Proceedings of
The 18th International Symposium on
Power Semiconductor Devices & ICs

June 4th-8th, 2006

University of Naples Federico II
Naples, ITALY
Plenary Sessions
Chair: Paolo Spirito – University of Naples "Federico II"
Claudio Contiero – ST Microelectronics, Italy
M.K. Han – Seoul National University, Korea

P-1 Future Trend of Flat Panel Displays and Comparison of its Driving Methods
SHUICHI UCHIKOGA
Toshiba Corporation, Corporate R & D Center, JAPAN

P-2 Power Drive Circuits for Diagnostic Medical Ultrasound
BRUNO HAIDER
General Electric, Niskayuna, USA

P-3 Trend and Challenges in Automotive Electronics
VALENTIN VON TILS
Robert Bosch GmbH, GERMANY

Session 1: Diodes and IGBT
Chair: Daniel Kinzer - International Rectifier, USA
Stefan Linder - ABB, Switzerland

1-1 Mechanical stress dependence of power device electrical characteristics
HIROAKI TANAKA, KOJI HOTTA, SATOSHI KUWANO, MASANORI USUI*, MASAYASU ISHIKO*
TOYOTA MOTOR Corp., \ Aichi, JAPAN
*TOYOTA CENTRAL R&D LABS. INC. Nagakute, Aichi, JAPAN

1-2 Theoretical investigation of Silicon limit characteristics of IGBT
AKIO NAKAGAWA
Semiconductor Company, Toshiba Corporation, Japan

1-3 A novel diode structure with Controlled Injection of Backside Holes (CIBH)
MIN CHEN, JOSEF LUTZ, MARTIN DOMEIJ, HANS PETER FELSL*, HANS-JOACHIM SCHULZE*
Chemnitz University of Technology, Chemnitz, Germany
*KTH Stockholm, 2Infineon Technologies AG, Munich

1-4 Electro-thermal simulation of current filamentation in 3.3-kV silicon p-i-n diodes with different edge terminations
H. P. FELSL, E. FALCK, F. J. NIEDERNOSTHEIDE, *S. MILADY, **D. SILBER and **J. LUTZ
Infineon Technologies AG, Munich, Germany
* University of Bremen, Germany
** Chemnitz University of Technology, Germany
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Chair: Thomas Stockmeier - Semikron, Germany
Yasukazu Seki - Fuji Hitachi Power Semiconductor, Japan

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Chair: Vishnu Khemka - Freescale Semiconductor, USA
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Chair: Mohamed Darwish - Fultec Semiconductor, USA
C. Andre T. Salama - University of Toronto, Canada

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STMicroelectronics, Italy

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ETTORE NAPOLI, FLORIN UDREA*
Electronic and Telecom. Engineering dept. University of Napoli, Napoli Italy
* Department of Engineering University of Cambridge, Cambridge, UK
* Cambridge Semiconductor (Camsemi), Cambridge, UK

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YOSHIIKI HATTORI** AND HITOSHI YAMAGUCHI
DENSO CORPORATION, Nissin, Aichi, 470-0111, Japan
*SUMCO CORPORATION, Japan
**TOYOTA CENTRAL R&D LABS., Japan

Session 5: Diamond devices

Chair: Gehan Amaratunga - Cambridge University, UK
Anant Agarwal - Cree, USA

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Waseda University, Okubo 3-4-1, Shinjyuku-ku, Tokyo, Japan

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1Department of Engineering, University of Cambridge, UK
2National Institute for R&D in Microtechnology (IMT-Bucharest), Romania
3Element Six Ltd., King’s Ride Park, Ascot, UK
4Dynex Semiconductor Ltd., Lincoln, UK
5University Politehnica Bucharest, Bucharest, Romania
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*Device Technology Laboratory, Fuji Electric Advanced Technology Co., Japan  
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Taiyo Nippon Sanso Corporation, Japan |
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* CREE Inc., Durham, USA
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National Institute of Advanced Industrial Science and Technology, Japan

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S. E. BERBERICH, M. MARZ, A. J. BAUER, S. K. BEUER, H. RYSSL
Fraunhofer Institute of Integrated Systems and Device Technology (IISB)
Erlangen, Germany

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Power Device Works, Mitsubishi Electric Corporation, Japan

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J. VOBECKY AND P. HAZDRA
Microelectronics Dept., Czech Technical University, Prague, Czech Republic

