz. The simulated isolation between the orthogonal polarization ports is better than - 65 dB across the 60 – 90 GHz band.

We P2-64 **Use Of Cyclotron Resonance Absorption For Amplitude Modulation Of CW Microwave Radiation 698**

Irina Zotova; Naum Ginzburg; Alexander Sergeev
Institute of Applied Physics RAS, Russian Federation

We suggest to use the effect of cyclotron resonance absorption for modulation of microwave signals. Stationary signal transforms into the sequence of soliton-like pulses during interaction with rectilinear electron beam. For operating frequency of 250 GHz output pulses can possess subnanosecond durations.

We P2-65 **Background Corrected Transmittance And Reflectance Measurements In The FIR 699**

Mathias Kehrt; Ralf Müller; Andreas Steiger; Christian Monte
Physikalisch-Technische Bundesanstalt, Germany

Transmittance and reflectance measurements with Fourier transform spectrometers in the MIR and FIR can exhibit significant deviations when working with cooled detectors. By measuring at two flux levels and by using an appropriate evaluation scheme systematic deviations can be largely reduced in the range from 25 µm up to 1000 µm.

We P2-66 **Identification Of Adulterants In Turmeric Powder Using Terahertz Spectroscopy 701**

Kathirvel Nallappan; Jyotirmayee Dash; Shaumik Ray; Bala Pesala
CSIR-CEERI, India

Turmeric is a common spice used as a vital ingredient in Ayurvedic medicines and food. Adulteration of turmeric with chalk powder causes severe health problems in humans. Conventional methods of identifying adulterants via chemical reactions are inaccurate. Here, we use Terahertz spectroscopy to effectively identify adulteration of turmeric with chalk powder. This method shows good potential for non-intrusive detection of adulterated spices and foods in packages.

We P2-67 **Reflection Measurement Of Hexogen From 5-m Distance 703**

Michal Walczakowski[1]; Norbert Palka[1]; Mieczyslaw Szustakowski[1]; Adam Czerwinski[2]; Maciej Sypek[2]
[1]Institute of Optoelectronics, Military University of Technology, Poland; [2]Faculty of Physics, Warsaw University of Technology, Poland

The paper presents results of research on a reflection measurement of a Hexogen (RDX) sample from 5 m distance. An experimental setup consisted of a tuning optical parametric oscillator and a hot electron bolometer. The study was carried out with presence of water vapor in the air. The reflectivity of RDX is similar to the reflectivity measured by a time domain spectroscopy setup.

We P2-68 **Non-Destructive Inspection Of Internal Defects In Concrete Using Continuous Wave 2D Terahertz Imaging System 705**

Jyotirmayee Dash[1]; Shaumik Ray[1]; Kathirvel Nallappan[1]; Saptarshi Sasmal[2]; Bala Pesala[1]
[1]CSIR-CEERI, India; [2]CSIR-SERC, India

Terahertz imaging can be used as a vital tool for non-destructive evaluation of internal structure and defects in concrete. Here we show successful detection of internal defects in concrete samples using THz imaging. This method gives higher resolution images than conventional Radar and has higher penetration depth compared to Infrared tomography.

We P2-69 **3D Millimeter Waves Tomosynthesis For The Control Of Aeronautics Materials 707**

Patrick Mounaix[1]; Benoit Recur[1]; Jean Paul Guillet[1]; Jean Baptiste Perraud[1]; Inka Manek-Hönninger[1]; Pascal Desbarats[2]; Louis Fredérique[2]
[1]LOMA UMR 5798, France; [2]LaBRI, Bordeaux 1 University, CNRS UMR 5800, France

3D Tomosynthesis based reconstructions from THz acquisitions in transmission and reflection modes are investigated in order to enhance 3D image quality. Results are compared to usual 2D THz imaging and 3D THz tomography techniques.

We P2-70 **Easily Scalable Resonator Based On Hollow-core Photonic Band Gap Crystal Cladding For Extremely High Frequencies 708**

Denis Ferachou[1]; Georges Humbert[2]; Amine Ould Hamouda[2]; Jean-Michel le Floch[3]; Aurelian Crunteanu[2]; Michael Tobar[3]; Dominique Cros[2]; Jean-Marc Blondy[2]
[1]Department of Chemical Engineering and Biotechnology, United Kingdom; [2]Xlim Research Institute, France; [3]University of Western Australia, Australia

We propose a scalable resonator structure based on two-dimensional out-of-plane photonic band gap crystal. This resonator offers the possibility to obtain a strong confinement at terahertz domain with high quality factor.

We P2-71 WITHDRAWN

We P2-72 **Responsivity At 0.27 THz Of A Heterostructure Field Effect Transistor Detector In A Quasi-optical Package 710**

Valeria Giliberti[1]; Roberto Casini[1]; Alessandra Di Gaspare[1]; Alvydas Lisauskas[2]; Hartmut G. Roskos[2]; Michele Ortolani[3]
[1]CNR-IFN Institute for Photonics and Nanotechnologies, Italy; [2]Physikalisches Institut,

Johann Wolfgang Goethe-Universität Frankfurt, Germany; [3]Physics Department, Sapienza University of Rome, Italy
We have fabricated AlGaAs/InGaAs/AlGaAs heterostructure field effect transistors (HFET) with integrated on-chip antennas and we have measured their optical responsivity when mounted in an in-house developed quasi-optical package with a silicon substrate lens.

We P2-73 **Spectrally Resolved Beam Profiles Of The Ultra-Broadband THz-Mid-Infrared Emission From A Two-Color-Excited Gas Plasma 712**
Mark D. Thomson; Volker Blank; Hartmut G. Roskos
Physikalisches Institut, University of Frankfurt, Germany
We combine spectrally and spatially resolved measurements of the ultra-broadband THz-mid-infrared (IR) emission from a two-color-excited gas plasma, which provides a more detailed picture of the emission process and allows one to simulate the predicted spatio-temporal propagation through a subsequent focal region.

We P2-74 **Continuous Wave Millimeter And TeraHertz Generation Using A Photonic Integrated Circuit 714**
Alvaro Jimenez; Robinson Guzman; Luis Enrique Garcia; Daniel Segovia; Guillermo Carpintero
Universidad Carlos III de Madrid, Spain
Sub-terahertz and terahertz frequencies can be generated by optical heterodyning of two wavelengths. Two laser modes, generated with a Photonic Integrated Circuit which integrates an Arrayed Waveguide Grating, are employed to create terahertz frequencies. The wavelength difference of the two optical modes defines the frequency of the generated wave, which can be discretely tunable by selecting different channels of the integrated filter.

We P2-75 **Simulating A Traveling-Wave Resonator For High-Power ECRH Testing 715**
Bryan Fox[1]; Benjamin Rock[2]; Ronald Vernon[1]
[1]University of Wisconsin- Madison, United States; [2]Naval Beam Physics Branch, Plasma Physics Division, The Naval Research Laboratory, United States
A traveling-wave resonator may have many times the power supplied by a microwave source, making it possible to test components at a much higher power than would otherwise be available. Here, the simulation results of a traveling-wave resonator are presented.

We P2-76 **THz Diffuser Using An Air-polymer Composite Material 717**
Sajad Ghatreh-Samani[1]; Graham Town[1]; Stefan Busch[2]; Martin Koch[2]
[1]Macquarie University, Australia; [2]Philipps-Universität Marburg, Germany
We present numerical modeling and experimental results demonstrating strong spatial scattering of THz radiation from a randomly micro-structured air-polymer composite material. Such materials could be used as a THz diffuser.

We P2-77 **Possibility Of THz Donor Lasing In Electrically Pumped Silicon 719**
Roman Zhukavin[1]; Valery Shastin[1]; Sergey Pavlov[2]; Heinz-Wilhelm Hübers[2]; Veniamin Tsyplenkov[1]
[1]IPM RAS, Russian Federation; [2]DLR, Germany
A possible way to create silicon terahertz laser under electric field excitation is presented. Electrical pulses with both period and duration in nanosecond range should be applied to moderately doped stressed bulk silicon. The purpose of short pulse excitation is impurity breakdown followed by capture and population of upper lasing state. The mechanisms responsible for population inversion and losses are described.

We P2-78 **THz Absorption Spectroscopy: Probing The Fast Hydrogen Bond Dynamics Around Ions And Proteins. 720**
Valeria Conti Nibali[1]; Matthias Heyden[2]; Jessica Dielmann[1]; Erik Bruendermann[1]; Martina Havenith[1]

[1]*Ruhr University, Bochum, Germany;* [2]*University of California, Department of Chemistry, Natural Sciences, Irvine, United States*
We have used THz absorption spectroscopy as a tool to probe the collective hydration dynamics of ions and proteins. Whereas in bulk water, the hydrogen bonds break and reform every picosecond on average, in the vicinity of solutes like proteins, water molecules show a retardation of hydrogen bonds rearrangement dynamics. We report here THz absorption spectroscopic measurements of anions and ions as well as proteins and explain the underlying molecular mechanism of the collective hydration dynamics.

We P2-79 **THz Microscopy Measurements On Inhibitor Dependence Of Protein Intramolecular Modes 721**

Katherine Niessen; Mengyang Xu; Edward Snell; Andrea Markelz
SUNY at Buffalo, United States
We use a rapid data acquisition technique to test reproducibility and inhibitor binding sensitivity of the recently reported narrow band resonances for lysozyme protein crystals using THz microscopy. The spectra are reproducible, and change dramatically with inhibitor binding. The results indicate the resonances arise from intramolecular modes.

We P2-80 **Development Of Broadband Frequency Tunable Gyrotron Operating At The Fundamental Resonance For 600 MHz DNP-NMR Spectroscopy 723**

Ryosuke Ikeda; Toshitaka Idehara; Yoshinori Tatematsu; Isamu Ogawa; Yuusuke Yamaguchi; Tomohiro Kanemaki; Teruo Saito
University of Fukui, Japan
A broadband frequency tunable gyrotron operating at fundamental resonance for 600 MHz DNP-NMR has been developed. A cavity resonator and a magnetron injection gun are newly designed. In the preliminary experiments, the continuously frequency tuning bandwidth was 1.3 GHz and the output power was increased up to 100 W.

We P2-81 **Low Loss Microstrip Transmission-Lines Using Cyclic Olefin Copolymer COC-substrate For Sub-THz And THz Applications 725**

Abdallah Chahadih[1]; Magdalena Chudzik[2]; Israel Arnedo[2]; Abbas Ghaddar[1]; Ivan Arregui[2]; Fernando Teberio[2]; Aintzane Lujambio[2]; Miguel A. G. Laso[2]; Txema Lopetegi[2]; Tahsin Akalin[1]
[1]*IEMN, Lille 1 University, France;* [2]*UPNA, Public University of Navarra, Pamplona, Spain*
We describe low loss microstrip transmission line with compact coplanar waveguide transitions for sub-terahertz application. The conducting transmission line is fabricated on the surface of a thin cyclic olefin copolymer dielectric layer. A vector network analyzer (VNA) has been used to obtain the transmission parameters and to validate our simulation results.

We P2-82 **Beam Deflection Lens At Terahertz Frequencies Using a Hole Lattice Metamaterial 727**

Daniel Headland[1]; Withawat Withayachumnankul[1]; Michael Webb[2]; Derek Abbott[1]
[1]*School of Electrical & Electronic Engineering, The University of Adelaide, Australia;* [2]*Centre for Defence Communications & Information Networking (CDCIN), The University of Adelaide, Australia*
The design and simulation of a dielectric lens for beam deflection in the terahertz range is presented. The device consists of a lattice of sub-wavelength holes in a rectangular dielectric slab, and by varying the radii of the holes with respect to position, a gradient index (GRIN) lens can be realised. Beam deflection is achieved by giving the refractive index a ramp-like characteristic. The lens has a flat-profile, and is likely to be more compact than lenses based on geometric optics. A Fresnel lens-like design is used to expand the lens aperture. Additionally, this lens is expected to have lower loss, higher bandwidth, and be less sensitive to polarisation than similar lenses constructed from resonant metamaterials.

Thursday	Congress Hall
	Plenary Session
08:55 – 09:40	Plenary session Th-Pl1 **Semiconductor Spectroscopy Using THz Free-Electron Lasers** *Manfred Helm* *Institute of Ion Beam Physics and Material Research, Helmholz-Zentrum Dresden-Rossendorf, Germany*
09:40 – 09:50	**Best Student Paper Prize**
09:50 – 10:35	Plenary session Th-Pl2 **Graphene Active Plasmonics For Superradiant Terahertz Lasing** *Taiichi Otsuji* *Research Institute of Electrical Communication, Tohoku University, Japan*
10:35 – 11:00	**Coffee Break (Rhein Foyer)**

Thursday	Gutenberg 1	Gutenberg 2
	Th1 Graphene 2	**Th2 Metal Meshes**
11:00 – 11:15	Th1-1 (invited talk) **Hot Carrier Multiplication In Graphene** *Soeren Jensen[1]; Klaas-Jan Tielrooij[2]; Frank Koppens[2]; Mischa Bonn[3]* *[1]MPIP, Germany; [2]The Institute of Photonic Sciences, Spain; [3]Max Planck Institute for Polymer Research, Germany*	Th2-1 **Achromatic THz Wave Plate Based On The Structured Parallel Metal Plates** *Masaya Nagai; Noriyuki Mukai; Yosuke Minowa; Masaaki Ashida* *School of Engineering Science, Osaka University, Japan*
11:15 – 11:30		Th2-2 **Microstructured Frequency Selective Quasi-Optical Components For Subterahertz And Terahertz Applications** *Sergey Kuznetsov; Mikhail Astafyev; Andrey Arzhannikov; Manfred Thumm* *Novosibirsk State University, Russian Federation*
11:30 – 11:45	Th1-3 **Intense Terahertz-Field-Induced Nonlinearity In Graphene** *Hassan Hafez* *Institut National de la Recherche Scientifique (INRS-EMT), Canada*	Th2-3 **High-Transparency Metal Mesh Filters Based On Cyclic Olefin Copolymer Films For Broadband THz Applications** *Fabio Pavanello[1]; Mohan-Babu Kuppam[2]; Frédéric Garet[2]; Emilien Peytavit[3]; Mathias Vanwolleghem[1]; François Vaurette[1]; Jean-Louis Coutaz[2]; Jean-François Lampin[1]* *[1]IEMN, France; [2]IMEP-LAHC, France; [3]IEMN, France*

Gutenberg 3	Gutenberg 4	Congress Hall
Th3 THz Spectr.: Liquids	**Th4 Imaging**	
Th3-1 (invited talk) **Terahertz Spectroscopy Of Hydrogen-Bonded Glass-Forming Liquids** *Juraj Sibik; J. Axel Zeitler* *University of Cambridge, United Kingdom*	Th4-1 **A Passive THz Imaging System Based On The Crank-Rocker Mechanism** *Jingshui Zhang[1]; Yuejin Zhao[1]; Weiwen Zhu[1]; Hong Wu[1]; Liangliang Zhang[2]; Liquan Dong[1]; Cunlin Zhang[2]* *[1]Beijing Institute of Technology, China; [2]Capital Normal University, China*	
	Th4-2 **Image Reconstruction Of Targets Illuminated By Terahertz Gaussian Beam With Phase Shift Migration Technique** *Chao Li* *Institute of Electronics, Chinese Academy of Sciences, China*	
Th3-3 **Ion Effects On Liquid Structure Of Water Monitored By Terahertz Time-Domain Spectroscopy** *Masato Kondoh[1]; Yasuhiro Ohshima[2]; Masaaki Tsubouchi[1]* *[1]Japan Atomic Energy Agency, Japan; [2]Institute for Molecular Science, Japan*	Th4-3 **Imaging Of Diffuse Objects With Dispersive Imagers** *Alex Mrozack[1]; Kalyani Krishnamurthy[1]; David J Brady[1]; Guy Lipworth[2]; David Smith[2]* *[1]Duke Imaging and Spectroscopy Program, United States; [2]Center for Metamaterials and Integrated Plasmonics, Duke University, United States*	

Thursday	Gutenberg 1	Gutenberg 2
	Th1 Graphene 2	**Th2 Metal Meshes**
11:45 – 12:00	Th1-4 **Ultrafast Graphene-Based THz Detection At Room Temperature** *Martin Mittendorff[1]; Stephan Winnerl[1]; Josef Kamann[2]; Jonathan Eroms[2]; Dieter Weiss[2]; Harald Schneider[1]; Manfred Helm[1]* *[1]Helmholtz-Zentrum Dresden-Rossendorf, Germany; [2]Universität Regensburg, Germany*	Th2-4 **Effects Of Thin Dielectric Layer On Plasmon Excitation In Perforated Metal Films** *Vaiva Kaveckyte; Rimvydas Venckevicius; Linas Minkevicius; Gediminas Raciukaitis; Gintaras Valusis; Bogdan Voisat; Irmantas Kasalynas* *Center for Physical Sciences and Technology, Lithuania*
12:00 – 12:15	Th1-5 **Terahertz Photoconductivity Of Graphene Nanostructures** *Soeren Jensen[1]; Ronald Ulbricht[2]; Akimitsu Narita[1]; Xinliang Feng[1]; Klaus Muellen[1]; Dmitry Turchinovich[1]; Tobias Hertel[3]; Mischa Bonn[1]* *[1]Max Planck Institute for Polymer Research, Germany; [2]FOM Institute for Atomic and Molecular Physics, Netherlands; [3]Julius-Maximilan University, Germany*	Th2-5 **Terahertz Electromagnetic Response Of Random-Bond Metal Mesh** *Yuichiro Okui[1]; Keisuke Takano[1]; Hideaki Kitahara[1]; Abdallah Chahadih[2]; Xiang-Lei Han[2]; Abbas Ghaddar[2]; Tahsin Akalin[2]; Masanori Hangyo[1]* *[1]Osaka University, Japan; [2]Lille 1 University, France*
12:15 – 12:30	Th1-6 **Perspectives Of Graphene SymFETs For THz Applications** *Berardi Sensale Rodriguez[1]; Pei Zhao[2]; Debdeep Jena[2]; Huili Grace Xing[2]* *[1]University of Utah and University of Notre Dame, United States; [2]University of Notre Dame, United States*	Th2-6 **Babinet's Principle, Percolation And Kramers-Kronig Relation In Metallic Checkerboard Pattern With Randomness** *Keisuke Takano[1]; Fumiaki Miyamaru[2]; Yasunori Tokuda[3]; Masanori Hangyo[1]* *[1]Osaka University, Japan; [2]Shinshu University, Japan; [3]Okayama Prefectural University, Japan*
12:30 – 14:00	**Lunch (on your own)**	

Gutenberg 3	Gutenberg 4	Congress Hall
Th3 THz Spectr.: Liquids	**Th4 Imaging**	
Th3-4 **Evaluation Of Intracellular Water Dynamics In The Picosecond Timescales Investigated By Terahertz Spectroscopy** *Keiichiro Shiraga[1]; Yuichi Ogawa[1]; Tetsuhito Suzuki[1]; Naoshi Kondo[1]; Akiyoshi Irisawa[2]; Motoki Imamura[2]* *[1]Kyoto University, Japan; [2]ADVANTEST Corporation, Japan*	Th4-4 **A Novel Active Millimeter-Wave Imaging Scheme Suitable For Fast Personal Screening** *Xiang Gao; Guangyou Fang; Chao Li* *Institute of Electronics, Chinese Academy of Sciences, China*	
Th3-5 **Microstructure Analysis Of Confined Liquids With Terahertz Time-Domain Spectroscopy** *Nicholas Tan; Lynn Gladden; Axel Zeitler* *University of Cambridge, United Kingdom*	Th4-5 (invited talk) **Image Retrieval Techniques For THz Applications In Cultural Heritage** *John Bowen[1]; Gillian Walker[1]; Soumali Roychowdhury[1]; Bianca Jackson[2]; John Roberts[1]; Julien Labaune[3]; Gerard Mourou[3]; Wendy Matthews[1]; Michel Menu[4]; Ian Hodder[5]* *[1]University of Reading, United Kingdom; [2]University of Rochester, United States; [3]Ecole Polytechnique, France; [4]C2RMF, France; [5]Stanford University, United States*	
Th3-6 **A New Method For Alcohol Content Determination Of Fuel Oils By Terahertz Spectroscopy** *Enis Arýk; Can Koral; Hakan Altan; Okan Esentürk* *Middle East Technical University, Turkey*		
Lunch (on your own)		