High current gain silicon carbide bipolar power transistors
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KTH Royal Institute of Technology, Electrum 229, S-16440 Kista-Stockholm, Sweden
*Acreo AB, Electrum 236, S-16440 Kista-Stockholm, Sweden

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Toyota Motor Corporation, Toyota, Aichi 470-0309, Japan
*Discrete Semiconductor Division, Toshiba Corporation, Kawasaki, Japan

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M. BUZZO***, M. CIAPPA**, M. RUEB*, AND W. FITCHNER**
*Infineon Technologies, Villach, Austria
**Swiss Federal Institute of Technology (ETH), Zurich, Switzerland

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University of Napoli “Federico II” Napoli, Italy
* Dipartimento di Scienze Fisiche e INFN Napoli, Napoli, Italy
** International Rectifier Corporation Italiana, Borgaro (TO), Italy

Dynamic Behavior of High-Power Diodes Analyzed by EBIC
BERGISCHE UNIVERSITÁT WUPPERTAL, WUPPERTAL, GERMANY
*INFINEON TECHNOLOGIES AG, MÜNCHEN, GERMANY
**INFINEON AG, WARSTEIN, GERMANY

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*CNM, Campus Universidad Autonoma de Barcelona, Barcelona, Spain

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*Department of Electronics and Telecommunications Engineering, University of Naples “Federico II”, Naples, Italy
**IRCI-International Rectifier Corporation Italia, Turin, Italy

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School of Electrical Engineering, Seoul National University, Korea

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Fujitsu Electric Device Technology Co., Ltd., Nagano, Japan
*Fujitsu Electric Advanced Technology Co., Ltd., Nagano, Japan

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School of Electrical Engineering, Seoul National University, Korea
* Fairchild Semiconductor, Korea

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†Institut für Halbleitertechnik, RWTH-Aachen, Aachen, Germany,
‡Institut für Halbleitertechnik, TU-Braunschweig, Braunschweig, Germany
‡AMICA/AMO GmbH, Aachen, Germany

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*Emerging Technologies Research Centre, De Montfort University, Leicester, UK
**Dynex Semiconductor, Lincoln, UK
***Semefab (Scotland) Ltd, Glenrothes, Fife, UK

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School of Electrical Eng., Seoul Nat’l Univ., Korea
* Fairchild Semiconductor, Korea

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Mitsubishi Electric Corporation, Japan

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<td>** Proton Mikrotechnik GmbH, Bremen, Germany</td>
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Fuji Electric Device Technology Co., Ltd., Nagano, Japan

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6-49 Analytical design rules for field compensated structures (paper not available at the time of proceedings print)
Igor Sankin

6-50 Fast transient infrared thermal analysis of smart Power MOSFETs in permanent short circuit operation
* DIET, University of Naples Federico II, Naples, Italy
**STMicroelectronics Catania, Catania, Italy

Wednesday, June 7th 2006

Session 7: SiC Unipolar
Chair: Jose Millan - CNM, Spain
Masakatsu Hoshi - Nissan, Japan

7-1 Successful Development of 1.2 kV 4H-SiC MOSFETs with the Very Low On-Resistance of 5 mohmcm²
Naruhiisa Miura, Keiko Fujihira, Yukiyasu Nakao, Tomokatsu Watanabe, Yoichiro Tarui, Shin-iichi Kinouchi, Masayuki Imaizumi and Tatsuo Oomori
Advanced Technology R&D Center, Mitsubishi Electric Corporation, Japan

7-2 10 kV, 5A 4H-SiC Power DMOSFET
Sei-Hyung Ryu, Sumi Krishnaswami, Brett Hull, James Richmond, Anant Agarwal, and Allen Hefner*
Cree, Inc., Durham, USA
*Natl. Inst. of Standards and Tech., USA

7-3 „2nd Generation“ SiC Schottky diodes: A new benchmark in SiC device ruggedness.
Roland Rupp1, Michael Treu2, Stephan Voss1, Fanny Björk2, Tobias Reimann3
1Infineon Technologies AG Munich, Germany
2Infineon Technologies AG Villach, Austria
3ISLE Steuerungstechnik und Leistungselektronik GmbH Ilmenau, Germany

7-4 Dose designing and fabrication of 4H-SiC double RESURF MOSFETs
M. Noborio, J. Suda, and T. Kimoto
Department of Electronic Science and Engineering, Kyoto University, Japan

Session 8: SiC Bipolar
Chair: P. Chow - Rensselaer Polytechnic Institute, USA
Jean L. Sanchez - LAAS-CNRS, France