Thursday	Gutenberg 1	Gutenberg 2
	Th5 Electr. Sourc. & Detec.	**Th6 Solid State Physics**
14:00 – 14:15	Th5-1 (invited talk) **Balanced Medium Power Amplifier MMICs From 200 To 270 GHz** *Joachim Längst[1]; Sebastian Diebold[2]; Hermann Massler[3]; Sandrine Wagner[3]; Axel Tessmann[3]; Arnulf Leuther[3]; Thomas Zwick[2]; Ingmar Kallfass[1]* *[1]University of Stuttgart, Germany; [2]Karlsruhe Institute of Technology, Germany; [3]Fraunhofer Institute for Applied Solid State Physics, Germany*	Th6-1 **Coherent Control Of Ultrafast Photocurrents Using Polarization-Shaped Optical Pulses** *Shekhar Priyadarshi[1]; Klaus Pierz[2]; Mark Bieler[2]* *[1]PTB Braunschweig, Germany; [2]Physikalisch-Technische Bundesanstalt, Germany*
14:15 – 14:30		Th6-2 **Spin-Polarized Currents Of Dirac Fermions At Cyclotron Resonance** *Sergey Ganichev[1]; Christina Zoth[1]; Patricia Vierling[1]; Kathrin-Maria Dantscher[1]; Grigory Budkin[2]; Sergey Tarasenko[2]; Vasily Bel'kov[2]; Dimitry Kozlov[3] et al.* *[1]University of Regensburg, Germany; [2]A.F. Ioffe Physical-Technical Institute, Russian Fedearation; [3]ISP SB RAS, Russian Federation*
14:30 – 14:45	Th5-3 **A 220GHz Frequency Doubler Based On Plannar Schottky Diodes** *Peng Chen* *Institute of Electronic Engineering, China Academy of Engineering Physics, China*	Th6-3 **Single-Pulse Terahertz Coherent Control Of Spin Resonance In A Canted Antiferromagnet** *Zuanming Jin[1]; Zoltan Mics[1]; Guohong Ma[2]; Zhenxiang Cheng[3]; Mischa Bonn[1]; Dmitry Turchinovich[1]* *[1]Max Planck Institute for Polymer Research, Germany; [2]Shanghai University, China; [3]University of Wollongong, Australia*

Gutenberg 3	Gutenberg 4	Congress Hall
Th7 Quasi-Optical Devices	**Th8 Sensing**	
Th7-1 **High Reflectivity THz Multilayer Mirrors For Spectral Filtering Of Pulsed Far-Infrared Free Electron Laser** *Patrick Balzerowski[1]; Erik Bründermann[1]; Gerhard W. Schwaab[1]; Jens Soetebier[1]; Trung Quan Luong[1]; Wim J. van der Zande[2]; Rienk T. Jongma[2]; Martina Havenith[1]* *[1]Ruhr-Universität Bochum, Germany; [2]Radboud University, Netherlands*	Th8-1 **Terahertz Nano-Film Sensing Based On Metallic Rod Array** *Borwen You[1]; Chien-Chun Peng[2]; Jia-Shing Jhang[3]; Cheng-Han Ho[2]; Ja-Yu Lu[2]; Chin-Ping Yu[3]; Tze-An Liu[4]; Jin-Long Peng[4]; Chi-Kuang Sun[1]* *[1]Molecular Imaging Center, Taiwan; [2]National Cheng Kung University, Taiwan; [3]National Sun Yat-Sen University, Taiwan; [4]Industrial Technology Research Institute, Taiwan*	
Th7-2 **Apodized Fiber Bragg Gratings For Terahertz Applications** *Laurence Reekie; Shu Fan Zhou; Hau Ping Chan; Kwai Man Luk; Yuk Tak Chow* *City University of Hong Kong, Hong Kong*	Th8-2 **Probing Frequency Selective Surfaces With Terahertz Subwavelength Fibers** *Martin Girard; Maksim Skorobogatiy; Andrey Markov* *École Polytechnique de Montréal, Canada*	
Th7-3 **Design Of Terahertz Wire-Grid Polarizer Of Laminated Parallel Plates On Cyclo Olefin Polymer Films For High Extinction Ratio Less Than 10^{-6}** *Yudai Kishi[1]; Masaya Nagai[2]; John Young[3]; Keisuke Takano[2]; Motoki Asai[2]; Masanori Hangyo[2] et al.* *[1]Ibaraki University, Japan; [2]Osaka University, Japan; [3]University of Kentucky, United States*	Th8-3 **Chemical Analysis Of Exhaled Human Breath Using A Novel Sub-Millimeter/Terahertz Spectroscopic Approach** *Ivan Medvedev; Alyssa Fosnight; Benjamin Moran; Daniela Branco; Jessica Thomas* *Wright State University, United States*	

Thursday	Gutenberg 1	Gutenberg 2
	Th5 Electr. Sourc. & Detec.	**Th6 Solid State Physics**
14:45 – 15:00	Th5-4 **Broadband Zero-Bias Schottky Detector For E-field Measurements Up To 100 GHz And Beyond** *Matthias Hoefle[1]; Andreas Penirschke[1]; Oleg Cojocari[2]; Rolf Jakoby[1]* *[1]TU Darmstadt, Germany; [2]ACST GmbH, Germany*	Th6-4 **Dynamical Spin Reorientation Transition In Orthoferrite $NdFeO_3$ Studied With Terahertz Time-Domain Spectroscopy** *Guohong Ma; Junjie Jiang; Zuangming Jin; shixun Cao* *Shanghai University, China*
15:00 – 15:15	Th5-5 **Terahertz Monochromatic Coherent Emission From An Asymmetric Chirped Dual-Grating-Gate InP-HEMT With A Photonic Vertical Cavity** *Takayuki Watanabe[1]; Yuki Kurita[1]; Akira Satou[1]; Tetsuya Suemitsu[1]; Wojciech Knap[2]; Viacheslav Popov[3] et al.* *[1]Tohoku University, Japan; [2]Universite Montpellier 2 & CNRS, France; [3]Russian Academy of Sciences, Russian Federation*	Th6-5 **Electromagnon In The Pyroelectric Ferrimagnet ε-Fe_2O_3** *Filip Kadlec[1]; Jan Prokleška[2]; Maxim Savinov[1]; Veronica Goian[1]; Martí Gich[3]; Milan Orlita[4]; Stanislav Kamba[1] et al.* *[1]Institute of Physics, v.v.i., Acad. Sci.,Czech Republic; [2]Charles University, Czech Republic; [3]Institut de Ciència de Materials de Barcelona, Spain; [4]Grenoble High Magnetic Field Lab, France*
15:15 – 15:30	Th5-6 **Room-Temperature Terahertz Heterodyne Mixing In GaAs Commercial Transistors** *Lucie Tohme; Stéphane Blin; Luca Varani; Philippe Nouvel; Annick Panarier* *University of Montpellier 2, France*	Th6-6 **Terahertz-Field-Induced Photoluminescence Of Nanostructured Gold Films** *Krzysztof Iwaszczuk; Radu Malureanu; Maksim Zalkovskij; Andrew Strikwerda; Peter Jepsen* *DTU Fotonik, Denmark*
15:30 – 16:00	**Coffee Break (Rhein Foyer)**	

Gutenberg 3	Gutenberg 4	Congress Hall
Th7 Quasi-Optical Devices	**Th8 Sensing**	
Th7-4 **Highly Refracting Terahertz Lenses Made Of Polymeric Compounds** *Matthias Wichmann[1]; Abdullah-Saif Mondol[2]; Nikola Kocic[3]; Sina Lippert[1]; Thorsten Probst[1]; Steffen Schumann[1]; Michael Schwerdtfeger[1]; Thomas Hochrein[3] et al.* *[1]Philipps-Universität Marburg, Germany; [2]Rhine-Waal University of Applied Sciences, Germany; [3]SKZ – German Plastics Center, DE*	Th8-4 **Terahertz Sensing Of Supercooled Glycerol Using A 1D Photonic Crystal** *Juraj Sibik[1]; Hynek Nemec[2]; Christelle Kadlec[2]; Filip Kadlec[2]; Vladimir Skoromets[2]; Karine Blary[3]; J. Axel Zeitler[1]; Petr Kuzel[2]* *[1]University of Cambridge, United Kingdom; [2]Academy of Sciences of the Czech Republic, Czech Republic; [3]Universite Lille Nord de France, France*	
Th7-5 **Design, Fabrication, And Measurement Of Dielectric Reflectarray Antennas At 100 GHz** *Min Liang[1]; Payam Nayeri[2]; Rafael Sabory-García[1]; Mingguang Tuo[1]; Fan Yang[3]; Michael Gehm[1]; Hao Xin[1]; Atef Z. Elsherbeni[2]* *[1]University of Arizona, Unites States; [2]University of Mississippi, Unites States; [3]Tsinghua University, China*	Th8-5 (invited talk) **Performance Evaluation Of An Integrated Terahertz Sensor For Biomolecule Detection In Liquid Phase** *Vladimir Matvejev; Yuchen Zhang; Johan Stiens* *Vrije Universiteit Brussel, Belgium*	
Th7-6 **Nanoantenna-Enhanced Mid-IR Vibration Spectroscopy With Single Molecular Layer Sensitivity** *Frank Neubrech; Daniel Dregely; Jun Zhao; Harald Giessen* *4th Physics Institute and Research Center SCoPE, University of Stuttgart, Germany*		
Coffee Break (Rhein Foyer)		

Thursday	Gutenberg 1	Gutenberg 2
	Th10 Mixers	**Th11 Superconductors**
16:00 – 16:15	Th10-1 (invited talk) **Sub-Harmonic Mixing at 591 GHz In AlGaAs/InGaAs Two-Dimensional Electron Gas Transistors** *Alessandra Di Gaspare[1]; Valeria Giliberti[1]; Ennio Giovine[1]; Sebastian Boppel[2]; Alvydas Lisauskas[2]; Hartmut G. Roskos[2]; Michele Ortolani[3]* *[1]CNR-Institute for Photonics and Nanotechnologies, Italy; [2]Physikalisches Institut, Johann Wolfgang Goethe-Universität Frankfurt, Germany; [3]Physics Department, Sapienza University of Rome, Italy*	Th11-1 (invited talk) **Intense THz Pulse-Induced Higgs Amplitude Mode In A BCS Superconductor $Nb_{1-x}Ti_xN$** *Ryusuke Matsunaga[1]; Yuki I. Hamada[1]; Kazumasa Makise[2]; Yoshinori Uzawa[3]; Hirotaka Terai[2]; Zhen Wang[2]; Ryo Shimano[1]* *[1]The University of Tokyo, Japan; [2]National Institute of Information and Communication Technology, Japan; [3]National Astronomical Observatory of Japan, Japan*
16:15 – 16:30		
16:30 – 16:45	Th10-3 **Hot Electron Bolometer Waveguide Mixers Up To 4.7 THz For The upGREAT Focal Plane Array Receiver On SOFIA** *Patrick Pütz; Cornelia E. Honingh; Denis Büchel; Karl Jacobs; Michael Schultz; Jürgen Stutzki* *KOSMA, 1. Physikalisches Institut, Universität zu Köln, Germany*	Th11-3 **Phase-Sensitive THz Nonlinear Spectroscopy In High-T_c Superconductor Thin Film** *Masaya Nagai; Eiichi Matsubara; Masaaki Ashida* *School of Engineering Science, Osaka University, Japan*

Gutenberg 3	Gutenberg 4	Congress Hall
Th12 THz Spectr.: Semico. 1	**Th13 Non-Destructive Test.**	
Th12-1 (invited talk) **THz Free-Electron Laser Spectroscopy Of Magnetoexcitons In Semiconductor Quantum Wells** *Jayeeta Bhattacharyya[1]; Sabine Zybell[1]; Stephan Winnerl[1]; Lukas Schneebeli[2]; Christoph Böttge[2]; Benjamin Breddermann[2]; Mackillo Kira[2]; Stephan W. Koch[2]; Manfred Helm[1]; Harald Schneider[1]* *[1]Helmholtz-Zentrum Dresden-Rossendorf, Germany; [2]University of Marburg, Germany*	Th13-1 **Millimeter-Wave Non-Destructive Testing Of A Cured In Place Pipe Sample** *Moll Jochen[1]; Maryam Manavipour[2]; Christoph Sklarczyk[2]; Viktor Krozer[1]; Christian Boller[2]* *[1]Goethe University Frankfurt am Main, Germany; [2]Fraunhofer Institute for Nondestructive Testing, Germany*	
	Th13-2 **Structural Health Monitoring Using A Scanning THz System** *Marijke Vandewal[1], coordinator for the DOTNAC project consortium[2]* *[1]Royal Military Academy, Belgium; [2]http://www.dotnac-project.eu/vpage/1/0/Project-Partners*	
Th12-3 **Terahertz Nonlinear Optics In Semiconductors** *Dmitry Turchinovich[1]; Jørn Hvam[2]; Matthias Hoffmann[3]* *[1]Max Planck Institute for Polymer Research, Germany; [2]DTU Fotonik, Technical University of Denmark, Denmark; [3]SLAC Linear Accelerator Laboratory, United States*	Th13-3 **Inline Multilayer Thickness Sensing By Using Terahertz Time-Domain Spectroscopy In Reflection Geometry** *Soufiene Krimi; Jens Klier; Michael Herrmann; Joachim Jonuscheit; René Beigang* *Fraunhofer Institute for Physical Measurement Techniques, Germany*	

Thursday	Gutenberg 1	Gutenberg 2
	Th10 Mixers	**Th11 Superconductors**
16:45 – 17:00	Th10-4 **Planar D-Band Frequency Doubler And Y-Band Tripler On PTFE Laminates** *Michael Hrobak[1]; Michael Sterns[1]; Andreas Ziroff[2]; Wadim Stein[1]; Jan Schuer[1]; Lorenz-Peter Schmidt[1]; Florian Poprawa[2]* *[1]Friedrich-Alexander University / Institute of Microwaves and Photonics (LHFT), Germany; [2]Siemens AG Corporate Technology, Munich, Germany*	Th11-4 **Evaluation Of Terahertz Emission From Intrinsic Josephson Junctions Using A High-T_c Superconductor Grain Boundary Josephson Junction** *Deyue An[1]; Jie Yuan[2]; Nickolay Kinev[3]; Mengyue Li[1]; Xianjing Zhou[1]; Min Ji[1]; Ya Huang[1]; Takeshi Hatano[2] et al.* *[1]Nanjing University, China; [2]National Institute for Materials Science, Japan; [3]IRE RAS, Russian Federation*
17:00 – 17:15	Th10-5 **Millimeter-Wave Mixer Measurement: Comparison Of Different Methods** *Itziar Maestrojuan[1]; Simon Rea[2]; Iñigo Ederra[3]; Ramon Gonzalo[3]* *[1]Electrical and Electronic Engineering Department, Spain; [2]Millimetre Technology Group, Rutherford Appleton Laboratory, United Kingdom; [3]Public University of Navarra, Spain*	Th11-5 **Photosensitivity Of Lead Telluride Doped With Mixed Valence Impurities In The Terahertz Spectral Range** *Dmitriy Khokhlov[1]; Vladimir Chernichkin[1]; Alexandre Dobrovolsky[1]; Andrey Nicorici[2]; Sergey Danilov[3]; Ludmila Ryabova[1]* *[1]Moscow State University, Russian Federation; [2]IAP, Acad. of Science, Republic of Moldova; [3]University of Regensburg, Germany*
17:15 – 17:30	Th10-6 **THz Schottky Diode Harmonic Mixers For QCL Phase-Locking** *Jeffrey Hesler[1]; Berhanu Bulcha[1]; David Kurtz[1]; Chris Groppi[2]; Scott Barker[3]* *[1]Virginia Diodes Inc., United States; [2]Arizona State University, United States; [3]University of Virginia, United States*	Th11-6 **Towards Practical Applications Of THz Josephson Oscillators With Sub-mW Power And 500 GHz Frequency Tunability** *Huabing Wang[1]; Jie Yuan[1]; Deyue An[2]; Nickolay Kinev[3]; Mengyue Li[2]; Xianjing Zhou[2]; Min Ji[2]; Ya Huang[2]; Takeshi Hatano[1] et al.* *[1]National Institute for Materials Science, Japan; [2]Nanjing University, China; [3]IRE RAS, Russian Federation*
17:30 – 18:45	**Poster session P3 (Rhein Foyer West)**	

Gutenberg 3	Gutenberg 4	Congress Hall
Th12 THz Spectr.: Semico. 1	**Th13 Non-Destructive Test.**	**Th14**
Th12-4 **Probing The Critical Electronic Properties Of III-V Nanowires Using Optical Pump-Terahertz Probe Spectroscopy** *Hannah Joyce[1]; Callum Docherty[1]; Chaw-Keong Yong[1]; Jennifer Wong-Leung[2]; Qiang Gao[2]; Suriati Paiman[2]; Hark Hoe Tan[2]; Chennupati Jagadish[2] et al.* *[1]University of Oxford, United Kingdom; [2]The Australian National University, Australia*	Th13-4 **Measuring A Crack: Three-Dimensional Imaging Of Sub-Wavelength Fractures In Sculpture And Construction Materials** *Michael Schwerdtfeger[1]; Kirsti Krügener[2]; Wolfgang Viöl[2]; Martin Koch[1]; Enrique Castro-Camus[3]* *[1]Philipps-Univ. Marburg, Germany; [2]Univ. of Applied Sciences and Arts, Germany; [3]Centro de Investigaciones en Optica A.C., Mexico*	Th14-4
Th12-5 **Fast Relaxation Of Free Carriers In Compensated n- And p-type Germanium** *Nils Deßmann[1]; Sergey Pavlov[2]; Martin Mittendorff[3]; Stephan Winnerl[3]; Roman Zhukavin[4]; Veniamin Tsyplenkov[4]; Vladimir Shengurov[4]; Valery Shastin[4]; Nikolai Abrosimov[5] et al.* *[1]TU Berlin, Germany; [2]DLR, Germany; [3]HZDR, Germany; [4]IPM RAS, Russian Federation; [5]IKZ, Germany*	Th13-5 **THz Non-Destructive Evaluation Using Correlation Processing** *Samuel Henry[1]; Orlando Baiocchi[1]; Lisa Zurk[2]* *[1]University of Washington, Tacoma, United States; [2]Portland State University, United States*	Th14-5
Th12-6 **Determining Carrier Multiplication Efficiencies: Time-Resolved Terahertz Spectroscopy On Colloidal Quantum Dot Solutions** *Alexander Knight-Percival[1]; Ben F. Spencer[1]; Steven P. Jamison[2]; Wendy R. Flavell[1]; Darren M. Graham[1]* *[1]University of Mancester, United Kingdom; [2]Cockroft Institute, ASTeC, STFC Daresbury Laboratory, United Kingdom*	Th13-6 **THz Bragg Gratings By CO_2 Laser Inscription And Their Application To Monitoring Of Paper Quality** *Guofeng Yan[1]; Yasser Chinifooroshan[2]; Wojtek J. Bock[2]; Maksim Skorobogatiy[1]; Saurabh Tripathi[2]* *[1]Ecole Polytechnique de Montreal, Canada; [2]Université du Québec en Outaouais, Canada*	Th14-6
Poster session P3 (Rhein Foyer West)		

Thursday, September 5th

Th Pl1 **08:55 - 09:40** **Thursday Plenary 1** **Congress Hall**
Chair: Gian Piero Gallerano

Semiconductor Spectroscopy Using THz Free-Electron Lasers **729**
Manfred Helm
Institute of Ion Beam Physics and Material Research, Helmholz-Zentrum Dresden-Rossendorf, Germany

I will briefly review the history of THz free-electron lasers (FEL) as versatile sources for semiconductor spectroscopy and present some recent experiments using the FEL in Dresden.

Th Pl2 **09:50 - 10:35** **Thursday Plenary 2** **Congress Hall**
Chair: X.-C. Zhang

Graphene Active Plasmonics For Superradiant Terahertz Lasing **731**
Taiichi Otsuji
Research Institute of Electrical Communication, Tohoku University, Japan

We theoretically discovered and experimentally manifested that the carrier population inversion in graphene results in stimulating emission of plasmons with a giant gain, leading to superradiant terahertz lasing from a structured graphene.

Th1 **11:00 - 12:30** **Graphene 2** **Gutenberg 1**
Chair: Dmitry Khokhlov

Th1-1 11:00 **Hot Carrier Multiplication In Graphene** **735**
Soeren Jensen[1]; Klaas-Jan Tielrooij[2]; Frank Koppens[2]; Mischa Bonn[3]
[1]MPIP, Germany; [2]The Institute of Photonic Sciences, Spain; [3]Max Planck Institute for Polymer Research, Germany
The efficiency of hot carrier multiplication in monolayer graphene was studied using optical pump-THz probe spectroscopy. An energy conversion efficiency from photon to hot electrons exceeding 75 % was found.

Th1-3 11:30 **Intense Terahertz-Field-induced Nonlinearity In Graphene** **737**
Hassan Hafez
Institut National de la Recherche Scientifique (INRS-EMT), Canada
We report nonlinear terahertz effects in monolayer graphene using intense few-cycle THz pulses. We observe enhancement in the THz transmission through graphene when we increase the THz electric field. Following photo-excitation, we observed reduction in the THz transmission. This photo-induced reduction in the THz transmission is found to decrease when we increase the THz electric field.

Th1-4 11:45 **Ultrafast Graphene-based THz Detection At Room Temperature** **739**
Martin Mittendorff[1]; Stephan Winnerl[1]; Josef Kamann[2]; Jonathan Eroms[2]; Dieter Weiss[2]; Harald Schneider[1]; Manfred Helm[1]
[1]Helmholtz-Zentrum Dresden-Rossendorf, Germany; [2]Universität Regensburg, Germany
We present an ultrafast terahertz detector suitable for wavelengths from 30 µm to 220 µm, which is based on a graphene flake. A logarithmic-periodic antenna is used to couple the radiation to the flake. The detector, characterized by a fast rise time combined with room temperature operation, is well suited for determining timing differences of THz laser pulses.

Th1-5 12:00 **Terahertz Photoconductivity Of Graphene Nanostructures 740**

Soeren Jensen[1]; Ronald Ulbricht[2]; Akimitsu Narita[1]; Xinliang Feng[1]; Klaus Muellen[1]; Dmitry Turchinovich[1]; Tobias Hertel[3]; Mischa Bonn[1]
[1]Max Planck Institute for Polymer Research, Germany; [2]FOM Institute for Atomic and Molecular Physics, Netherlands; [3]Julius-Maximilan University, Germany

We present an ultrafast terahertz detector suitable for wavelengths from 30 μm to 220 μm, which is based on a graphene flake. A logarithmic-periodic antenna is used to couple the radiation to the flake. The detector, characterized by a fast rise time combined with room temperature operation, is well suited for determining timing differences of THz laser pulses.

Th1-6 12:15 **Perspectives Of Graphene SymFETs For THz Applications 742**

Berardi Sensale Rodriguez[1]; Pei Zhao[2]; Debdeep Jena[2]; Huili Grace Xing[2]
[1]University of Utah and University of Notre Dame, United States; [2]University of Notre Dame, United States

We explore the potential of graphene symmetric tunneling field effect transistors (SymFETs) for THz applications. The interplay between the negative differential conductance in these devices and electron plasma waves occurring in the graphene layers might lead to very sensitive THz detection (R > 100 kV/W) or amplifiers with power gains ~7 dB at RT.

Th2 11:00 - 12:30 Metal Meshes Gutenberg 2
Chair: Ken Wood

Th2-1 11:00 **Achromatic THz Wave Plate Based On The Structured Parallel Metal Plates 743**

Masaya Nagai; Noriyuki Mukai; Yosuke Minowa; Masaaki Ashida
School of Engineering Science, Osaka Univ., Japan

We propose a simple THz wave plate based on the structured parallel metal plates. The fast and slow propagation properties for TE and TM waveguide modes bring in the controllable birefringence in wide frequency region. Using this optics, we experimentally obtained intense single-cycle THz pulse with the circular polarization.

Th2-2 11:15 **Microstructured Frequency Selective Quasi-Optical Components for Subterahertz And Terahertz Applications 745**

Sergey Kuznetsov; Mikhail Astafyev; Andrey Arzhannikov; Manfred Thumm
Novosibirsk State University, Russian Federation

We overview the results of extensive research-and-development activities on elaborating novel microstructured components of quasi-optical instrumentation for the terahertz band. The components include frequency filters, non-profiled focusing devices, polarization transformers, ultra-thin absorbers and absorber-based bolometric sensors.

Th2-3 11:30 **High-transparency Metal Mesh Filters Based On Cyclic Olefin Copolymer Films For Broadband THz Applications. 747**

Fabio Pavanello[1]; Mohan-Babu Kuppam[2]; Frédéric Garet[3]; Emilien Peytavit[4]; Mathias Vanwolleghem[1]; François Vaurette[1]; Jean-Louis Coutaz[2]; Jean-François Lampin[1]
[1]IEMN - UMR CNRS 8520, France; [2]IMEP-LAHC UMR CNRS 5130, France; [3]IMEP-LAHC, UMR CNRS 5130, France; [4]IEMN, UMR CNRS 8520, France

Here, we demonstrate the possibility of employing a novel low-loss dielectric material as substrate for free-space THz devices through the design, fabrication and characterization of broadband high-transparency high-pass mesh filters. Time-domain spectroscopy measurements show that a transmittance higher than 75 % is achieved over a bandwidth of 1 THz.

Th2-4 11:45 **Effects Of Thin Dielectric Layer On Plasmon Excitation In Perforated Metal Films 749**
Vaiva Kaveckyte; Rimvydas Venckevicius; Linas Minkevicius; Gediminas Raciukaitis; Gintaras Valusis; Bogdan Voisat; Irmantas Kasalynas
Center for Physical Sciences and Technology, Lithuania
Transmission and reflection spectra of resonant metallic filters fabricated by the laser direct writing technique were investigated in terahertz frequency range. Effect of thin dielectric layer on surface waves excitation was observed as a larger red shift of the transmittance peak dependent of dielectric film thickness and metal film surface smoothness.

Th2-5 12:00 **Terahertz Electromagnetic Response Of Random-Bond Metal Mesh 751**
Yuichiro Okui[1]; Keisuke Takano[1]; Hideaki Kitahara[1]; Abdallah Chahadih[2]; Xiang-Lei Han[2]; Abbas Ghaddar[2]; Tahsin Akalin[2]; Masanori Hangyo[1]
[1]Osaka University, Japan; [2]Lille 1 University, France
A metal mesh shows Drude-like metallic effective permittivity dispersion. By cutting all wires of the mesh, the metal mesh becomes a metal cross array and shows Lorentz-like effective permittivity dispersion. We prepared the samples of metal mesh with random cut systematically and measured the transmission spectra in the terahertz region. The spectra show a characteristic change from metallic to insulating ones through the percolation limit.

Th2-6 12:15 **Babinet's Principle, Percolation, And Kramers-Kronig Relation In Metallic Checkerboard Pattern With Randomness 753**
Keisuke Takano[1]; Fumiaki Miyamaru[2]; Yasunori Tokuda[3]; Masanori Hangyo[1]
[1]Osaka University, Japan; [2]Shinshu University, Japan; [3]Okayama Prefectural University, Japan
Terahertz transmission spectra of metallic checkerboard patterns with randomness have been investigated systematically. The spectrum changes from capacitive type to inductive one rapidly with the nominal size of the metal squares around the critical size with invariant-transmission at some frequencies. The characteristic properties of the transmission spectra are interpreted in terms of the Babinet's principle, percolation, and Kramers-Kronig relation.

Th3 11:00 - 12:30 THz Spectroscopy: Liquids Gutenberg 3
Chair: Thomas Dekorsy

Th3-1 11:00 **Terahertz Spectroscopy Of Hydrogen-Bonded Glass-Forming Liquids 755**
Juraj Sibik; J. Axel Zeitler
University of Cambridge, United Kingdom
We have measured the temperature dependent changes in the terahertz spectra of three different amorphous polyols: sorbitol, glycerol and xylitol. As samples of each material are heated from temperatures well below its glass transition temperature, T_g, to temperatures close to its melting point a clear change in absorption coefficient at T_g is observed in all three samples. In addition, the spectra of sorbitol and xylitol both reveal a marked change in absorption coefficient at temperatures of 0.6 T_g. This change indicates a change in molecular mobility that we attribute to a secondary relaxation process.

Th3-3 11:30 **Ion Effects On Liquid Structure Of Water Monitored By Terahertz Time-Domain Spectroscopy 758**
Masato Kondoh[1]; Yasuhiro Ohshima[2]; Masaaki Tsubouchi[3]
[1]Japan/Japan Atomic Energy Agency, Japan; [2]Institute for Molecular Science, Japan; [3]Japan Atomic Energy Agency, Japan
We have investigated dielectric relaxation in aqueous ionic solutions by terahertz time-domain spectroscopy to elucidate the ionic hydration effect on the structure of water. Our finding suggests the dissolved ion induces the "structure breaking effect" which weakens the hydrogen bonding of water beyond the ion hydration shell.

Th3-4 11:45 **Evaluation Of Intracellular Water Dynamics In The Picosecond Timescales Investigated By Terahertz Spectroscopy 760**

Keiichiro Shiraga[1]; Yuichi Ogawa[1]; Tetsuhito Suzuki[1]; Naoshi Kondo[1]; Akiyoshi Irisawa[2]; Motoki Imamura[2]
[1]Kyoto University, Japan; [2]ADVANTEST Corporation, Japan

The complex dielectric constant of human cultured cell, HeLa, is determined in the terahertz region. Since they are sensitive to picosecond motions, intracellular water dynamics mediated by hydrogen bonds are discussed. As a result, it is suggested that about 25 % of water molecules are slightly perturbed and hydrogen bonds are more "unstructured" in the cellular milieu, indicating 6 % of total intracellular water molecules are isolated from hydrogen bond network of water.

Th3-5 12:00 **Microstructure Analysis Of Confined Liquids With Terahertz Time-domain Spectroscopy 762**

Nicholas Tan; Lynn Gladden; Axel Zeitler
University of Cambridge, United Kingdom

We present the first systematic study of the terahertz absorption spectra of confined polar liquids in porous catalysts. The spectra of liquid loaded MCM-41 are acquired using THz time domain spectroscopy over the frequency range of 0.5 – 2.5 THz. The spectra are also compared against bulk liquids to determine the effects of confinement.

Th3-6 12:15 **A New Method For Alcohol Content Determination Of Fuel Oils By Terahertz Spectroscopy 764**

Enis Arýk; Can Koral; Hakan Altan; Okan Esentürk
Middle East Technical University, Turkey

In this study, we developed a simple method for alcohol content analysis in fuel oils by Time-Domain Terahertz (THz) Spectroscopy. Frequency dependent absorption coefficients, refractive indices, and dielectric constants were calculated from the measurements of pure fuel oils and their mixtures with ethanol. Ethanol mixtures of gasoline were modeled successfully with a simple model in which the mixture behavior was described with a basic contribution approach of pure liquids. The results suggest that there is no strong interaction between the ethanol and the molecules in the gasoline. We concluded that this new approach offers a simple and useful method to determine the concentration of ethanol in gasoline currently with a 3% (by volume) maximum absolute error. With improvements, this error would be reduced to below 1%.

Th4 11:00 - 12:30 Imaging Gutenberg 4
Chair: Tahsin Akalin

Th4-1 11:00 **A Passive THz Imaging System Based On The Crank-rocker Mechanism 765**

Jingshui Zhang[1]; Yuejin Zhao[1]; Weiwen Zhu[1]; Hong Wu[1]; Liangliang Zhang[2]; Liquan Dong[1]; Cunlin Zhang[2]
[1]Beijing Institute of Technology, China; [2]Capital Normal University, China

A novel passive single-channel THz imaging system employing a Cassegrain antenna of 390 mm in diameter and Schottky diodes as detecting part, and the cooperation of a high-speed line scanning mirror driven by a crank-rocker mechanism and a frame scanning mirror as two-dimensional optical-mechanical scanning part is described in this paper. The single frame imaging time of the system is only 20 s, the field of view (FOV) is 30° × 36°, and the angle resolution is up to 0.6°. The experimental results show that the low cost, simple structure and efficient system can clearly image the human body, and effectively detect dangerous items concealed under the clothes.

Th4-2 11:15 **Image Reconstruction Of Targets Illuminated By Terahertz Gaussian Beam With Phase Shift Migration Technique 767**

Chao Li
Institute of Electronics, Chinese Academy of Sciences, China

Phase shift migration was extended for THz imaging. 3D point-spread function was derived to evaluate the quantitative relationship between the image qualities and the Gaussian beam parameters. Theoretical results were verified by simulations and 0.2 THz proof-of-principle experiments.

Th4-3 11:30 **Imaging Of Diffuse Objects With Dispersive Imagers 769**

Alex Mrozack[1]; Kalyani Krishnamurthy[1]; David J Brady[1]; Guy Lipworth[2]; David Smith[2]
[1]Duke Imaging and Spectroscopy Program, United States; [2]Center for Metamaterials and Integrated Plasmonics, Duke University, United States

Dispersive imagers measure multiple speckle realizations of the object to be estimated. This poses a challenge for coherent imaging as classically objects are backpropagated and then despeckled. We present initial findings on an intensity based method for estimating the scattering density.

Th4-4 11:45 **A Novel Active Millimeter-wave Imaging Scheme Suitable For Fast Personal Screening 771**

Xiang Gao; Guangyou Fang; Chao Li
Institute of Electronics, Chinese Academy of Sciences, China

A millimeter-wave (MMW) imaging scheme suitable for fast personal screening was presented, which employs special quasi-optics design to generate a spot beam with nearly translational scanning pattern to ensure the image uniformity. Experimental results based on a prototype system demonstrate its capability for concealed threat objects detection.

Th4-5 12:00 **Image Retrieval Techniques For THz Applications In Cultural Heritage 773**

John Bowen[1]; Gillian Walker[1]; Soumali Roychowdhury[1]; Bianca Jackson[2]; John Roberts[1]; Julien Labaune[3]; Gerard Mourou[3]; Wendy Matthews[1]; Michel Menu[4]; Ian Hodder[5]
[1]University of Reading, United Kingdom; [2]University of Rochester, United States; [3]Ecole Polytechnique, France; [4]C2RMF, France; [5]Stanford University, United States

Techniques to retrieve reliable images from complicated objects are described, overcoming problems introduced by uneven surfaces, giving enhanced depth resolution and improving image contrast. The techniques are illustrated with application to THz imaging of concealed wall paintings.

Th5 14:00 - 15:30 Electronic Sources & Detectors Gutenberg 1
Chair: Jan Stake

Th5-1 14:00 **Balanced Medium Power Amplifier MMICs From 200 To 270 GHz 775**

Joachim Längst[1]; Sebastian Diebold[2]; Hermann Massler[3]; Sandrine Wagner[3]; Axel Tessmann[3]; Arnulf Leuther[3]; Thomas Zwick[2]; Ingmar Kallfass[1]
[1]University of Stuttgart, Germany; [2]Karlsruhe Institute of Technology, Germany; [3]Fraunhofer Institute for Applied Solid State Physics, Germany

Balanced amplifier monolithic millimeter-wave integrated circuits (MMICs) for application in high resolution radar and wireless communication with an output power of up to 7.5 dBm at 210 GHz are shown in this paper. The small-signal gain is more than 13 dB from 200 to 270 GHz and more than 23 dB between 200 and 240 GHz, respectively. Air bridge microstrip transmission lines are used for matching, biasing and for the design of 90° hybrid couplers.

Th5-3 14:30 **A 220GHz Frequency Doubler Based On Plannar Schottky Diodes 778**

Peng Chen
Institute of Electronic Engineering, China Academy of Engineering Physics, China

The development of a 220GHz frequency doubler based on GaAs plannar Schottky diodes is described in this paper. The doubler works at room temperature, and its structure is very simple. A plannar Schottky varactor flip chip which has four anodes arranged in anti-series is mounted onto a quartz based microstrip circuit to realize frequency multiplication. DC bias is put on the varactor through a low-pass filter circuit which is also constructed on a quartz microstrip. All the quartz circuits are glued into the waveguide block with conductive adhesive. The block is split in the E-plane and the surface of it is gold plated. Test data for the 220 GHz doubler show 15 mW output power with 5 % efficiency when appropriate external bias resister is selected. Over the 213~230 GHz band, the output power of the doubler is above 10 mW, and the power fluctuation in this band is very small.

Th5-4 14:45 **Broadband Zero-Bias Schottky Detector For E-field Measurements Up To 100 GHz And Beyond 780**

Matthias Hoefle[1]; Andreas Penirschke[1]; Oleg Cojocari[2]; Rolf Jakoby[1]
[1]TU Darmstadt, Germany; [2]ACST GmbH, Germany

A broadband detector for electrical field measurements is presented in this paper, deploying an attenuated dipole resonance. High sensitive zero-bias Schottky diodes with anode diameters of 1.5 µm allow electrical field characterization down to 1.6 V/m at millimeter wave frequencies. The covered frequency range from 1 to 100 GHz shows a potential voltage response flatness of ±1 dB.

Th5-5 15:00 **Terahertz Monochromatic Coherent Emission From An Asymmetric Chirped Dual-Grating-Gate InP-HEMT With A Photonic Vertical Cavity 782**

Takayuki Watanabe[1]; Yuki Kurita[1]; Akira Satou[1]; Tetsuya Suemitsu[1]; Wojciech Knap[2]; Viacheslav Popov[3]; Taiichi Otsuji[1]
[1]Tohoku University, Japan; [2]Universite Montpellier 2 & CNRS, France; [3]Russian Academy of Sciences, Russian Federation

We propose InAlAs/InGaAs/InP high electron mobility transistors with an asymmetric chirped dual-grating-gate structure which greatly enhances plasmon instabilities. The fabricated device demonstrates an intense stimulated emission of terahertz monochromatic radiation at cryogenic temperatures for the first time.

Th5-6 15:15 **Room-temperature Terahertz Heterodyne Mixing In GaAs Commercial Transistors 784**

Lucie Tohme; Stéphane Blin; Luca Varani; Philippe Nouvel; Annick Panarier
University of Montpellier 2, France

In this paper, we report on the detection of terahertz heterodyne mixing in GaAs ultra-low noise Pseudomorphic High Electron Mobility Transistors (pHEMT) at room temperature. For this purpose, we used two 0.300 THz sources in order to generate mixing up to 45 GHz.

Th6 14:00 - 15:30 Solid State Physics Gutenberg 2
Chair: Dmitry Turchinovich

Th6-1 14:00 **Coherent Control Of Ultrafast Photocurrents Using Polarization-shaped Optical Pulses 786**

Shekhar Priyadarshi[1]; Klaus Pierz[2]; Mark Bieler[2]
[1]PTB Braunschweig, Germany; [2]Physikalisch-Technische Bundesanstalt, Germany

We demonstrate all-optically induced real-space charge transfer in semiconductors, which reverse its direction upon a change of the temporal order of two excitation fields. Such charge transfer leads to a new type of photocurrent and only appears for certain polarization-shaped optical pulses while it ceases for continuous-wave excitation.

Th6-2 14:15 **Spin-polarized Currents Of Dirac Fermions At Cyclotron Resonance 788**

Sergey Ganichev[1]; Christina Zoth[1]; Patricia Vierling[1]; Kathrin-Maria Dantscher[1]; Grigory Budkin[2]; Sergey Tarasenko[2]; Vasily Bel'kov[2]; Dimitry Kozlov[3]; Ze Don Kvon[3]; Nikolay Mikhailov[3]; Sergey Dvoretsky[3]; Peter Olbrich[1]
[1]THz Center, University of Regensburg, Germany; [2]A.F. Ioffe Physical-Technical Institute, St. Petersburg, Russian Federation; [3]Institute of Semiconductor Physics, Novosibirsk, Russian Federation

We report on the observation of the giant photocurrent in HgTe/HgCdTe quantum wells (QW) of critical thickness at which a Dirac spectrum emerges. Exciting QW of 6.6 nm width by terahertz (THz) radiation and sweeping the magnetic field we detected a resonant photocurrent. Remarkably, the position of the resonance can be tuned from negative (-0.4 T) to positive (up to 1.2 T) magnetic fields by means of optical doping. We show that the photocurrent is caused by cyclotron resonance (CR) in a Dirac fermion system, which allows us to obtain the electron velocity $v \sim 7.2\ 10^5$ m/s. We develop a microscopic theory of the effect and show that the inherent spin-dependent asymmetry of the Dirac fermion scattering in QWs causes the electric current to flow.

Th6-3 14:30 **Single-pulse Terahertz Coherent Control Of Spin Resonance In A Canted antiferromagnet 789**

Zuanming Jin[1]; Zoltan Mics[1]; Guohong Ma[2]; Zhenxiang Cheng[3]; Mischa Bonn[1]; Dmitry Turchinovich[1]
[1]Max Planck Institute for Polymer Research, Germany; [2]Shanghai University, China; [3]University of Wollongong, Australia

We report on the coherent control of terahertz (THz) spin waves in a canted antiferromagnet, $YFeO_3$ associated with a quasi-ferromagnetic spin resonance at a frequency of 0.3 THz, using a single THz pulse. The intrinsic dielectric anisotropy of $YFeO_3$ in the THz range allows for coherent control of both amplitude and phase of the excited spin wave.

Th6-4 14:45 **Dynamical Spin Reorientation Transition In Orthoferrite $NdFeO_3$ Studied With Terahertz Time-Domain Spectroscopy 792**

Guohong Ma; Junjie Jiang; Zuangming Jin; shixun Cao
Shanghai University, China

Temperature dependence of FID signal emitted by AFM in $NdFeO_3$ is investigated by employing THz time-domain spectroscopy. Our results reveal that $\Gamma_4 \rightarrow \Gamma_{24}$ phase transition occurs around T_1=170 K, and both two phases have the same AFM resonant frequency of 0.485 THz. The frequency softening is observed for $\Gamma_{24} \rightarrow \Gamma_2$ occurring around T_2=110 K.