8-1 A 180 A/4.5 kV 4H-SiC PiN Diode for High Current Power Modules
Cree, Inc., Durham, USA
*Powerex, Inc., Youngwood, USA
8-2 Analysis of SiC BJTs RBSSOA
North Carolina State University, Raleigh, USA
* Cree Inc, Durham, USA
# US Army Research Laboratory, 2800 Powder Mill Road, Adelphi, USA

8-3 Design and Fabrications of High Voltage IGBTs on 4H-SiC
Qingchun Zhang, Charlotte Jonas, Sei-Hyung Ryu, Anant Agarwal and John Poulmou
Cree, Inc., Durham, USA

8-4 4 kV, 10 A Bipolar Junction Transistors in 4H-SiC
Sumi Krishnaswami, Anant Agarwal, James Richmond, T. Paul Chow*,
Bruce Geil**, Ken Jones**, and Charles Scozzie**
Cree, Inc., 4600 Silicon Drive, USA
*Rensselaer Polytechnic Institute, USA
**Army Research Laboratory, USA

Session 9: SuperJunction devices
Chair: D. Pattanayak - Vishay-Siliconix, USA
L. Lorenz - Infineon Technologies, Germany

9-1 A 15.5 mOhmcm2-680V Superjunction MOSFET Reduced On-Resistance by Lateral Pitch Narrowing
Wataru Saito, Ichiro Omura, Satoshi Aida, Shigeo Koduki, Masaru Izumisawa,
Hironori Yoshioka, Hideki Okumura, Masakazu Yamaguchi and Tsuneo Ogura
Toshiba Corp, Semiconductor Company, Kawasaki, Japan

9-2 20 mohm-cm2 660V Super junction MOSFETs fabricated by deep trench etching and epitaxial growth
K. Takahashi, H. Kuribayashi, T. Kawashima, S. Wakimoto, K. Mochizuki and H. Nakazawa
Fuji Electric Advanced Technology Co., Ltd., Nagano, Japan

9-3 Electrical and Physical Characterization of 150-200V FLYMOSFETs
Jaume Roig, Yann Weber*, J-M. Reynès, F. Moranco, E. Stefanov, M. Dilhan,
G. Sarrabayrouse
LAAS / CNRS, Toulouse, France

9-4 A 600V, 8.7Ohmm2 Lateral SuperJunction Transistor
C. Tolkisdorfer**, A. Willemothc**
Infineon Technologies Austria AG, Villach
*Infineon Asia Pacific Pte. Ltd., Singapore
**Infineon Technologies AG, Neubiberg

Session 10: GaN devices
Chair: H.R. Chang ASCE Power, USA
P. Mawby University of Wales Swansea, UK

10-1 Enhancement-Mode n-Channel GaN MOSFETs on p and n- GaN/Sapphire substrates
W. Huang, T. Khan and T. P. Chow
Center for Power Electronics Systems, Rensselaer Polytechnic Institute, USA
10-2 High temperature operation AlGaN/GaN HFET with a low on-state resistance, a high breakdown voltage and a fast switching capability
TAKEHICO NOMURA, KAMAYASHI HIROSHI, MITSURU MASUDA, SONOMI ISHII, NARIKI IKEDA AND SEIKOH YOSHIDA
The Furukawa Electric Co., Ltd., Yokohama, Japan

10-3 Fabrication of an AlGaN/GaN HFET with a high breakdown voltage of over 1050 V
S. YOSHIDA, J. LI, H. TAKEHARA, K. KAMAYASHI, AND N. IKEDA
The Furukawa Electric Co., Ltd., Yokohama, Japan

10-4 GaN Switching Devices For High-Frequency, KW Power Conversion
K. S. BOUTROS, S. CHANDRASEKARAN, W.B. LUO, AND V. MEHROTRA
Rockwell Scientific Company LLC, , Thousand Oaks, CA, USA

Thursday, June 8th 2006

Session 11: Integration - power devices
Chair: T. Efland - Texas Instruments, USA, Chair
W.T. Ng - University of Toronto, Canada

11-1 Novel power transistor design for a process independent high voltage option in standard CMOS
A. HERINGA AND J. ŠONSKÝ
Philips Research Leuven, Leuven, Belgium

11-2 Low gate charge 20V class trench-aligning lateral power MOSFET
S. MATSUNAGA, M. SAWADA, A.SUGI, K. TAKAGIWA AND N. FUJISHIMA
Device Technology Laboratory, Fuji Electric Advanced Technology, Nagano, Japan