Th6-5 15:00 **Electromagnon In The Pyroelectric Ferrimagnet ε-Fe_2O_3 N/A**

Filip Kadlec[1]; Jan Prokleška[2]; Maxim Savinov[1]; Veronica Goian[1]; Martí Gich[3]; Milan Orlita[4]; Stanislav Kamba[1]; Christelle Kadlec[1]; Maxim Savinov[1]; Martin Kempa[1]
[1]Institute of Physics, v.v.i., Acad. Sci. Czech Rep., Czech Republic; [2]Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic; [3]Institut de Ciència de Materials de Barcelona Bellaterra, Spain; [4]Grenoble High Magnetic Field Lab, Grenoble, France

The pyroelectric-structured ε-Fe_2O_3 phase is stable only in the form of nanoparticles. We studied its dynamic properties by THz and other spectroscopies, including experiments in magnetic field. The spectra reveal an electromagnon, a mixed phonon-spin excitation, earlier known only from multiferroics.

Th6-6 15:15 **Terahertz-Field-Induced Photoluminescence Of Nanostructured Gold Films 794**

Krzysztof Iwaszczuk; Radu Malureanu; Maksim Zalkovskij; Andrew Strikwerda; Peter Jepsen
DTU Fotonik, Denmark

We experimentally demonstrate photoluminescence from nanostructured ultrathin gold films subjected to strong single-cycle terahertz transients with peak electric field over

300 kV/cm. We show that UV-Vis-NIR light is being generated and the efficiency of the process is strongly enhanced at the percolation threshold.

Th7	**14:00 - 15:30**	**Quasi-Optical Devices** **Chair: Nuria Llombart**	**Gutenberg 3**

Th7-1 14:00 **High Reflectivity THz Multilayer Mirrors For Spectral Filtering Of Pulsed Far-infrared Free Electron Laser 795**

Patrick Balzerowski[1]; Erik Bründermann[1]; Gerhard W. Schwaab[1]; Jens Soetebier[2]; Trung Quan Luong[2]; Wim J. van der Zande[3]; Rienk T. Jongma[3]; Martina Havenith[1]
[1]Ruhr-Universität Bochum, Physikalische Chemie II, Bochum, Germany; [2]Ruhr-Universität Bochum, Applied Competence Cluster (ACC) Terahertz, Bochum, Germany; [3]Radboud University in Nijmegen, Institute for Molecules and Materials, FELIX Facility, Nijmegen, Netherlands

We have built THz multilayer mirrors based on fabricated z-cut quartz wafers of 25 mm diameter. Using THz time-domain spectroscopy initial measurements show that the mirror reflectivity can be tuned at least up to 98.6 %. We also observed cavity modes in a THz cavity made from such mirrors.

Th7-2 14:15 **Apodized Fiber Bragg Gratings For Terahertz Applications 797**

Laurence Reekie; Shu Fan Zhou; Hau Ping Chan; Kwai Man Luk; Yuk Tak Chow
City University of Hong Kong, Hong Kong

We report on an apodization scheme for terahertz fiber Bragg gratings. The grating consists of only 90 ablated notches on two opposite sides of a subwavelength polymer fiber. Side-lobe suppression of 14 dB was experimentally achieved.

Th7-3 14:30 **Design Of Terahertz Wire-Grid Polarizer Of Laminated Parallel Plates On Cyclo Olefin Polymer Films For High Extinction Ratio Less Than 10^{-6} 799**

Yudai Kishi[1]; Masaya Nagai[2]; John Young[3]; Keisuke Takano[4]; Motoki Asai[4]; Masanori Hangyo[4]; Takehito Suzuki[1]
[1]Ibaraki University/Department of Electrical and Electronic Engineering, College of Engineering, Japan; [2]Osaka University/Graduate School of Engineering Science, Japan; [3]University of Kentucky/Department of Electrical and Computer Engineering, College of Engineering, United States; [4]Osaka University/Institute of Laser Engineering, Japan

This paper presents the analysis and design of a wire-grid polarizer comprising laminated parallel plates with a high extinction ratio less than 10^{-6} over the range 0.1 to 1.91 THz. One waveguide is extracted with the periodicity of the wire-grid and is analyzed using the mode matching method. Cyclo olefin polymer film which has low loss in the terahertz frequency band is used for a supporting substrate in order to prevent the reduction in transmittance of the TM mode. The copper parallel plates were fabricated on cyclo olefinpolymer films by etching. The mode matching method is used to predict the TM mode transmittance and analysis results are compared to measured results. The loss of the TM mode transmittance can be improved by the reduction of the film area. The TE mode transmittance is too small to distinguish from noise in the measurement system.

Th7-4 14:45 **Highly Refracting Terahertz Lenses Made Of Polymeric Compounds 801**

Matthias Wichmann[1]; Abdullah-Saif Mondol[2]; Nikola Kocic[3]; Sina Lippert[1]; Thorsten Probst[1]; Steffen Schumann[1]; Michael Schwerdtfeger[1]; Thomas Hochrein[3]; Peter Heidemeyer[3]; Martin Bastian[3]; Georg Bastian[2]; Martin Koch[1]
[1]Department of Physics and Materials Sciences Center, Philipps-Universität Marburg, Germany; [2]Rhine-Waal University of Applied Sciences, Germany; [3]SKZ – German Plastics Center, Germany

We present terahertz lenses made of polymeric compounds which provide a better focusing capability and an increased functionality than state of the art lenses made of pure base polymers. This is achieved by employing mixtures between polypropylene

and alumina as well as polypropylene and zinc sulfide which allows for a significant increase of the refractive index of the lens base material.

Th7-5 15:00 **Design, Fabrication, And Measurement Of Dielectric Reflectarray Antennas At 100 GHz 803**

Min Liang[1]; Payam Nayeri[2]; Rafael Sabory-García[1]; Mingguang Tuo[1]; Fan Yang[3]; Michael Gehm[1]; Hao Xin[1]; Atef Z. Elsherbeni[2]
[1]Department of Electrical and Computer Engineering, University of Arizona, United States; [2]Center of Applied Electromagnetic Systems Research, Department of Electrical Engineering, The Univer, United States; [3]Microwave and Antenna Institute, Electronic Engineering Department, Tsinghua University, China

Dielectric reflectarray antennas are proposed as a possible low-loss solution for high gain THz antennas. A 3-D printing technology is utilized to fabricate the antenna, and numerical and experimental results are presented for a prototype operating at 100 GHz. This study shows that the proposed design approach is well suited for high gain THz antennas.

Th7-6 15:15 **Nanoantenna-enhanced Mid-IR Vibration Spectroscopy With Single Molecular Layer Sensitivity 805**

Frank Neubrech; Daniel Dregely; Jun Zhao; Harald Giessen
4th Physics Institute and Research Center SCoPE, University of Stuttgart, Germany

Plasmonic nanoantennas confine electromagnetic fields at infrared wavelengths to volumes of only a few cubic nanometers, resulting in huge local fields in the vicinity of the resonantly excited metal particles. We exploited these fields to enhance the infrared vibrational bands of molecular monolayers with ultra-high sensitivity.

Th8 14:00 - 15:30 Sensing Gutenberg 4
Chair: Joachim Jonuscheit

Th8-1 14:00 **Terahertz Nano-film Sensing Based On Metallic Rod Array 807**

Borwen You[1]; Chien-Chun Peng[2]; Jia-Shing Jhang[3]; Cheng-Han Ho[2]; Ja-Yu Lu[2]; Chin-Ping Yu[3]; Tze-An Liu[4]; Jin-Long Peng[4]; Chi-Kuang Sun[1]
[1]Molecular Imaging Center, Taiwan; [2]Department of Photonics, National Cheng Kung University, Taiwan; [3]Department of Photonics, National Sun Yat-Sen University, Taiwan; [4]Center for Measurement Standards, Industrial Technology Research Institute, Taiwan

Terahertz waves bound inside a metallic rod-array is successfully demonstrated and used to sense ultra-thin molecular layers in the presentation. From the transmitted surface waves with constructive interference, nanometer-thick films of SiO_2 and ZnO are successfully identified, corresponding to $\lambda/1923$ and superior to the available THz sensors.

Th8-2 14:15 **Probing Frequency Selective Surfaces With Terahertz Subwavelength Fibers 809**

Martin Girard; Maksim Skorobogatiy; Andrey Markov
École Polytechnique de Montréal, Canada

Frequency selective surface is interrogated using optical fibers in THz. Both the band diagram and S-parameter transmission calculations are used in our analysis. Transmission spectrum is explained using Fano resonances, slow light and surface modes.

Th8-3 14:30 **Chemical Analysis Of Exhaled Human Breath Using A Novel Sub-Millimeter/Terahertz Spectroscopic Approach 811**

Ivan Medvedev; Alyssa Fosnight; Benjamin Moran; Daniela Branco; Jessica Thomas
Wright State University, United States

A novel technique that utilizes terahertz high resolution molecular spectra to quantitative chemical analysis of exhaled human breath is described. We successfully identified and quantified concentrations of acetone, methanol, ethanol, acetaldehyde and

dimethyl sulfide in expired human breath samples collected from healthy donors.

Th8-4 14:45 **Terahertz Sensing Of Supercooled Glycerol Using A 1D Photonic Crystal 813**
Juraj Sibik[1]; Hynek Nemec[2]; Christelle Kadlec[2]; Filip Kadlec[2]; Vladimir Skoromets[2]; Karine Blary[3]; J. Axel Zeitler[1]; Petr Kuzel[2]
[1]University of Cambridge, United Kingdom; [2]Academy of Sciences of the Czech Republic, Czech Republic; [3]Universite Lille Nord de France, France
We have developed a 1D photonic crystal that can be used for sensing purposes at terahertz frequencies and which requires less than one microliter of sample material. Using this sensor we have obtained temperature dependent measurements of refractive index and extinction coefficient of glycerol in the temperature range 100 - 294 K.

Th8-5 15:00 **Performance Evaluation Of An Integrated Terahertz Sensor For Biomolecule Detection In Liquid Phase 815**
Vladimir Matvejev; Yuchen Zhang; Johan Stiens
Vrije Universiteit Brussel, Belgium
Integrated Terahertz Sensor operating at 0.25THz detects in 4 - 40 nL volume liquids: biomolecule concentration, conformation, binding and cell physiology. The sensor exhibits State-of-the-Art performance: sensitivity up to $50dB\cdot(g/L)^{-1}$ and detection limit down to 9 mg/L.

Th10 16:00 - 17:30 Mixers Gutenberg 1
Chair: Heinz-Martin Hübers

Th10-1 16:00 **Sub-Harmonic Mixing at 591 GHz in AlGaAs/InGaAs Two-Dimensional Electron Gas Transistors 818**
Alessandra Di Gaspare[1]; Valeria Giliberti[1]; Ennio Giovine[1]; Sebastian Boppel[2]; Alvydas Lisauskas[2]; Hartmut G. Roskos[2]; Michele Ortolani[3]
[1]CNR-Institute for Photonics and Nanotechnologies, Italy; [2]Physikalisches Institut, Johann Wolfgang Goethe-Universität Frankfurt, Germany; [3]Physics Department, Sapienza University of Rome, Italy
We demonstrate sub-harmonic and heterodyne mixing beyond cutoff in AlGaAs/InGaAs with integrated planar antenna connected to the channel ends.

Th10-3 16:30 **Hot Electron Bolometer Waveguide Mixers Up To 4.7 THz For The upGREAT Focal Plane Array Receiver On SOFIA 821**
Patrick Pütz; Cornelia E. Honingh; Denis Büchel; Karl Jacobs; Michael Schultz; Jürgen Stutzki
KOSMA, 1. Physikalisches Institut, Universität zu Köln, Germany
We report on our waveguide hot electron bolometer (HEB) mixer development for the heterodyne focal plane array receiver upGREAT, which is the multi-pixel extension to the German Receiver for Astronomy at Terahertz frequencies (GREAT) currently in operation on the Stratospheric Observatory for Infrared Astronomy (SOFIA). We will present results for our new generation of HEB mixers for operation at frequencies up to 4.7 THz reviewing the RF circuit design, device fabrication and waveguide technology.

Th10-4 16:45 **Planar D-Band Frequency Doubler And Y-Band Tripler On PTFE Laminates 822**
Michael Hrobak[1]; Michael Sterns[1]; Andreas Ziroff[2]; Wadim Stein[1]; Jan Schuer[1]; Lorenz-Peter Schmidt[1]; Florian Poprawa[2]
[1]Friedrich-Alexander University / Institute of Microwaves and Photonics (LHFT), Germany; [2]Siemens AG Corporate Technology, Munich, Germany
To extend the frequency range of existing short-range radar modules for industrial applications, millimeter-wave frequency multipliers based on cost-effective PCB technology arerequired. This paper describes a zero-bias D-band frequency doubler and Y-band frequency tripler based on pure PTFE material and the commercially available DBES105a diode from United Monolithic Semiconductors (UMS). At an input drive level range of 16 dBm to 18 dBm the multipliers deliver output power levels

$P_{OUT} \in [5, -5]$ dBm from 100 GHz to 160 GHz and $P_{OUT} \in [-11, -20]$ dBm from 180 GHz to 230 GHz.

Th10-5 17:00 **Millimeter-wave Mixer Measurement: Comparison Of Different Methods 824**

Itziar Maestrojuan[1]; Simon Rea[2]; Iñigo Ederra[3]; Ramon Gonzalo[3]
[1]Electrical and electronic Engineering Department, Spain; [2]Millimetre Technology Group, Rutherford Appleton Laboratory, United Kingdom; [3]Public University of Navarra, Spain

This paper compares three different procedures for characterising the Noise Temperature and Conversion Loss of a millimetre wave mixer. To carry out this study a 183 GHz sub-harmonic mixer has been measured using three alternative procedures, i.e. the "Attenuator", the "Gain" and the "Noise injection" procedures. Furthermore for every measurement procedure three different detection methods have been used; a Broadband Power Meter, a YIG Filter working together with a Broadband Power Meter and a Spectrum Analyser. The "Gain procedure" has turned out to be the most stable one in terms of less variation between consecutive values and flatter results along all the frequency range. Results obtained with every detection method are consistent with each other, showing a similar performance of the mixer independently the detection method used.

Th10-6 17:15 **THz Schottky Diode Harmonic Mixers For QCL Phase-Locking 826**

Jeffrey Hesler[1]; Berhanu Bulcha[1]; David Kurtz[1]; Chris Groppi[2]; Scott Barker[3]
[1]Virginia Diodes Inc., United States; [2]Arizona State University, United States; [3]University of Virginia, United States

A fundamental 1.9-2.8 THz Schottky diode mixer has been modified to enable high harmonic mixing, thus allowing use of the mixer for phase locking of a quantum cascade laser (QCL) to an stable external microwave source. Phase locking to a reference will transfer the spectral line profile of the reference to the THz source; this will control the phase precisely. Stabilizing a QCL for a single frequency operation will help to reduce the drift due to temperature and other external biases. The mixer can be used for several applications, such as, heterodyne interferometer in far-infrared range and high-resolution heterodyne spectroscopy. The design and characterization of the harmonic mixer will be presented. A conversion loss of 63 dB for harmonic mixing at N=9 and 45 dB for N=3 were measured with a 2 THz input signal.

Th11 16:00 - 17:30 Superconductors Gutenberg 2
Chair: Oleg Mitrofanov

Th11-1 16:00 **Intense THz Pulse-Induced Higgs Amplitude Mode In A BCS Superconductor $Nb_{1-x}Ti_xN$ 828**

Ryusuke Matsunaga[1]; Yuki I. Hamada[1]; Kazumasa Makise[2]; Yoshinori Uzawa[3]; Hirotaka Terai[2]; Zhen Wang[2]; Ryo Shimano[1]
[1]The University of Tokyo, Japan; [2]National Institute of Information and Communication Technology, Japan; [3]National Astronomical Observatory of Japan, Japan

By using the intense THz pump-THz probe spectroscopy, we observed the collective Higgs amplitude mode of the BCS order parameter in a nonadiabatically-excited superconducting $Nb_{1-x}Ti_xN$ films. The result opens a new pathway for ultrafast optical coherent control of macroscopic quantum states.

Th11-3 16:30 **Phase-sensitive THz Nonlinear Spectroscopy In High-T_C Superconductor Thin Film 830**

Masaya Nagai; Eiichi Matsubara; Masaaki Ashida
School of Engineering Science, Osaka Univ., Japan

We experimentally demonstrate CEP-sensitive nonlinear transmission spectroscopy in high-T_C superconductor $YBa_2Cu_3O_{7-x}$ (YBCO) thin film. The above-threshold current changes strongly influence the THz nonlinear responses, which reveal the inherent material properties in condensed matters.

Th11-4 16:45 **Evaluation Of Terahertz Emission From Intrinsic Josephson Junctions Using A High-T_c Superconductor Grain Boundary Josephson Junction 832**

Deyue AN[1]; Jie Yuan[2]; Nickolay Kinev[3]; Mengyue Li[1]; Xianjing Zhou[1]; Min Ji[1]; Ya Huang[1]; Takeshi Hatano[2]; Valery Koshelets[4]; Dieter Koelle[5]; Reinhold Kleiner[5]; Weiwei Xu[1]; Huabing Wang[2]; Peiheng Wu[1]
[1]Nanjing University, China; [2]National Institute for Materials Science, Japan; [3]Kotel'nikov Institute of Radio Engineering and Electronics, Russian Federation; [4]Kotel'nikov Institute of Radio Engineering and Electronics, Russian Federation; [5]Universitaet Tuebingen, Germany

To evaluate terahertz emission from intrinsic Josephson junctions, we use a $YBa_2Cu_3O_7$ grain boundary Josephson junction as a detector. Shapiro steps on the current-voltage characteristics of the detector were clearly observed and their positions moved with the bias voltage of the emitter accordingly. Analyzing the current-voltage characteristics of the detector, we found that the emission was tuned over a wide frequency range, e.g., between 496.6 GHz and 540 GHz, at a temperature of 24 K.

Th11-5 17:00 **Photosensitivity Of Lead Telluride Doped With Mixed Valence Impurities In The Terahertz Spectral Range 834**

Dmitriy Khokhlov[1]; Vladimir Chernichkin[1]; Alexandre Dobrovolsky[1]; Andrey Nicorici[2]; Sergey Danilov[3]; Ludmila Ryabova[1]
[1]Moscow State University, Russian Federation; [2]Institute of Applied Physics, Academy of Science of Moldova, Moldova, Republic of; [3]Faculty of Physics, University of Regensburg, Germany

The effect of PbTe doping with In, Ga and V on photoconductive response at wavelengths up to 280 μm is studied. Mechanisms responsible for photoresponse appearance at light quant energy sufficiently lower than all characteristic energies in electronic spectrum are discussed.

Th11-6 17:15 **Towards Practical Applications Of THz Josephson Oscillators With Sub-mW Power And 500 GHz Frequency Tunability 836**

Huabing Wang[1]; Jie Yuan[1]; Deyue An[2]; Nickolay Kinev[3]; Mengyue Li[2]; Xianjing Zhou[2]; Min Ji[2]; Ya Huang[2]; Takeshi Hatano[1]; Valery Koshelets[3]; Dieter Koelle[4]; Reinhold Kleiner[4]; Weiwei Xu[2]; Peiheng Wu[2]
[1]National Institute for Materials Science, Japan; [2]Nanjing University, China; [3]Kotel'nikov Institute of Radio Engineering and Electronics, Russian Federation; [4]Universitaet Tuebingen, Germany

Using a double-sided fabrication method, we fabricated $Bi_2Sr_2CaCu_2O_8$ (BSCCO) intrinsic Josephson junctions (IJJs) with a gold-BSCCO-gold structure. Coherent emission is observed at large dc input power, where a hot spot and "cold" part of the stack, coexist. The power, directly detected with a bolometer, is as high as 25 μW, implying the integrated power should be already in the order of sub-mW. We have successfully pumped a Nb-based Josephson junction and a grain boundary Josephson junction. Also with a wide tunable frequency range, BSCCO THz emitters will find themselves many practical applications, e.g., local oscillators of SIS, HEB, and Josephson mixers.

Th12 16:00 - 17:30 THz Spectroscopy: Semiconductors 1 Gutenberg 3
Chair: Juliette Mangeney

Th12-1 16:00 **THz Free-electron Laser Spectroscopy Of Magnetoexcitons In Semiconductor Quantum Wells 837**

Jayeeta Bhattacharyya[1]; Sabine Zybell[1]; Stephan Winnerl[1]; Lukas Schneebeli[2]; Christoph Böttge[2]; Benjamin Breddermann[2]; Mackillo Kira[2]; Stephan W. Koch[2]; Manfred Helm[1]; Harald Schneider[1]
[1]Helmholtz-Zentrum Dresden-Rossendorf, Germany; [2]Univ. Marburg, Germany

Transitions between the 1s and 2p levels of the fundamental heavy-hole exciton in GaAs quantum wells, followed by scattering into the 2s state, are investigated by resonant

THz excitations using a free-electron laser. We report on the external control of this intra-excitonic population transfer by an external magnetic field.

Th12-3 16:30 **Terahertz Nonlinear Optics In Semiconductors 838**

Dmitry Turchinovich[1]; Jørn Hvam[2]; Matthias Hoffmann[3]
[1]Max Planck Institute for Polymer Research, Germany; [2]DTU Fotonik, Technical University of Denmark, Denmark; [3]SLAC Linear Accelerator Laboratory, United States

We demonstrate the nonlinear optical effects – self-phase modulation and saturable absorption of a single-cycle THz pulse in a semiconductor. Resulting from THz-induced modulation of Drude plasma, these nonlinear optical effects, in particular, lead to self-shortening and nonlinear spectral breathing of a single-cycle THz pulse in a semiconductor.

Th12-4 16:45 **Probing The Critical Electronic Properties Of III-V Nanowires Using Optical Pump-Terahertz Probe Spectroscopy 840**

Hannah Joyce[1]; Callum Docherty[1]; Chaw-Keong Yong[1]; Jennifer Wong-Leung[2]; Qiang Gao[2]; Suriati Paiman[2]; Hark Hoe Tan[2]; Chennupati Jagadish[2]; James Lloyd-Hughes[1]; Laura Herz[1]; Michael Johnston[1]
[1]University of Oxford, United Kingdom; [2]The Australian National University, Australia

Optical pump-terahertz probe spectroscopy was used to study the key electronic properties of GaAs, InAs and InP nanowires at room temperature. Of all nanowires studied, InAs nanowires exhibited the highest mobilities of 6000 $cm^2V^{-1}s^{-1}$. InP nanowires featured the longest photoconductivity lifetimes and an exceptionally low surface recombination velocity of 170 cm/s.

Th12-5 17:00 **Fast Relaxation Of Free Carriers In Compensated n- And p-type Germanium 842**

Nils Deßmann[1]; Sergey Pavlov[2]; Martin Mittendorff[3]; Stephan Winnerl[3]; Roman Zhukavin[4]; Veniamin Tsyplenkov[5]; Vladimir Shengurov[6]; Valery Shastin[4]; Nikolai Abrosimov[7]; Helge Riemann[7]; Heinz-Wilhelm Hübers[8]
[1]TU Berlin, Germany; [2]DLR Berlin, Germany; [3]HZDR, Germany; [4]Institute for Physics of Microstructures, Russian Federation; [5]Instute for Physics of Microstructures, Russian Federation; [6]Institute of Physics in Microstructures, Russian Federation; [7]IKZ, Germany; [8]DLR, Germany

The relaxation of free holes and electrons in highly compensated germanium doped by gallium (p-Ge:Ga:Sb) and antimony (n-Ge:Sb:Ga) has been studied by a pump-probe experiment with the free-electron laser FELBE at the Helmholtz-Zentrum Dresden-Rossendorf. The relaxation times vary between 20 ps and 300 ps and depend on the incident THz intensity and compensation level. The relaxation times are about five times shorter than previously obtained for uncompensated n-Ge:Sb and p-Ge:Ga. The results support the development of fast photoconductive detectors in the THz frequency range.

Th12-6 17:15 **Determining Carrier Multiplication Efficiencies: Time-Resolved Terahertz Spectroscopy On Colloidal Quantum Dot Solutions 844**

Alexander Knight-Percival[1]; Ben F. Spencer[1]; Steven P. Jamison[2]; Wendy R. Flavell[3]; Darren M. Graham[3]
[1]The University of Mancester, United Kingdom; [2]The Cockroft Institute, ASTeC, STFC Daresbury Laboratory, United Kingdom; [3]The University of Manchester, United Kingdom

Determination of carrier multiplication efficiencies in colloidal quantum dots may be performed using transient absorption or time-resolved terahertz spectroscopy. We aim to find whether terahertz techniques allow these values to be determined more reliably. Initial measurements on commercial dots demonstrate the viability of the technique.

Th13	16:00 - 17:30	Non-Destructive Testing Chair: Kaori Fukunaga	Gutenberg 4

Th13-1 16:00 **Millimeter-Wave Non-Destructive Testing Of A Cured In Place Pipe Sample 846**

Moll Jochen[1]; Maryam Manavipour[2]; Christoph Sklarczyk[2]; Viktor Krozer[1]; Christian Boller[2]
[1]Goethe University Frankfurt am Main, Germany; [2]Fraunhofer Institute for Nondestructive Testing, Germany

The goal of this paper is to present a case study that considers the non-destructive testing problem of a cured in place pipe sample. We employ synthetic aperture radar (SAR) to remotely detect artificial boreholes in the dielectric object. Broadband frequency modulated signals are generated and recorded by a vector network analyzer in the frequency range between 75 and 100 GHz. Subsequent processing of the signals in time-domain reveals the locations of the structural defects.

Th13-2 16:15 **Structural Health Monitoring Using A Scanning THz System 848**

Marijke Vandewal[1]; Edison Cristofani[1]; Anna Brook[1]; Wouter Vleugels[2]; Frank Ospald[3]; René Beigang[3]; Sabine Wohnsiedler[4]; Carsten Matheis[4]; Joachim Jonuscheit[4]; Jean-Paul Guillet[5]; Patrick Mounaix[5]; Pablo Venegas[6]; Ion Lopez[6]; Rafael Martinez[7]; Yehuda Sternberg[8]; Benoit Recur[5]; Inka Manek Hönninger[5]
[1]Royal Military Academy, Belgium; [2]Verhaert New Products and Services, Belgium; [3]Technical University of Kaiserslautern, Germany; [4]Fraunhofer IPM, Germany; [5]Centre National de la Recherche Scientifique, France; [6]Fundación Centro de Tecnologías Aeronáuticas, Spain; [7]Applus+ LGAI Technological Centre S.A., Spain; [8]Israel Aerospace Industries, Israel

Terahertz waves can provide in-depth information on defects for structural health monitoring of composite materials. This paper describes the technology of a continuous-wave and a time-domain terahertz system operating on a 2-D and 3-D motion platform to provide 3-D high spatial resolution. The system as well as the overall detection performance will be described.

Th13-3 16:30 **Inline Multilayer Thickness Sensing By Using Terahertz Time-Domain Spectroscopy In Reflection Geometry 850**

Soufiene Krimi; Jens Klier; Michael Herrmann; Joachim Jonuscheit; Rene Beigang
Fraunhofer Institute for Physical Measurement Techniques, Germany

We present a novel approach to determine the individual layer thickness in a dielectric multilayer sample using pulsed terahertz spectroscopy in reflection geometry. In a first step, the optical parameters of each layer have to be determined. Based on these parameters, we simulate the reflected THz-pulse from the multilayer system and compare it to the measurement. A genetic algorithm is used to determine the best agreement between simulation and measurement by varying the thickness of each layer.

Th13-4 16:45 **Measuring A Crack: Three-dimensional Imaging Of Sub-wavelength Fractures In Sculpture And Construction Materials 852**

Michael Schwerdtfeger[1]; Kirsti Krügener[2]; Wolfgang Viöl[2]; Martin Koch[1]; Enrique Castro-Camus[3]
[1]Philipps-Universität Marburg, Germany; [2]University of Applied Sciences and Arts, Germany; [3]Centro de Investigaciones en Optica A.C., Mexico

We use reflection THz spectroscopy to produce three-dimensional images of air gaps between stones that resemble fractures of sub-wavelength thicknesses.

Th13-5 17:00 **THz Non-destructive Evaluation Using Correlation Processing 854**

Samuel Henry[1]; Orlando Baiocchi[1]; Lisa Zurk[2]
[1]University of Washington, Tacoma, United States; [2]Portland State University, United States

Terahertz (THz) has been well known for its unique ability to propagate through non-polar packaging material. At the same time, THz wavelengths are small enough to

provide meaningful imaging resolution, leading to their large potential in non-destructive evaluation. Correlation processing is a technique that has been shown to detect phase resonances in illicit chemicals, and in this paper, is extended to detect defects in a device with THz reflection data. A small diagonal crack in a solar panel is used to demonstrate this new technique.

Th13-6 17:15 **THz Bragg Gratings By CO_2 Laser Inscription And Their Application To Monitoring Of Paper Quality 856**

Guofeng Yan[1]; Yasser Chinifooroshan[2]; Wojtek J. Bock[2]; Maksim skorobogatiy[1]; Saurabh Tripathi[3]
[1]Génie physique, École Polytechnique de Montreal, Québec, Canada; [2]Département d'informatique et d'ingénierie, Canada; [3]Université du Québec en Outaouais, Canada

We report fabrication of THz fiber Bragg gratings (TFBG) using CO_2 laser inscription on subwavelength step-index polymer fibers. A TFBG with 48 periods shows a ~4 GHz-wide stop band and ~15 dB transmission loss. The simulated and experimental results demonstrate potential of such gratings in paper thickness monitoring, with experimental spectral sensitivities of ~ -0.67 GHz / 10 μm.

Th P3 17:30 - 18:45 Poster 3 Rhein Foyer West

Th P3-01 **Investigation Of Modified GaSe Crystal Compositions For Nonlinear THz Applications 858**

John Molloy[1]; Mira Naftaly[1]; Gregory Lanskii[2]; K.A. Kokh[2]; Yury Andreev[2]
[1]National Physical Laboratory, United Kingdom; [2]Institute for Monitoring of Climatic and Ecological Systems SB RAS, Russian Federation

Gallium Selenide crystals having compositions modified with a range of elements are investigated using THz time-domain spectroscopy, Raman, FTIR and ellipsometry. The optical properties are related to modifications in the crystal structure.

Th P3-02 **Solar Observations With ALMA - How To Minimize Saturation In SIS Mixers 859**

Pavel Yagoubov
European Southern Observatory, Germany

This paper reviews different mechanisms of saturation in SIS mixers and presents results of the modeling and experimental verification of the proposed solution to increase the saturation level by de-tuning the SIS mixers, to allow solar observations with ALMA.

Th P3-03 **Terahertz Emission From Quantum-Sized Silicon p^+-n Junctions 861**

Andrey Kaveev[1]; Nikolay Bagraev[2]; Eduard Danilovskii[2]; Dmitrii Gets[2]; Leonid Klyachkin[2]; Grigory Kropotov[1]; Andrey Kudryavtsev[2]; Roman Kuzmin[2]; Anna Malyarenko[2]; Ivan Tzibizov[1]; Dmitry Tsypishka[1]; Ilya Vinerov[1]
[1]Tydex J. S. Co, Russian Federation; [2]Ioffe Physical Technical Institute, Russian Federation

We present the first findings of the THz emission from the ultra-narrow p-type Si quantum well confined by the superconductor (SC) δ-barriers on the n-type Si(100) surface. The EL spectra revealed by the voltage applied along the Si-QW plane appear to result from the value of the SC energy gap.

Th P3-04 **THz Radiation In The Tapered $LiNbO_3$ Ribbon Waveguide 862**

Anahit Nikoghosyan[1]; Hans-Peter Roeser[2]; Radik Martirosyan[1]; Martin Chamberlain[3]; Harutyun Hakobyan[1]; Dave Haslam[2]; Artur Bohr[2]; Santiago López[2]; Marco Stepper[2]
[1]Yerevan State University, Armenia; [2]Institute of Space Systems, University of Stuttgart, Germany; [3]University of Durham, United Kingdom

We present our results on THz pulse generation in the 0.1-2.5 THz band via optical rectification of femtosecond laser pulses in a tapered crystal. A simulation study for visualization of THz wave propagation in the crystal has been performed. It is shown that the mode structure and phase velocity of the THz wave in the crystal are changed.

Th P3-05 **Terahertz Kerr Effect In Gallium Phosphide Crystal 864**

Jerome Degert; Marion Cornet; Emmanuel Abraham; Eric Freysz
Université Bordeaux, France

Terahertz induced Kerr effect in a (100) GaP crystal is reported. The measured dependence of the optical birefringence with respect to the azimuthal orientation of the crystal agrees with theoretical calculations. Additional electro-optic contribution to the detected signal is observed and attributed to crystal abnormity.

Th P3-06 **Radiation Polarization Dependence Of Microwave-Induced Magnetoresistance Oscillations In High-Mobility 2D Electron Systems 865**

Xiaolin Lei[1]; S.Y. Liu[2]
[1]Shanghai Jiao Tong University, China; [2]Department of Physics, Shanghai Jiao Tong University, China

Effects of incident microwave polarization on electron energy absorption, electron temperature and radiation-induced magnetoresistance oscillation are examined in magnetic-field biased high-mobility two-dimensional electron systems. It is found that the absorption rate and the rise of the electron temperature are dependent on the polarization type of the radiation but independent of the direction of linearly polarized radiation. The amplitude of radiation-induced magnetoresistance oscillation, however, not only strongly depends on the polarization type but also sensitively varies with changing linear-polarization direction of the incident radiation, in agreement with recent experimental observation.

Th P3-07 **Towards Terahertz Pulse Shaping 867**

Jan-Martin Rämer; Georg von Freymann
Fraunhofer Institute for Physical Measurement Techniques IPM, Germany

We demonstrate the combination of phase-only optical pulse shaping and terahertz time domain spectroscopy. Temporal delay of pulses and generation of bit patterns is shown.

Th P3-09 **Real-time THz Imaging Of Human Tissue Characteristics And Cancer Margins 869**

Woon-Gi Yeo[1]; Niu K. Nahar[2]; Charles L. Hitchcock[3]; Ogan Gurel[4]; Sungchan Park[5]; Kubilay Sertel[1]
[1]ElectroScience Laboratory / The Ohio State University, United States; [2]ElectroSicence Laboratory / The Ohio State University, United States; [3]Davis Heart & Lung Research Institute / The Ohio State University, United States; [4]Samsung Advanced Institute of Technology and Samsung Advanced Institute for Health Sciences & Techno, Korea, Republic of; [5]Samsung Advanced Institute of Technology, Korea, Republic of

We investigate the use of real-time THz camera imaging for differentiating between benign and malignant tissues in major human tissue groups. Using broadband time-domain THz spectroscopy, we discriminate between tumor and nerve margins on the basis of different THz refractive indices and reflectivity. Particular focus is given to easily accessible malignancies, such as skin, larynx, esophagus, and colon cancers. Time domain THz response due to tissue chemistry and morphology is recorded and tabulated to create a "THz tissue database" that can be used as a reference for diagnosis as well as tumor and nerve margin differentiation using THz waves.

Th P3-10 **High-energy, Tunable Intracavity Terahertz-wave Parametric Oscillator With Surface-emitted Configuration 871**

Yuye Wang; Degang Xu; Hao Jiang; Jianquan Yao
Tianjin University, China

A high-energy, low threshold THz-wave output has been experimentally demonstrated with intracavity terahertz-wave parametric oscillator based on surface-emitted configuration. The maximum THz-wave output energy of 283 nJ/pulse was obtained at 1.54 THz under the pump threshold of 12.9mJ/pulse in the cavity. The continuously tunable range from 0.75 to 2.75 THz was realized.

Th P3-11 **Analysis On THz Applications For DNA Nanomachines 873**

Miki Hirabayashi[1]; Ibuki Kawamata[2]; Masami Hagiya[2]; Hiroaki Kojima[3]; Kazuhiro Oiwa[3]
[1]Biological ICT Lab., Advanced ICT Research Institute, National Institute of Information and Communic, Japan; [2]Univ. Tokyo, Japan; [3]NICT, Japan

We present an analysis on bond-dissociation dynamics of DNA-based molecular machines under terahertz radiation. Our goal is to control micro/nanoworld utilizing artificial molecular machines. In this work we aim to provide fundamental findings to construct platform technologies to control artificial molecular systems using terahertz waves.

Th P3-12 **Measuring The THz Optical Constants Of Low-absorbing Polymers 875**

Harald Pühringer; Michael Pfleger; Stefan Katletz; Karin Wiesauer
RECENDT GmbH, Austria

We develop a stacking technique for precisely measuring the terahertz (THz) refractive index and absorption coefficient of low-absorbing polyethylene. Due to an increased interaction length more reliable results with considerably smaller confidence intervals are obtained.

Th P3-13 **Transient Terahertz Spectroscopy Of Mono- And Tri-Layer CVD-grown MoS2 877**

Callum Docherty[1]; Hannah Joyce[1]; Lain-Jong Li[2]; Michael Johnston[1]
[1]University of Oxford, United Kingdom; [2]Academia Sinica, Taiwan

Molybdenum disulpide, a novel two-dimensional semiconductor, was studied using optical-pump terahertz-probe spectroscopy. Mono and trilayer samples grown by chemical vapour deposition were compared to reveal their dynamic electrical response.

Th P3-14 **A 1.0-1.3 MW CW, 238 GHz Conventional Cavity Gyrotron 879**

Kartikeyan MV[1]; John Jelonnek[2]; Manfred Thumm[2]
[1]Indian institute of Technology Roorkee, India; [2]KIT/IHM, Germany

In this paper, we present the design feasibility of a megawatt class, continuous wave (CW), conventional cylindrical cavity gyrotron operating at 238 GHz for future thermonuclear fusion reactors, like the DEMO machine. Rigorous mode search followed by studies on mode competition and design feasibility are presented in this work.

Th P3-15 **Laser-Driven $LiNbO_3$ Crystal Wedge THz Antenna 881**

Anahit Nikoghosyan
Yerevan State University, Armenia

Results on THz pulse generation in the 0.1-2.5 THz band via optical rectification of femtosecond laser pulses in a wedge crystal are presented. The finite-element method was employed to model and simulate the THz wave propagation in a $LiNbO_3$ wedge antenna in order to analyze experimental results; and to visualize how the form of the crystal influences the THz radiation both inside and outside the crystal in the near-field zone.

Th P3-16 **Injection Induced Terahertz Electroluminescence From 4H-SiC p-n-Junctions Under Forward Bias 883**

Jay Prakash Gupta[1]; James Kolodzey[1]; Alex Adrianov[2]; A.O. Zakhar[2]; V.I Sankin[3]; Yu. B. Vasilev[2]
[1]University of Delaware, United States; [2]Ioffe Institute, Russian Federation; [3]Ioffe Institue, Russian Federation

We report on injection induced terahertz electroluminescence from SiC p-n junctions. The emission is assigned to intracenter optical transitions in shallow donors, initiated by the injection.

Th P3-17 **Generation Of Wide Range THz Waves Using A Laser Chaos And A High Bias Voltage 885**

Fumiyoshi Kuwashima[1]; Takuya Shirao[1]; Masahiko Tani[2]; Kazuyoshi Kurihara[2]; Kohji Yamamoto[2]; Masanori Hangyo[3]; Takeshi Nagashima[3]; Hiroshi Iwasawa[4]
[1]Fukui University of Technology, Japan; [2]University of Fukui, Japan; [3]Osaka Univ., Japan; [4]Professor Emeritus, Univ. of Fukui, Japan

Generation of a wide-range and stable THz waves from a photoconductive antenna excited by a multimode semiconductor chaotic oscillation laser with an optical delayed feedback using an external mirror is investigated. A high bias voltage is also used to generate wide range THz wave. The THz wave near to 1 THz is obtained using this system.

Th P3-18 **Microwave Property And Optical Response Of MKIDs Using NbN Symmetrical Spiral Resonator Array 887**

Atsushi Saito[1]; Kento Hayashi[1]; Kensuke Nakajima[1]; Seiichiro Ariyoshi[2]; Shigetoshi Ohshima[1]; Hironobu Yamada[1]; Tohru Taino[3]; Chiko Otani[4]
[1]Yamagata University, Japan; [2]Nagoya Institute of Technology, Japan; [3]Saitama University, Japan; [4]RIKEN, Japan

We investigated the microwave properties and optical responses of the microwave kinetic inductance detectors (MKIDs) using niobium nitride (NbN) symmetric spiral resonator array for Fourier transform terahertz spectrometer. The 9-arrays MKIDs were designed around 4.7 GHz and fabricated using the NbN thin film deposited on the m-sapphire substrate. The microwave responses of the 9-arrays MKIDs were measured using a low-noise amplifier and a vector network analyzer. We observed nine half-wavelength resonances around 4.7 GHz at 4.2 K. The frequency shifts of the resonances were also observed by an optical irradiation.

Th P3-19 **Development Of Tunable Terahertz Source Using Poled Nonlinear Crystal 888**

Kyu-Sup Lee[1]; Shunji Takekawa[2]; Kenji Kitamura[2]; Do-Kyeong Ko[1]; Nan Ei Yu[3]
[1]Gwangju Institute of Science and Technology, Korea, Republic of; [2]National Institute for Materials Science, Japan; [3]Advanced Photonics Research Institute, Korea, Republic of

Frequency and bandwidth of terahertz wave were simultaneously tuned by selectively choosing domain period in a fan-shaped periodically poled stoichiometric lithium tantalate crystal.

Th P3-20 **Probing Of Local Electron States In $Pb_{1-x}Sn_xTe(In)$ Narrow-Gap Semiconductors Using Laser Terahertz Radiation 890**

Dmitry Khokhlov[1]; Vladimir Chernichkin[1]; Ludmila Ryabova[1]; Andrey Nicorici[2]; Sergey Danilov[3]
[1]M.V. Lomonosov Moscow State University, Russian Federation; [2]Institute of Applied Physics, Moldova, Republic of; [3]University of Regensburg, Germany

A new type of semiconductor local states is revealed in $Pb_{1-x}Sn_xTe(In)$ narrow-gap semiconductors. The energy position of these states is not linked to any specific location in the semiconductor energy spectrum, but follows the quasiFermi level position, which may be tuned by photoexcitation.