11-3 Stepped-Drift LDMOSFET: A Novel Drift Region Engineered Device for Advanced Smart Power Technologies
R. ZHU, V. KHEKMA, A. BOSE, T. ROGGENBAUER
Freescale Semiconductor, , Tempe, USA

11-4 Experimental Implementation and Characterization of a CMOS Compatible Buffered Super Junction LDMOST
IL-YONG PARK AND C. ANDRE T. SALAMA
Edward S. Rogers Sr. Dept. of ECE, University of Toronto, Toronto, Canada

Session 12: Integration technology 1
Chair: J. Sin - Hong Kong University of Science and Technology, China
S. Ekkanath Madathil - De Montfort University, UK

12-1 Wide Voltage Power Device Implementation in 0.25um SOI BiC-DMOS
RENESAS TECHNOLOGY CORP. JAPAN
* Renesas Semiconductor Engineering Corp., Japan

12-2 LDMOSFETs with Current Diverter for Advanced Smart Power Technologies
VISHNU KHEKMA, RONGHUA ZHU, TODD ROGGENBAUER AND AMITAVA BOSE
SMARTMOS Technology Center, Freescale Semiconductor, USA
12-3  High Voltage (up to 20V) Devices Implementation in 0.13 um A035 BiCMOS Process Technology for System-On-Chip (SOC) Design  
Texas Instruments Inc., , Dallas, USA  
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12-4  High Voltage CMOS Line-up for Display Driver Applications based on 0.13µm CMOS with Aluminum metallization Scheme  
TAKAHIRO OOHORI, HIROSHI SAIJO*, HI DEHIKO KAMIZONO, HIROYUKI MIYAKAWA and TOSHIRO KUBOTA  
Toshiba Corporation Semiconductor Company, Japan  
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Chair: R. Zhu  Freescale Semiconductor, USA  
D. Disney  Advanced Analogic Technologies, USA

13-1  650V SOI LIGBT for Switch Mode Power Supply Application  
T. LETAVIC1, J. PETRUZZELLO1, J. CLAES2, P. EGGENKAMP2, E. JANSSEN2, A. VAN DER WAL2  
1 PHILIPS RESEARCH NORTH AMERICA, , NY, USA  
2 PHILIPS SEMICONDUCTORS, NIJMEGEN, THE NETHERLANDS  
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13-2  Development of ESD protection structures for BULK and SOI BCD6 technology  
A. TAZZOLI, L. CERATI*, M. DISSEGNA*, A. ANDREINI*, E. ZANONI, G. MENEGHESO  
UNIVERSITY OF PADOVA, DEI, PADOVA, ITALY.  
* STMicroelectronics FTM R&D , Italy  
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13-3  Self-Heating Driven Vth Shifts in Integrated VDMOS Transistors  
*AMI Semiconductor Belgium, Oudenaarde, Belgium  
**Institute for Material Research, Diepenbeek, Belgium  
***Now with Infineon Technologies, Munich, Germany.  
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13-4  1200V Interconnection Technique with Isolated Self-Shielding Structure  
SUNG-LYONG KIM, CHANG-KI JEON, MIN-SUK KIM and JONG-JIB KIM  
Fairchild Semiconductor, Kyonggi-Do, Korea  
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Session 14: Applications

Chair: G. Majumdar  Mitsubishi, Japan  
D. Silber  University of Bremen, Germany

14-1  A Digitally Controlled DC-DC Converter Module with a Segmented Output Stage for Optimized Efficiency  
O. TRESCAES1, WAI TUNG NG1, H. NISHIO2, MASAHARU EDO2 and TETSUYA KAWASHIMA2  
1University of Toronto, Toronto, Canada  
2Fuji Electric Advanced Technology Co., Japan  
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14-2  Design of a CMOS Integrated Controller for High Current Low Voltage DC-DC Converters with Variable Switching Frequency  
XIAOMING DUAN, JINSEOK PARK, KENDY WU*, ALEX Q. HUANG  
Semiconductor Power Electronics Center, NCSU, Raleigh, USA  
* NIKO Semiconductor Co., Ltd. Taipei, Taiwan  
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14-3  Simulation, Design and Testing of Integrated Power Supply for Insulated Gate Transistors  
N. ROUGER, J-C CREBIER, R. MITOVA, L. AUBARD, C. SCHAFFER  
LEG - ENSIEG, INPG, St Martin d'Hères, France  
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