Th P3-21 **Cherenkov Phase-matched Monochromatic THz Difference Frequency Generation In $LiNbO_3$ Crystal 891**

Pengxiang Liu; Degang Xu; Yuye Wang; Kai Zhong; Wei Shi; Jianquan Yao
Tianjin University, China

We present our theoretical and experimental work on Cherenkov phase-matched monochromatic THz difference frequency generation. A theoretical model is developed by solving wave equation via spatial Fourier expansion. Cherenkov-type THz-wave is generated with $LiNbO_3$ crystal. A tuning range of 0.1-5.5 THz is achieved, with highest energy of 0.56 nJ/pulse.

Th P3-22 WITHDRAWN

Th P3-23 **Phase Modulation And Second-harmonic Nulling To Eliminate Interference Fringes From The Spectrum Of A Coherent Frequency-domain THz Spectrometer 893**

Joseph Demers; Bryon Kasper
Emcore Corporation, United States

We report on the continued progress of a portable, battery-operated frequency domain terahertz spectrometer with an integrated, fiber-coupled, lithium-niobate optical phase-modulator. We discuss the progress on shifting the THz phase 90 degrees between consecutive data samples to remove the interference pattern and on developing a method of employing second harmonic nulling to actively adjust the THz phase and continuously maintain a maximum detected THz signal.

Th P3-24 **Structural Evolution Of Tetraphenylethene With Temperature Observed Using THz-TDS 894**

Edward Parrott[1]; Nicholas Tan[2]; Rong Rong Hu[3]; Axel Zeitler[2]; Ben Zhong Tang[3]; Emma Pickwell-MacPherson[1]
[1]The Chinese University of Hong Kong, Hong Kong; [2]University of Cambridge, United Kingdom; [3]The Hong Kong University of Science and Technology, Hong Kong

Structural evolution with temperature of tetraphenylethene (TPE) is followed using THz-TDS. The observed changes in the terahertz spectra are rationalized by performing DFT calculations on experimentally determined low and high temperature crystal structures, thus allowing the changes to be rationalized in terms of the subtle changes in the supramolecular structure.

Th P3-25 **Optical Characterization Of Novel Terahertz Emitters 896**

Julian Steele[1]; Krunal Radhanpura[1]; Roger Lewis[1]; Ion Tiginyanu[2]; Lilian Sirbu[3]
[1]University of Wollongong, Australia; [2]Academy of Science of Moldova, Moldova, Republic of; [3]Technical University of Moldova, Moldova, Republic of

Bulk (111) and (100) InP wafers and nanoporous membranes have been studied using free space time-domain spectroscopy. The nonlinear optical response is shown to be dependent on heavy ion (Kr^{+15}, Xe^{+23}) dose, crystallographic orientation and subsequent pore formation whereby optical techniques are employed for the purpose of surface characterization.

Th P3-26 **Terahertz Time Domain Spectroscopy Of Rat Skin Tissues 898**

Shuting Fan[1]; Edward Parrott[2]; Yi-Xiang Wang[2]; Emma Pickwell-MacPherson[2]
[1]Hong Kong University of Science and Technology, Hong Kong; [2]Chinese University of Hong Kong, Hong Kong

Terahertz time domain spectroscopy has been used to characterize various tissues in biomedical research to date. In this paper the terahertz properties of three groups of rat skin tissues treated with different injections (normal saline control, high dose of Dotarem, and high dose of Omniscan) are measured. The difference in terahertz properties of the tissues can be clearly observed from the results.

Th P3-27 **Aqueous Diffusion In Porous Polymer Powder Compacts Studied By Terahertz Pulsed Imaging 900**

Samy Yassin; Hungyen Lin; Axel Zeitler; Lynn Gladden
University of Cambridge, United Kingdom

Terahertz pulsed imaging (TPI) was used to analyse the diffusion of water into hydroxypropyl methyl cellulose (HPMC) matrices as well as acrylate copolymer matrices in reflection. Using TPI it is possible to monitor the phase changes that occur in the polymer matrix, investigate the growth kinetics of the process as well as follow the water diffusion front as it propagates through the porous polymer matrix.

Th P3-28 **Terahertz Spectroscopic Analysis Of Collagen Fibers In The Presence Of Salts 902**

Maya Mizuno; Akira Yamada; Kaori Fukunaga
National Institute of Information and Communications Technology, Japan

Collagen sheets were prepared from sea cucumber and their absorption properties were measured at terahertz frequencies. Adding salt to the collagen sheet caused the spectral shape to noticeably change at around 170 cm^{-1}, and this change was related to the contraction and condensation of collagen fibers.

Th P3-29 **Single Flange 2-port Design For THz Integrated Circuit S-parameter Characterization 904**

Johanna Hanning[1]; Jörgen Stenarson[2]; Klas Yhland[2]; Peter Sobis[3]; Tomas Bryllert[1]; Jan Stake[1]
[1]Chalmers University of Technology, Sweden; [2]SP Technical Research Institute of Sweden, Sweden; [3]Omnisys Instruments AB, Sweden

A single flange 2-port TRL calibration and measurement setup for accurate THz S-parameter characterization of integrated membrane circuit devices is proposed. The proposed setup facilitates shorter access waveguides, which greatly improves the calibration uncertainty.

Th P3-30 **High-Q, Easy-to-realize Terahertz Bandpass Filters Based On Fabry-Pérot Reflections Between Meta-surfaces 906**

Marco Reuter[1]; Norman Born[1]; Ajanthkrishna Velauthapillai[1]; Martin Koch[1]; Maik Scheller[2]
[1]Philipps-Universität Marburg, Germany; [2]University of Arizona, United States

We present easy-to-realize and compact terahertz bandpass filters with a high Q-factor in the order of 500. The filters are based on Fabry-Pérot reflections between two meta-surfaces, whose reflectivity is given by the design of the metal structure of the surface.

Th P3-31 **Progress Report On The DIII-D ECH System N/A**

John Lohr; Mirela Cengher; Yuri Gorelov; Charles Moeller; Sirivong Noraky; Dan Ponce
General Atomics, United States

See poster **We P2-27**.

Th P3-32 **Realizing Of Extremely Wide Dynamic Range Measurement Using High-brightness Terahertz-wave N/A**

Shin'ichiro Hayashi[1]; Kouji Nawata[1]; Kodo Kawase[2]; Hiroaki Minamide[1]
[1]RIKEN, Japan; [2]Nagoya University / RIKEN, Japan

See oral presentation **Fr3-5**

Th P3-33 **Reflection Properties Of Porcine Skin As Human Skin Surrogate In The Terahertz Frequency Range 908**

Katja Dutzi; Heinz-Wilhelm Hübers
German Aerospace Center, Germany

The reflection properties of porcine skin are examined in the terahertz (THz) frequency range utilizing a Fourier transform infrared spectrometer with a reflection unit. Their dependence on the frequency and other parameters such as the surface structure is analyzed in order to determine whether porcine skin can be used as surrogate for human skin in the THz frequency range.

Th P3-34 **Inline Monitoring Of Paper Thickness In An Industrial Setting 909**

Stefan Busch[1]; Thorsten Probst[1]; Lennart Duschek[1]; Rafal Wilk[2]; Martin Voitsch[3]; Frank Fender[4]; Sven Lübbecke[5]; Gerhard Gärtner[6]; Vincent P. Wallace[7]; Martin Koch[1]
[1]Fachbereich Physik, Philipps-Universität Marburg, Germany; [2]Menlos Systems, Germany; [3]BATOP GmbH, Germany; [4]iNOEX GmbH, Germany; [5]TEM Messtechnik GmbH, Germany; [6]Papiertechnische Stiftung, Germany; [7]School of Physics, University of Western Australia, Australia

We present a THz-TDS based inline monitoring system for quality control in the production of paper. The system provides accurate live data about the paper quality and thickness, and is directly connected to the production process control.

Th P3-35 **Detection Of A Human Hair With Polarization-Dependent THz-Time Domain Spectroscopy 911**

Norihisa Hiromoto[1]; Ken Yamamoto[2]; Naotaka Shiba[1]
[1]Shizuoka University, Japan; [2]Ajinomoto Co., Inc., Japan

Terahertz spectroscopy of human hair has attracted much interest in fields such as biochemistry of biopolymer fiber, nondestructive food inspection, and monitoring health condition. We have measured human hairs by two orthogonal polarization directions with transmission terahertz time-domain spectroscopy (THz-TDS) in 0.2 to 3 THz band, and detected a difference between spectra of the two polarizations. The spectra also display the existence of specific spectral bands to identify human hairs. Particularly, we have demonstrated that it is possible to detect even one hair by this method.

Th P3-36 **Nondestructive Determination Of Defects In Firmly Joint Plastic Compounds With Portable THz System 913**

Thorsten Probst[1]; Stefan F. Busch[1]; Benjamin Baudrit[2]; Eduard Kraus[2]; Vincent P. Wallace[3]; Martin Koch[1]
[1]Department of Physics and Materials Sciences Center, Philipps-Universität Marburg, Germany; [2]SKZ - Das Kunststoff Zentrum, Germany; [3]School of Physics, University of Western Australia, Australia

We present a novel THz-TDS system used for the identification of defects in joint plastic. The system utilizes two delay lines, one long, for defect location and the other short, for imaging of the defect. Cross-sectional THz images that reveal defects (air gaps) are been confirmed using CT measurements.

Th P3-37 **Terahertz Magnetoconductivity Of Magnetoresistive Self-assembled $(La_{0.7}Sr_{0.3}MnO_3)_{0.5}$:$(ZnO)_{0.5}$ Nanocomposites 915**

James Lloyd-Hughes[1]; Samuel Jones[2]; Judith MacManus-Driscoll[3]; Zhenxing Bi[4]; Quanxi Jia[4]
[1]University of Warwick, United Kingdom; [2]University of Oxford, United Kingdom; [3]University of Cambridge, United Kingdom; [4]Los Alamos National Laboratory, United States

Terahertz time-domain spectroscopy was used to probe the magnetoconductivity of nanocolumns of the colossal magnetoresistance compound $La_{0.7}Sr_{0.3}MnO_3$ strained by a ZnO scaffold. The terahertz conductivity of the nanocomposite increased rapidly below the metal-insulator transition. A magnetic field enhanced the conductivity, particularly close to the metal-insulator transition.

Th P3-38 WITHDRAWN

Th P3-39 **Terahertz Magnetospectroscopy Of Narrow-gap HgCdTe-based Structures 916**

Maksim Zholudev[1]; Frederic Teppe[2]; Wojciech Knap[2]; Milan Orlita[3]; Vladimir Aleshkin[1]; Vladimir Gavrilenko[1]; Nikolai Mikhailov[4]; Sergei Dvoretskii[4]
[1]Institute for Physics of Microstructures RAS, Russian Federation; [2]Laboratoire Charles Coulomb, Université Montpellier II, France; [3]Laboratoire National des Champs Magnetiques Intenses, Grenoble, France; [4]Institute of Semiconductor Physics SB RAS, Russian Federation

Magnetoabsorption in HgCdTe-based structures in quantizing magnetic fields have been measured. The results were fit with numerical calculations made within four-band model.

Th P3-40 **Rigorous Modelling And Design Of Microtuned Resonator Filters And Carbon Nanointerconnects Via A Nonstandard LOD-FDTD Technique 917**

Dimitrios Tzarouchis; Vassilios Vlachodimitropoulos; Stamatios Amanatiadis; Nikolaos Kantartzis
Aristotle University of Thessaloniki/Department of Electrical and Computer Engineering, Greece

The accurate analysis of dual-mode resonator filters and carbon nanotube interconnects both in the millimeter and THz regime, is presented in this paper via a high-order nonstandard LOD-FDTD method. The novel 3-D schemes use a self-adjusting process to identify regions of rapid/smooth field variation and seriously subdue grid reflection errors. Therefore, complex setups can be successfully designed with affordable resources, as certified through several realistic applications.

Th P3-41 **Polymer Matrix With Nanoparticles As A High Refraction Material For The Waveguides 919**

Maxim Nazarov[1]; Eugenie Khaydukov[1]; Vladislav Panchenko[1]; Alexander Shkurinov[2]; Viktor Sokolov[1]
[1]ILIT RAS, Russian Federation; [2]M.V.Lomonosov Moscow State University, Russian Federation

Incorporation of small particles in polymer increases resulting refraction index. Waveguides form such material may be effectively coupled with photoconductive antennas. Refraction index as well as scattering losses of Si nano and micro particles in polystyrene matrix are experimentally studied. Fibers and structured waveguides are suggested.

Th P3-42 WITHDRAWN

Th P3-43 **Quantitative Evaluation Of The Photoexcited Carriers In Bulk Si Using Optical Pump-THz Probe Spectroscopy 921**

Genki Yamashita[1]; Eiichi Matsubara[1]; Masaya Nagai[1]; Yoshihiko Kanemitsu[2]; Masaaki Ashida[1]
[1]Osaka University, Japan; [2]Kyoto University, Japan

We perform optical pump-THz probe measurements in four types of silicon samples to investigate carrier multiplication. We evaluate the number of carriers from the transient change of transmission after photoexcitad carriers are thermalized to the bottom of the conduction band to discuss the possibility of carrier multiplication.

Th P3-44 **Characterization Of Electrical Properties Of SiC Epilayer By THz Ellipsometry 923**

Takeshi Nagashima[1]; Toshiyuki Iwamoto[2]; Yukinori Satou[2]
[1]Institute of Laser Engineering, Osaka University, Japan; [2]Nippo Precision Co. Ltd, Japan

Spectroscopic ellipsometry based on terahertz time-domain spectroscopy was used for non-contacting evaluation of SiC epilayers homo-epitaxially grown on opaque SiC substrates. The thickness, carrier density and scattering time of the epilayers were simultaneously determined.

Th P3-45 **Complex-Permittivity Measurement With Phase-Sensitive Continuous-Wave THz Homodyne Spectroscopy 925**

Jae-Young Kim; Ho-jin Song; Katsuhiro Ajito; Makoto Yaita; Naoya Kukutsu
NTT Microsystem Integration Laboratories, NTT Corp., Japan

We present a phase-sensitive continuous-wave THz homodyne spectroscopy system for simultaneous measurement of the THz intensity and phase responses in frequency domain. Using this system, complex permittivity evaluation of dielectric materials was successfully demonstrated.

Th P3-46 **High-Speed Broadband Frequency Sweep Of CW THz Radiation 927**

Dae-Su Yee[1]; Kyong Hwan Jin[2]; Jong Chul Ye[2]; Min Yong Jeon[3]; Kyung Hyun Park[4]
[1]Korea Research Institute of Standards and Science, Korea, Republic of; [2]Korea Advanced Institute of Science and Technology, Korea, Republic of; [3]Chungnam National University, Korea, Republic of; [4]Electronics and Telecommunications Research Institute, Korea, Republic of

We present experimental implementation of high-speed broadband frequency sweep of CW THz radiation applicable to high-speed THz spectroscopy and tomography. A wavelength-swept laser and a distributed-feedback laser diode constitute a high-speed frequency-swept optical beat source used for photomixing.

Th P3-47 **The Effect Of Bias Voltage On The Optical Conductance Of A Single Layer Graphene p-n Junction In THz Regime 928**

Shareef Al-Tikrity
University of Wollongong, Australia

We have carried out a theoretical and computational study of the nonlinear optical conductance in terahertz to infrared regime of a single layer graphene p-n junction (GPNJ) with intra and inter band transition under moderate electric field. It is shown that the negative connectivity of single layer graphene can be enhanced and affected by the bias voltage. The result can be important to the application of graphene in coherent terahertz radiation sources and optoelectronics devices.

Th P3-48 **THz Spectroscopy Of The Ammonothermal p-type GaN Substrate With And Without AlGaN/GaN Epilayers 930**

Andrius Biciunas[1]; Irmantas Kasalynas[1]; Ramunas Adomavicius[1]; Arunas Krotkus[1]; Pawel Prystawko[2]; Michal Leszczynski[2]; Robert Dwilinski[3]
[1]Center for Physical Sciences and Technology, Lithuania; [2]Institute of High Pressure Physics UNIPRESS, Poland; [3]Ammono S.A., Poland

Complex refractive index of the ammonothermal p-type GaN substrate and on top grown AlGaN/GaN epilayers were measured by the terahertz time domain spectroscopy over the frequency range 0.1 to 3.0 THz. High THz transparency and low dispersion of the refractive index were observed for different conductivity p-type GaN semiconductor samples.

Th P3-49 **Structure-specific THz Response On DNA Condensation 932**

Heyjin Son[1]; Da-Hye Choi[1]; Seonghoon Jung[2]; Jaehun Park[2]; R. Holland Cheng[3]; Gun-Sik Park[1]
[1]Seoul National University, Korea, Republic of; [2]Pohang Accelerator Laboratory, Korea, Republic of; [3]Department of Molecular and Cellular Biology, University of California, Davis, United States

DNA conformational change is proved in THz frequency range. Distinct difference in absorption and extended DNA is observed. The results suggest that THz spectroscopy identifies global change in DNA structure sensitively.

Th P3-50 **High-Resolution Broadly-Tunable MOPA-Based Terahertz Spectrometer To Non-Destructively Probe And Modulate Protein Electrodynamics 934**

Richard Lewis[1]; Ee-Leong Lim[1]; David Rowe[1]; Shaif-ul Alam[1]; Johan Nilsson[1]; Ogan Gurel[2]; James Wilkinson[1]; David Richardson[1]
[1]University of Southampton, United Kingdom; [2]Samsung Advanced Institute for Health Sciences and Technology, Korea, Republic of

We report on the development of a high-resolution (<1 GHz at 1.0 THz), broadly–tunable (~0.5 - 3.0 THz) fiber MOPA-based terahertz spectrometer system. The flexibility and performance of this system will be demonstrated with gaseous (water vapor) and aqueous (water and solvated protein) samples with a view towards selectively and non-destructively probing functionally significant large-scale protein motions.

Th P3-51 **Phonon Polariton And Infrared Absorption Effects In III-nitride Thin Films 936**

Keisuke Hatta; Yoshihiro Ishitani
Chiba University, Japan

We discuss photonphonon interaction in AlandGathin layer structures by spectroscopic analysis in 20 – 30 THz region. Optical absorption by the generation of electric dipole moment based on interface polarization charges is found besides interface phonon polariton propagation. The polariton and absorption properties are analyzed.

Th P3-52 **Terahertz Properties From The Surface Of Strained SiGe On Si Multilayered Structure 937**

Ken Omura; Akihiro Nakamura; Toshihiko Kiwa; Yoshifumi Yamashita; Kenji Sakai; Keiji Tsukada
Okayama Univ., Japan

A Large-scale integration (LSI) has been improved by scaling contraction. Strained Si has been proposed as a higher carrier mobility than usual. We have evaluated the strained SiGe wafer by LTEM, which is a method of analyzing to detect THz waves generated by fs laser irradiated into the sample.

Th P3-53 **3D Terahertz Imaging For The Control Of Aeronautics Composite Multilayered Structures 939**

Patrick Mounaix[1]; Frank Ospald[2]; Wissem Zouaghi[2]; Daniel Molter[2]; René Beigang[2]; Jean Paul Guillet[1]; Jean Baptiste Perraud[1]; Inka Manek-Hönninger[1]
[1]LOMA UMR 5798, France; [2]Department of Physics and Research Center OPTIMAS, TU Kaiserslautern, Germany

We present results from a TDS imaging system for non-destructive evaluation of aeronautics composite materials, like glass fiber laminate and sandwich structures. Time-of-flight information from reflection measurements allows for 3D reconstruction of test sample volumes. Clear identification and spatial positioning of defects like delamination and foreign inclusion is possible.

Th P3-54 **Upgraded Terahertz Spectroscopic Database By Using Modern Web Technology 940**

Takashi Notake[1]; Hiroaki Minamide[1]; Chiko Ohtani[1]; Kaori Fukunaga[2]; Iwao Hosako[2]
[1]RIKEN, Japan; [2]NICT, Japan

We present a review of pioneering database on terahertz spectroscopy. The database has been opened universally since 2008 and is restructured recently based on the contemporary HTML5 technology. Flexibilities to browse and search data are much improved. Besides, data upload system from general users is prepared to enrich the database further.

Th P3-55 **Local Oscillator Noise Suppression By A Balanced SIS Mixer In The 0.9 THz Band 941**

Takafumi Kojima[1]; Yasunori Fujii[1]; Shin'ichiro Asayama[2]; Yoshinori Uzawa[1]
[1]National Astronomical Observatory of Japan, Japan; [2]National Astronomical Observatory of Japan,Joint ALMA Observatory, Chile

Local oscillator (LO) sideband noise suppression by a balanced superconductor-insulator-superconductor (SIS) mixer was investigated in the 0.9 THz band. An LO signal in the 0.9 THz band was generated by using fixed tuned x9 (x3 by x3) multipliers located in the cryostat 4-K stage. Despite the huge LO noise of about 1000 K of a YIG driven LO, the measured receiver noise temperature for YIG and Gunn driven LOs was similar because of the high LO sideband noise rejection ratio (LNR) of the balanced mixer.

Th P3-56 **Chemometrics Applied To Analysis Of Terahertz Spectra 943**

Patrick Mounaix; Josette El Haddad; Bruno Bousquet; Lionel Canioni; Fredérick De Miollis
LOMA UMR 5798, France

Solid samples prepared as pressed pellets containing controlled amounts of three products, namely D-(-) Fructose, Citric acid monohydrate and α-Lactose monohydrate,

were analyzed by transmission terahertz spectroscopy. We report that chemometrics was efficiently applied to the terahertz spectra in order to retrieve both qualitative and quantitative information.

Th P3-57 **X-ray Versus 3D Terahertz Imaging For Sigillography Science 944**

Patrick Mounaix[1]; Jean Paul Guillet[1]; Benoit Recur[1]; Romain Durand[1]; Martine Fabre[2]; Sylvain Genot[3]
[1]LOMA UMR 5798, France; [2]CRBC (EA 4451), France; [3]Tomoadour, France

This study focuses on the seals, especially European wax seals. We use THz spectroscopy imaging for non-destructive evaluation of natural materials. Using a time domain THz spectroscopy and imaging system, THz reflection images are generated in the 0.1-3 THz range and demonstrate that we can inspect the internal structure under a thick layer of old wax. X-Ray images will be used as a reference and the both technologies will be compared.

Th P3-58 **Integrated Commissioning Of ECRH For W7-X 945**

Harald Braune[1]; Volker Erckmann[1]; Lothar Jonitz[1]; Walter Kasparek[2]; Heinrich Laqua[1]; Georg Michel[1]; Frank Noke[1]; Frank Purps[1]; Tino Schulz[1]; Peter Uhren[1]
[1]Institut für Plasmaphysik Garching, TI Greifswald, Germany; [2]Universität Stuttgart, Germany

The W7-X start-up scheduled for 2015 demands a lot of integrated tests at all auxiliaries as well as the ECRH installation in order to ensure a reliable interaction. Up to 10 gyrotrons have to be controlled as well as 10 different wave guides and two additional remote steering launchers apart from the 10 ordinary front steering launchers. The ECRH remote control system has to be connected to the central W7-X control system in a reliable and easily maintainable way. The main challenges and developed solutions will be discussed.

Th P3-59 **Proposal And Fabrication Of Resonant-tunneling-diode Terahertz Oscillator With Structure For High Frequency Modulation 947**

Safumi Suzuki; Kyo Minoguchi; Masahiro Asada; Kengo Okada
Tokyo Institute of Technology, Japan

Although the direct-modulation frequency in a resonant-tunneling-diode oscillator increases by reducing the metal-insulator-metal capacitance, the output power degrades simultaneously. We figured out this mechanism using an equivalent circuit model. Based on this result, a novel structure was proposed and fabricated, and terahertz oscillation without degradation in output power was obtained.

Th P3-60 **THz Photoconductivity In Si Nanocrystals: Issues Of (Non)Percolation 949**

Petr Kužel[1]; Hynek Němec[1]; Christelle Kadlec[1]; Kateřina Kůsová[1]; Ivan Pelant[1]; Vít Zajac[2]
[1]Institute of Physics, Academy of Sciences of the Czech Republic, Czech Republic; [2]Faculty of Mathematics and Physics, Charles University in Prague, Czech Republic

On a system of silicon nanocrystals we explain and demonstrate the importance of measuring THz photoconductivity spectra in a wide range of excitation densities. This allows one to independently characterize contributions of percolated and non-percolated parts of the sample to the total photoconductivity.

Th P3-61 **Quarter Waveplate At Upper Terahertz Range Based On Form Birefringence 951**

Banghong Zhang[1]; Yandong Gong[2]; Takashi Notake[3]; Hiroaki Minamide[3]
[1]Institute of Infocomm Research, Singapore; [2]Institute for Infocomm Research, Singapore; [3]RIKEN, Japan

Quarter waveplates (QWPs) at upper terahertz range are demonstrated based on form birefringence of silicon grating. With depth of 15.5 and 8.4 μm, the gratings act as QWPs at 4.9 and 9.5 THz, respectively. The QWP is also successfully used to measure the state of polarization in a polarimetric system.

Th P3-62 **Efficient Illumination For A Dielectric Lens Antenna Fed By A Spiral Antenna For Broadband THz Systems 953**

Alessandro Garufo; Nuria Llombart; Andrea Neto
TU Delft, Netherlands

Spiral antenna is widely used in THz regime as a ultra wide band-width feed for dielectric lenses. Indeed such antenna show a very flat behavior over a very wide band. Conversely these feeds generate very wide radiation patterns inside the lens which illuminate the lens in an inefficient way. In this contribution we want to show how is possible improving the performances of these types of antenna by using a small air gap between the dielectric lens and the spiral feed.

Th P3-63 **Investigation Of Aging Of Cross-linked Polyethylene By Terahertz Time-Domain Spectroscopy System 955**

Chengang Dong; Wei Shi; Lei Hou; Hong Liu; Yi Ding
Xi'an University of Technology, China

Cross-linked polyethylene (XLPE), as a dielectric material, has a wide application in power system. The security of the early stage cable is a problem due to the aging of XLPE. We investigated the XLPE by terahertz time-domain spectroscopy system, and calculated its refractive index, attenuation coefficient and dielectric constant, which provides valuable information to analysis the aging of XLPE.

Th P3-64 **Terahertz Sensor For Non-contact Thickness Measurement Of Car Paints 957**

Ke Su[1]; Robert K. May[2]; Philip F. Taday[2]; Ian S. Gregory[2]; Y.C. Shen[3]; J.Axel Zeitler[1]
[1]University of Cambridge, United Kingdom; [2]TeraView Ltd., United Kingdom;
[3]University of Liverpool, United Kingdom

We propose to use terahertz pulsed imaging (TPI) as a novel tool to characterise the thickness and uniformity of up to four layers of car paint on both metallic and non-metallic substrates. Results of the terahertz measurements are compared with other techniques, i.e. ultrasound, eddy current measurements, and X-ray computed tomography and good consistency is found between the techniques. Compared to other measurement techniques TPI has the advantage that it is a non-contact method.

Th P3-65 **Quadrature Phase Shifted Interferometry In The THz Spectrum 959**

Peter Földesy
MTA-SZTAKI, Hungary

This abstract describes a method that is capable of capturing quadrature phase shifted interferograms in the sub-THz and THz spectral range using linear and circularly polarized antenna arrays and FET detectors.

Th P3-66 **Dual-Wavelength Tunable Fiber Laser With Two Polymer Bragg Gratings For Continuous Wave Terahertz Optical Beat Source Generation 960**

Min Yong Jeon[1]; Ik-Gon Park[1]; Yong Seok Kwon[1]; Jong Hyun Byun[1]; Sang-Pil Han[2]; Namje Kim[2]; Hak Kyu Lee[3]; Kyung Hyun Park[2]
[1]Chungnam National University, Korea, Republic of; [2]ETRI, Korea, Republic of;
[3]ChemOptics Inc., Korea, Republic of

We report a continuously tunable dual-wavelength laser based on the polymer Bragg gratings for continuous wave terahertz optical beat source generation. The polymer Bragg gratings are used to wavelength selective components in the laser cavity. The measured wavelength tuning range is about 19 nm. The side mode suppression ratio is achieved more than 30 dB for dual wavelength.

Th P3-67 **Development Of A Recognition Algorithm For THz Spectra 962**

Anika Brahm[1]; Felix Wichmann[2]; Carsten Gerth[2]; Gunther Notni[2]; Andreas Tuennermann[1]
[1]Friedrich Schiller University, IAP, Germany; [2]Fraunhofer IOF, Germany

A new algorithm for the processing of THz absorption spectra is developed. It grants further applications of the THz radiation in the field of security control or chemical

substance identification. The algorithm processes the whole spectra with small information content by means of continuous wavelet transformation (CWT).

Th P3-68 **FIR Photoconductivity Spectra And Kinetics In Narrow-gap HgCdTe Bulk Films And HgCdTe Based QW 964**

Vladimir Rumyantsev[1]; Sergey Morozov[1]; Alexander Antonov[1]; Maksim Zholudev[1]; Konstantin Kudryavtsev[1]; Vladimir Gavrilenko[1]; Sergey Dvoretskii[2]; Nikolay Mikhailov[2]

[1]IPMRAS, Russian Federation; [2]ISP SB RAS, Russian Federation

Investigation into far infrared photoconductivity in narrow gap epitaxial bulk $Hg_{1-x}Cd_xTe$ ($x<0.2$) films and $Hg_{1-x}Cd_xTe/Cd_yHg_{1-y}Te$ QW structures grown by molecular beam epitaxy technique is presented. A broad band of photosensitivity in terahertz region is found at 4.2 K – 77 K. Some long-wavelength peculiarities of spectra are discovered and their origins are discussed. Lifetime studies demonstrate the possibility of radiative recombination at high excitation regime. Estimations of ampere-watt sensitivity show that some of the structures are applicable for detecting in very long-wavelength infrared range.

Th P3-69 **On The Optimization Of The Imaging Speed In Broadband THz Focal Plane Arrays Of Kinetic Inductance Detectors 966**

Nuria Llombart[1]; Andrea Neto[1]; Beatriz Blazquez[1]; Ozan Yurduseven[1]; Angelo Freni[2]

[1]Delft University of Technology, Netherlands; [2]University of Florence, Italy

The design of focal planes of power detectors for the characterization of radiometric distributed sources in the sub-mm wave regime is a problem of renewed interest for the scientific community. The important question is how to optimize the focal plane sampling and the focal plane feed elements for maximizing the acquisition speed. The key speed limitations for some popular feed solutions have been qualitatively discussed in the optical scientific literature. However, the actual realistic estimation of the acquisition speeds is complicated when rigorous electromagnetic calculations have to be performed. While, the basic estimations are supposedly well understood in the scientific astronomical communities, the realistic estimation requires the tools typical of antenna engineers. This is particularly important when the bandwidth of the desired systems is large.

Th P3-70 **Nb_5N_6 Microbolometers Integrated With Diffractive Lens Array For THz Imaging 967**

Xuecou Tu; Qingkai Mao; Lei Xu; Chao Wan; Zhenlong Sun; Lin Kang; Jian Chen; Peiheng Wu

School of Electronic Science and Engineering, Nanjing University, China

We designed and fabricated Nb_5N_6 microbolometers integrated with five staircases square diffractive lens array (DLA) for THz detection. It gives us a method for designing diffractive lens to improve the coupling efficiency of the incident power into the Nb_5N_6 microbolometers. We measured the voltage response of the Nb_5N_6 microbolometer integrated with diffractive lens. We find it has 30 times larger response than of the Nb_5N_6 microbolometer without diffractive lens. Preliminary results for THz radiation show that Nb_5N_6 microbolometers integrated with diffractive lens array as room-temperature detectors yield good responsivity and noise equivalent power (NEP). In addition, we use one of these microbolometers in a THz imaging system for THz imaging. Development of a focal plane array (FPA) using such devices as detectors is favorable since DLA has many advantages, such as light weight, low absorption loss, high resolution, and the most important point is that DLA can be easily integrated by ready mass production using standard micro-fabrication techniques.

Th P3-71 **THz Reflectometric Imaging Of Contemporary Panel Artwork 969**

Peter Uhd Jepsen; Corinna L. D. Dandolo

Technical University of Denmark, Denmark

Terahertz time-domain reflectometry has been applied to the investigation of a tempera panel replica. The technique has given useful information about the surface as well as

the internal structure of the artworks. Ultrathin layers of leaf gold are penetrated by THz radiation, revealing the underlying wood structure.

Th P3-72 **THz Reflectometric Imaging Of Medieval Wall Paintings 971**

Peter Uhd Jepsen; Corinna L. D. Dandolo
Technical University of Denmark, Denmark

Terahertz time-domain reflectometry has been applied to the investigation of a medieval Danish wall painting. The technique has been able to detect the presence of carbon-black layer on the surface of the wall painting and a buried insertion characterized by high reflectivity values has been found in depth of the lime-based historical plaster.

Th P3-73 **Terahertz Time-domain Spectroscopy Of Lysozyme And Mouse Urinary Protein Single Crystals. 973**

Katarzyna Tych; Andrew Burnett; Christopher Wood; Richard Malham; Lianhe Li; John Cunningham; Arwen Pearson; Emanuele Paci; Edmund Linfield; Giles Davies
University of Leeds, United Kingdom

Broadband time-domain spectroscopy was used to measure the terahertz frequency absorption of protein single crystals in order to study global protein dynamics. Temperature dependent dynamics were measured for lysozyme, and the terahertz frequency spectrum of mouse urinary protein was compared to calculated spectra.

Th P3-74 **Transport Property Of Organic Semiconductor Dependent On Crystalline Ordering 975**

Hyung Keun Yoo[1]; Joong Wook Lee[2]; In-Wook Hwang[1]; Chul Kang[1]
[1]GIST, Korea, Republic of; [2]Chonnam University, Korea, Republic of

We demonstrate that charge carrier transport in organic semiconductor, accompanying the modulation of terahertz transmission, depends on the crystalline ordering. We could obtain charge carrier concentrations in organic semiconductor layers, pentacene thin films, on a silicon substrate.

Th P3-75 WITHDRAWN

Th P3-76 **Photonic Generation Of CW Sub-THz And THz Waves Using An Efficient Gain-Switching Based VCSEL Optical Frequency Comb 977**

Angel Ruben Criado[1]; Cristina de Dios[1]; Estefanía Prior[1]; Pablo Acedo[1]; Markus Ortsiefer[2]; Peter Meissner[3]
[1]Universidad Carlos III de Madrid, Spain; [2]Vertilas GmbH, Germany; [3]Technische Universität Darmstadt, Germany

A Continuous Wave (CW) millimeter-wave photonic synthesizer based on Difference Frequency Generation (DFG) is presented. This system encompasses an Optical Frequency Comb Generator (OFCG), an optical mode selection stage and a high-bandwidth photodetector. The employed OF CG is a novel design based on Gain-Switching modulation of a VCSEL. This new OFCG offers equivalent optical span than commonly employed designs with fewer component count, and especially less input RF power, paving the way to stable, widely tunable, energy-efficient and compact OFCGs. In this paper, the application of this OFCG to sub-THz wave generation with ultra-low phase noise and ultra-high resolution is presented.

Th P3-77 **Effective Fill-Factor Design Results In Extraordinary Optical Transmission In A THz Wire-Grid Polarizer 978**

John Cetnar; John Middendorf; Elliott Brown; Matthieu Martin
Wright State University, United States

A terahertz (THz) wire-grid polarizer is designed and demonstrated using an effective fill-factor (EFF) approach. Full-wave numerical simulations are performed to compare the performance of the EFF device with that of a baseline design wire-grid polarizer at two fill-factors (FF). The simulation results predict that the physical effects seen in the baseline design can be realized in the EFF device. This behavior is confirmed in

experiments at 275, 530, and 720GHz.

Th P3-78 **An Impedance-matched Achromatic "Lenster" For Millimetre Wavelengths N/A**

Giorgio Savini[1]; Peter Ade[2]; Paul Moseley[1]; Elena Saenz[3]; Jin Zhang[2]
[1]University College London, United Kingdom; [2]Cardiff University, United Kingdom; [3]ESTEC, ESA, Netherlands

The graded refractive index of a metal mesh flat lens requires an equivalent graded mesh element to impedance mismatch to free space. We report here a significant improvement in the performance of a thin flat lens constructed of polypropylene-embedded graded metal-mesh structures by adding this type of antireflection coating.

Th P3-79 **Experimental Validation Of Thermal Model Of MM-Wave Frequency Multipliers 980**

Ion Oprea[1]; Oleg Cojocari[2]; Hans Ludwig Hartnagel[1]
[1]MWE, TU Darmstadt, Germany; [2]ACST GmbH, Germany

This paper presents a method for estimation of junction temperature of a Schottky diode used in a recently developed frequency doubler to 332 GHz. Our particular interest was the validation of the thermal model of the diode by comparison of the simulated junction temperature with the real junction temperature under operating conditions. RF operating condition is here artificially simulated by dissipating power from DC voltage and current to achieve similar heating effect in the diode.

Th P3-80 **Identification Of Tissue Interaction Of Terahertz Radiation Toward Functional Tissue Imaging By Terahertz Spectroscopic Imaging 982**

Seongsin Margaret Kim; Hamdullah Yokus; Soner Balci; David Wilbert; Patrick Kung
University Of Alabama, United States

In this study, we utilize Terahertz imaging to study the effects of hydrofluoric acid on both compact bone tissue and cartilage. We compare the differences observed in the exposure for formalin fixed and raw, dried, tissue as well as those resulting from a change in Hydrofluoric (HF) concentration. Measurements are performed with THz-TDS, and a variety of spectroscopic based image reconstruction techniques are utilized to develop contrast in the features of interest.

Th P3-81 **Pharmaceutical, Biological And Industrial Applications Of Terahertz Spectroscopy And Imaging 984**

Edward King; Eiji Kato; Mark Sullivan; David Heaps
Advantest America, Inc, United States

The terahertz range of the electromagnetic spectrum falls between the more familiar microwave and infrared regions. Advances in pulsed terahertz technology over the past decade have led to the development of commercial instrumentation for spectroscopy and imaging. Terahertz analysis is non-destructive for materials as well as living tissue and its high depth of penetration offers many advantages over other techniques. Terahertz spectroscopy is well suited for the identification of crystalline polymorphs and for real time monitoring of solid form changes in-situ. Terahertz imaging is ideal for measuring the thicknesses and properties of multilayered structures such as tablet and paint coatings. Terahertz techniques for measuring bulk physical properties (e.g. electric field permittivity) also have the potential to determine the efficacy of drugs and to detect disease states in cell cultures. In this poster, we present the background of terahertz analysis and instrumentation and provide examples of several recent applications from our laboratory.

Friday	Congress Hall
	Plenary Session
09:00 – 09:45	Plenary session Fr-Pl1 **THz Metrology** *Thomas Kleine-Ostmann* *Physikalisch-Technische Bundesanstalt, (PTB)* *Germany*
09:45 – 10:30	Plenary session Fr-Pl2 **THz Dielectric Fiber Based Imaging: In Vivo Molecular Imaging Of Water** *Chi-Kuang Sun* *National Taiwan University, Taiwan*
10:30 – 11:00	**Coffee Break (Rhein Foyer)**

Friday	Gutenberg 1	Gutenberg 2
	Fr1 THz Spectroscopy 2	**Fr2 THz Spectr.: Semico. 2**
11:00 – 11:15	Fr1-1 (invited talk) **Terahertz Frequency Electromagnon And Magnon Modes In Multiferroic Cupric Oxide** *Samuel Jones[1]; Stephen Gaw[1]; Dharmalingham Prabhakaran[1]; Andrew Boothroyd[1]; James Lloyd-Hughes[2]* *[1]University of Oxford, United Kingdom; [2]University of Warwick, United Kingdom*	Fr2-1 (invited talk) **Transient THz Photoconductivity In Dynamically Screened InGaN/GaN Quantum Wells** *Z. Jin[1,2]; S. Lahmann[3]; U. Rossow[3]; A Hangleiter[3]; M. Bonn[1]; D. Turchinovich[1,4]* *[1]Max Planck Institute for Polymer Research, Germany; [2]Shanghai University, China; [3]Technical University of Braunschweig, Germany; [4]Technical University of Denmark, Denmark*
11:15 – 11:30		
11:30 – 11:45	Fr1-3 **Visualization Of The Catalytic Reactions In The Fuel Cells Using THz Chemical Microscope** *Takafumi Hagiwara; Tetsuya Kusaka; Toshihiko Kiwa; Kenji Sakai; Keiji Tsukada* *Okayama University, Japan*	Fr2-3 **Extra-Long Hole Spin Relaxation Time In InGaAs/GaAs Quantum Wells Probed By Cyclotron Resonance Spectroscopy** *Kirill Spirin[1]; Oleksiy Drachenko[2]; Dmitry Kozlov[1]; Anton Ikonnikov[1]; Vladimir Gavrilenko[1]; Harald Schneider[2] et al.* *[1]IPM RAS, Russian Federation; [2]Helmholtz-Zentrum Dresden-Rossendorf, Germany*

Gutenberg 3	Gutenberg 4	Congress Hall
Fr3 Parametric Sources	**Fr4 Modulators**	
Fr3-1 **Parametric Amplification Of Terahertz Waves In Lithium Niobate Crystal** *Saroj Tripathi[1]; Taira Yuusuke[1]; Shin'ichiro Hayashi[2]; Hiroaki Minamide[2]; Kodo Kawase[1]* *[1]Nagoya University, Japan; [2]RIKEN, ASI, Japan*	Fr4-1 (invited talk) **An Electrically Driven Terahertz Modulator With Over 20 DB Of Dynamic Range** *Nicholas Karl[1]; Hou-tong Chen[2]; Antoinette Taylor[2]; Daniel Mittleman[1]; Kimberly Reichel[1]; Alexander Benz[3]; John Reno[3]; Rajind Mendis[1]; Igal Brener[3]* *[1]Rice University, United States; [2]Los Alamos National Laboratory, United States; [3]Sandia National Laboratories, United States*	
Fr3-2 **Generation Of Spectrally Shaped Terahertz Waves Under Femtosecond- Or Nanosecond-Pulsed Optical Pumping** *Alexander Sigov[1]; Galiya Kitaeva[2]; Alexey Mishin[2]; Oleg Samotokhin[2]; Anton Tuchak[2]; Pavel Yakunin[2] et al.* *[1]MIREA, Russian Federation; [2]M.V.Lomonosov Moscow State University, Russian Federation*		
Fr3-3 **Optimized Terahertz Generation In ZnTe Crystals** *Sebastien Vidal[1]; Jean Oberle[2]; Jerome Degert[2]; Marc Tondusson[2]; Eric Freysz[2]* *[1]ALPhaNOV, France; [2]LOMA, Université Bordeaux1, France*	Fr4-3 (invited talk) **Near-Field Enhanced Graphene Terahertz Modulator** *Rusen Yan[1]; Lei Liu[1]; Berardi Sensale-Rodriguez[2]; Huili Grace Xing[1]* *[1]University of Notre Dame, United States; [2]University of Utah and University of Notre Dame, United States*	

Friday	Gutenberg 1	Gutenberg 2
	Fr1 THz Spectroscopy 2	**Fr2 THz Spectr.: Semico. 2**
11:45 – 12:00	Fr1-4 **Sol-Gel Transition Of Supramolecular Gels Observed By Terahertz Spectroscopy** *Hiromichi Hoshina[1]; Atsumi Ozaki[2]; Yusuke Itagaki[2]; Setsuko Yajima[2]; Hal Suzuki[1]; Shinya Ishii[1]; Misaki Ishida[3]; Tetsuji Uchiyama[3]; Keiichi Kimura[2]; Chiko Otani[1]* *[1]RIKEN, Japan; [2]Wakayama University, Japan; [3]Miyagi University of Education, Japan*	Fr2-4 **Density-Dependent Electron Scattering In Photoexcited GaAs** *Zoltan Mics; Andrea D'Angio; Soeren Jensen; Mischa Bonn; Dmitry Turchinovich* *Max Planck Institute for Polymer Research, Germany*
12:00 – 12:15	Fr1-5 **Sub-THz Spectroscopy Of The Ground State Hyperfine Splitting Of Positronium** *Takayuki Yamazaki[1]; Akira Miyazaki[1]; Toshio Namba[1]; Shoji Asai[1]; Tomio Kobayashi[1]; Taikan Suehara[2]; Yoshinori Tatematsu[3]; Isamu Ogawa[3]; Toshitaka Idehara[3]* *[1]University of Tokyo, Japan; [2]Tohoku University, Japan; [3]University of Fukui, Japan*	Fr2-5 **Terahertz Spectroscopy Of Magnetoexciton In Ge Under An Uniaxial Stress** *Jeyoon Yoo; Fumiya Sekiguchi; Ryo Shimano* *University of Tokyo, Japan*
12:15 – 12:30	Fr1-6 **Understanding The Influence Of Morphology On The Terahertz Spectra Of A Powdered Ionic Crystalline System** *Andrew Burnett[1]; John Kendrick[2]; Jeppe Christensen[3]; Lianhe Li[1]; John Cunningham[1]; Arwen Pearson[1]; Edmund Linfield[1]; Giles Davies[1]* *[1]University of Leeds, United Kingdom; [2]University of Bradford, United Kingdom; [3]University of Bath, UK*	
12:45 – 13:00	**Concluding Remarks (Congress Hall)**	

Gutenberg 3	Gutenberg 4	Congress Hall
Fr3 Parametric Sources	**Fr4 Modulators**	
Fr3-4 **High-power High-Repetition-Rate Mid-IR Femtosecond Laser Sources For FTIR Spectroscopy Applications** *Robin Hegenbarth[1]; Tobias Steinle[1]; Joachim Krauth[1]; Andy Steinmann[1]; Stefan Mastel[2]; Harald Giessen[1]* *[1]4th Physics Institute and Research Center SCoPE, University of Stuttgart, Germany; [2]Neaspec GmbH, Germany and CIC nanoGUNE, Spain*		
Fr3-5 **Realizing Of Extremely Wide Dynamic Range Measurement Using High-Brightness Terahertz-Wave** *Shin'ichiro Hayashi[1]; Kouji Nawata[1]; Kodo Kawase[2]; Hiroaki Minamide[1]* *[1]RIKEN, Japan; [2]Nagoya University / RIKEN, Japan*	Fr4-5 **Graphene On Silicon As Optically Tuned Terahertz Modulator** *Peter Weis[1]; Juan L. Garcia-Pomar[2]; Michael Höh[1]; Jens Neu[1]; Benjamin Reinhard[1]; Alexander Brodyanski[3]; Marco Rahm[1]* *[1]University of Kaiserslautern, Germany; [2]Instituto de Óptica, C.S.I.C., Spain; [3]Institut für Oberflächen und Schichtanalytik IFOS GmbH, Germany*	
	Fr4-6 **High Temperature Anisotropy Of $NdFeO_3$ Determined Using Time-Domain THz Spectroscopy** *Evan Constable[1]; Joseph Horvat[1]; Roger A. Lewis[1]; Zhenxiang Cheng[1]; Shujuan Yuan[2]; Shixun Cao[2]; David Cortie[1]* *[1]University of Wollongong, Australia; [2]University of Shanghai, China*	
Concluding Remarks (Congress Hall)		

Friday, September 6th

Fr Pl1 **09:00 - 09:45** **Friday Plenary 1** **Congress Hall**
Chair: Peter Siegel

THz Metrology 986
Thomas Kleine-Ostmann
Physikalisch-Technische Bundesanstalt (PTB), Germany

The term metrology refers to the art and science of measurement. In the last three hundred years approaches and tools have been developed that allow for precise and reliable measurements with known measurement uncertainty in a multitude of disciplines in physics and technology. Trust in measurement results, comparability and interoperability are crucial for technology in everyday life. With the advent of THz science and technology new sophisticated measurement techniques have been developed that allow for insights that cannot be obtained otherwise. By now commercial systems making use of THz radiation are appearing on the market and the question of the reliability of measurements becomes increasingly important.

Fr Pl2 **09:45 - 10:30** **Friday Plenary 2** **Congress Hall**
Chair: Peter Siegel

THz Dielectric Fiber Based Imaging: In Vivo Molecular Imaging Of Water 990
Chi-Kuang Sun
National Taiwan University, Taiwan

In this presentation, we review our recent development on the dielectric THz fibers/waveguides and their applications on THz fiber-delivered and fiber-scanning bio-imaging. Within the sub-THz regime, we find that in vivo imaging contrasts are dominated by water, which acts as the THz signature of life.

Fr1 **11:00 - 12:30** **THz Spectroscopy 2** **Gutenberg 1**
Chair: Carsten Brenner

Fr1-1 11:00 **Terahertz Frequency Electromagnon And Magnon Modes In Multiferroic Cupric Oxide 994**
Samuel Jones[1]; Stephen Gaw[1]; Dharmalingham Prabhakaran[1]; Andrew Boothroyd[1]; James Lloyd-Hughes[2]
[1]University of Oxford, United Kingdom; [2]University of Warwick, United Kingdom
We examined the terahertz magnetoelectric response of cupric oxide, a high-temperature multiferroic with a cycloidal spin structure that induces an electrical polarisation. Terahertz time-domain spectroscopy at various temperatures and magnetic fields uncovered electromagnon and magnon modes, providing insights into the spin Hamiltonian.

Fr1-3 11:30 **Visualization Of The Catalytic Reactions In The Fuel Cells Using THz Chemical Microscope 995**
Takafumi Hagiwara; Tetsuya Kusaka; Toshihiko Kiwa; Kenji Sakai; Keiji Tsukada
Okayama University, Japan
THz Chemical Microscope can visualize the work function shift of the catalytic electrodes in fuel cells. We observed the variation of the terahertz wave intensity at the cathode and anode under fuel cell operation. From this result, TCM is a valuable tool for investigation and evaluation of the catalytic electrode and electrolyte in fuel cells.

Fr1-4 11:45 **Sol-Gel Transition Of Supramolecular Gels Observed By Terahertz Spectroscopy 997**

Hiromichi Hoshina[1]; Atsumi Ozaki[2]; Yusuke Itagaki[2]; Setsuko Yajima[2]; Hal Suzuki[1]; Shinya Ishii[1]; Misaki Ishida[3]; Tetsuji Uchiyama[3]; Keiichi Kimura[2]; Chiko Otani[1]
[1]RIKEN, Japan; [2]Wakayama University, Japan; [3]Miyagi University of Education, Japan

Terahertz (THz) absorption spectra of supramolecular gels ((1R,2R)-1,2-bis(dodecanoylamino)cyclohexane / 2-nitrophenyl octyl ether) were measured by Fourier transform far-infrared spectroscopy (FT-FIR). The spectra were measured by changing concentration and temperature of gels. The absorption intensities of the peaks around 8.6 THz show drastic change at the sol-gel transition temperature.

Fr1-5 12:00 **Sub-THz Spectroscopy Of The Ground State Hyperfine Splitting Of Positronium 999**

Takayuki Yamazaki[1]; Akira Miyazaki[1]; Toshio Namba[1]; Shoji Asai[1]; Tomio Kobayashi[1]; Taikan Suehara[2]; Yoshinori Tatematsu[3]; Isamu Ogawa[3]; Toshitaka Idehara[3]
[1]University of Tokyo, Japan; [2]Tohoku University, Japan; [3]University of Fukui, Japan

We plan to directly measure the hyperfine structure of the ground-state positronium. The hyperfine structure between ortho-positronium and para-positronium is about 203 GHz. We develop a new optical system to accumulate about 20 kW power using a gyrotron and high finesse Fabry-Pérot resonator. We report the current status of our experiment.

Fr1-6 12:15 **Understanding The Influence Of Morphology On The Terahertz Spectra Of A Powdered Ionic Crystalline System. 1001**

Andrew Burnett[1]; John Kendrick[2]; Jeppe Christensen[3]; Lianhe Li[1]; John Cunningham[1]; Arwen Pearson[1]; Linfield Edmund[1]; Giles Davies[1]
[1]University of Leeds, United Kingdom; [2]University of Bradford, United Kingdom; [3]University of Bath, United Kingdom

We show that the terahertz (THz) frequency spectra of powdered ionic crystalline systems are not described by their infrared active phonon modes alone. Instead, it is necessary to include the coupling of the phonon modes with the macroscopic electric field generated by the collective displacement of the vibrating ions.

Fr2 11:00 - 12:30 THz Spectroscopy: Semiconductors 2 Gutenberg 2
Chair: Ingrid Wilke

Fr2-1 11:00 **Transient THz Photoconductivity In Dynamically Screened InGaN/GaN Quantum Wells 1003**

Z. Jin[1,2]; S. Lahmann[3]; U. Rossow[3]; A Hangleiter[3]; M. Bonn[1]; D. Turchinovich[1,4]
[1]Max Planck Institute for Polymer Research, Germany; [2]Shanghai University, China; [3]Technical University of Braunschweig, Germany; [4]Technical University of Denmark, Denmark

Using optical pump -- THz probe spectroscopy we reveal complex ultrafast photoconductivity dynamics in InGaN/GaN quantum wells under dynamical screening conditions, where, at sufficiently high excitation densities, the photo-generated carriers fully screen the initial internal field of 3 MV/cm. The THz photoconductivity spectra contain features of both localized and free charges.

Fr2-3 11:30 **Extra-long Hole Spin Relaxation Time In InGaAs/GaAs Quantum Wells Probed By Cyclotron Resonance Spectroscopy 1005**

Kirill Spirin[1]; Oleksiy Drachenko[2]; Dmitry Kozlov[1]; Anton Ikonnikov[1]; Vladimir Gavrilenko[1]; Harald Schneider[2]; Manfred Helm[2]; Jochen Wosnitza[2]
[1]Institute for Physics of Microstructures, RAS, 603950 Nizhny Novgorod, Russia, Russian Federation; [2]Helmholtz-Zentrum Dresden-Rossendorf, Germany

We report a long, ms range, spin relaxation time of holes in InGaAs/GaAs quantum wells probed by cyclotron-resonance spectroscopy in pulsed magnetic fields up to 60 Tesla. We found a strong hysteresis in the spectral weights of the cyclotron resonance absorption when a rapidly changing magnetic field is used for the experiment, while the hysteresis vanishes when a much slower changing magnetic field is used. We attribute

this behavior to a long, comparable to the magnetic-field rise time, energy relaxation time between the two lowest spin-split hole Landau levels, i.e., a long hole spin relaxation time.

Fr2-4 11:45 **Density-dependent Electron Scattering In Photoexcited GaAs 1006**

Zoltan Mics; Andrea D'Angio; Soeren Jensen; Mischa Bonn; Dmitry Turchinovich
Max Planck Institute for Polymer Research, Germany

In a series of systematic optical pump - terahertz probe experiments we study the density-dependent electron scattering rate in photoexcited GaAs in a large range of carrier densities. The electron scattering time decreases by as much as a factor of 4, from 320 to 60 fs, as the electron density changes by 4 orders of magnitude, from 10^{15} to 10^{19} cm^{-3}.

Fr2-5 12:00 **Terahertz Spectroscopy Of Magnetoexciton In Ge Under An Uniaxial Stress 1008**

Jeyoon Yoo; Fumiya Sekiguchi; Ryo Shimano
University of Tokyo, Japan

We have investigated the high magnetic field effect on the photoexcited electron-hole system in Ge under an uniaxial stress by using optical pump and terahertz probe spectroscopy. The internal transition of magnetoexciton and the cyclotron resonance of the electron and the hole are systematically studied.

Fr3 11:00 - 12:30 Parametric Sources Gutenberg 3
Chair: Chico Otani

Fr3-1 11:00 **Parametric Amplification Of Terahertz Waves In Lithium Niobate Crystal 1010**

Saroj Tripathi[1]; Taira Yuusuke[1]; Shin'ichiro Hayashi[2]; Hiroaki Minamide[2]; Kodo Kawase[1]
[1]Nagoya University, Japan; [2]RIKEN, ASI, Japan

We report on terahertz (THz) wave amplification system based on parametric process in Lithium Niobate crystal. We amplified THz wave with the energy of few pJ/pulse to few nJ/pulse. We got maximum amplification factor of more than 1000 for the THz wave with low pulse energy. However the factor decreases with the increase in input pulse energy due to parametric gain saturation of non-linear crystal.

Fr3-2 11:15 **Generation Of Spectrally Shaped Terahertz Waves Under Femtosecond- Or Nanosecond-Pulsed Optical Pumping 1012**

Alexander Sigov[1]; Galiya Kitaeva[2]; Alexey Mishin[2]; Oleg Samotokhin[2]; Anton Tuchak[2]; Pavel Yakunin[2]; Yen-Chieh Huang[3]; Yen-Hung Chen[4]; Nikita Ilyin[2]
[1]Moscow State Institute of Radio Engineering, Electronics, and Automation, Russian Federation; [2]M.V.Lomonosov Moscow State University, Russian Federation; [3]National Tsinghua University, Taiwan; [4]National Central University, Taiwan

Various predesigned terahertz spectra can be generated via optical rectification of laser pulses in aperiodically poled crystals. The opportunity to manage the terahertz spectrum via the crystal domain structure is stored when the femtosecond transform-limited optical pulses are replaced by the non-transform-limited pulses of the same spectral bandwidth.

Fr3-3 11:30 **Optimized Terahertz Generation In ZnTe Crystals 1013**

Sebastien Vidal[1]; Jean Oberle[2]; Jerome Degert[2]; Marc Tondusson[2]; Eric Freysz[2]
[1]ALPhaNOV, France; [2]LOMA, Université Bordeaux1, France

Optimal control of the output energy of terahertz wave generated by optical rectification in ZnTe crystals is reported. An enhancement by factor up to 2.4 is reported. Two-photon absorption and spectral phase effects on the THz generation efficiency are numerically investigated and discussed.

Fr3-4 11:45 **High-power High-repetition-rate Mid-IR Femtosecond Laser Sources for FTIR Spectroscopy Applications 1015**

Robin Hegenbarth[1]; Tobias Steinle[1]; Joachim Krauth[1]; Andy Steinmann[1]; Stefan Mastel[2]; Harald Giessen[1]
[1] 4th Physics Institute and Research Center SCoPE, University of Stuttgart, Germany; [2]Neaspec GmbH, Germany and CIC nanoGUNE, Spain

We present broadband difference frequency generation into the mid-infrared based on a femtosecond dual-signal-wavelength optical parametric oscillator for near-field microscopy applications as well as a high-repetition-rate optical parametric amplifier for FTIR spectroscopy applications.

Fr3-5 12:00 **Realizing Of Extremely Wide Dynamic Range Measurement Using High-brightness Terahertz-wave 1017**

Shin'ichiro Hayashi[1]; Kouji Nawata[1]; Kodo Kawase[2]; Hiroaki Minamide[1]
[1]RIKEN, Japan; [2]Nagoya University / RIKEN, Japan

We report on a terahertz-wave generation and detection system based on parametric frequency conversion in $MgO:LiNbO_3$. The terahertz-waves are generated by a high peak power, narrowband and tunable injection-seeded terahertz-wave parametric generator, then, detected as up-converted near IR beams by PIN PD.

Fr4 11:00 - 12:30 Modulators Gutenberg 4
Chair: Woijech Knap

Fr4-1 11:00 **An Electrically Driven Terahertz Modulator With Over 20 dB Of Dynamic Range 1019**

Nicholas Karl[1]; Hou-tong Chen[2]; Antoinette Taylor[2]; Daniel Mittleman[1]; Kimberly Reichel[1]; Alexander Benz[3]; John Reno[3]; Rajind Mendis[1]; Igal Brener[3]
[1]Rice University, United States; [2]Los Alamos National Laboratory, United States; [3]Sandia National Laboratories, United States

We design and test a switchable diffraction grating based on active metamaterials for terahertz modulation. We observe off-axis diffraction which permits operation of the device as a high-contrast modulator, with better than 20 dB of dynamic range.

Fr4-3 11:30 **Near-field Enhanced Graphene Terahertz Modulator 1022**

Rusen Yan[1]; Lei Liu[1]; Berardi Sensale-Rodriguez[2]; Huili Grace Xing[1]
[1]University of Notre Dame, United States; [2]University of Utah and University of Notre Dame, United States

We demonstrate a proto-type of a new class of THz metamaterial modulators employing metallic frequency selective surfaces (FSS) in conjunction with patterned graphene placed within the near field of FSS. Owing to the field enhancement in the near field, this device structure can potentially circumvent the limited conductivity swing in large area graphene as well as promise high modulation depth, low insertion loss and high operation speed.

Fr4-4 12:00 **Graphene On Silicon As Optically Tuned Terahertz Modulator 1025**

Peter Weis[1]; Juan L. Garcia-Pomar[2]; Michael Höh[1]; Jens Neu[1]; Benjamin Reinhard[1]; Alexander Brodyanski[3]; Marco Rahm[1]
[1]University of Kaiserslautern, Germany; [2]Instituto de Óptica, C.S.I.C., Spain; [3]Institut für Oberflächen und Schichtanalytik IFOS GmbH, Germany

We show that the spectrally wideband optical tunability of terahertz transmission through silicon can be strongly improved by deposition of graphene. We measured enhanced modulation up to $\Delta M = 24$ % at a low modulation beam power of 40 mW and a maximal modulation depth of up to $M = 99$ %.

Fr4-5 12:15 **High Temperature Anisotropy Of $NdFeO_3$ Determined Using Time-domain THz Spectroscopy 1027**

Evan Constable[1]; Joseph Horvat[1]; Roger A. Lewis[1]; Zhenxiang Cheng[1]; Shujuan Yuan[2]; Shixun Cao[2]; David Cortie[1]

[1]University of Wollongong, Australia; [2]University of Shanghai, China

The temperature dependent anisotropic fields along two principal crystallographic axes (A_x and A_z) is calculated for the canted antiferromagnet neodymium iron oxide in the temperature range 300 - 470 K. The calculation is performed using the experimentally determined temperature dispersion of two orthogonal antiferromagnetic magnons, obtained via time-domain terahertz spectroscopy. The experiment demonstrates the potential use of THz spectroscopy for characterising magnetic materials and offers a complementary technique to traditional neutron and magnetic methods.