

2012 IEEE Ninth International Vacuum Electron Sources Conference

(IVESC 2012)

**Monterey, California, USA
24 – 26 April 2012**



**IEEE Catalog Number: CFP12VES-PRT
ISBN: 978-1-4673-0368-2**



Table of Contents

Welcome

Will Menninger (*General Chair IVEC-IVESC 2012*)

IVEC/IVESC 2012 Committee

EDS VACUUM ELECTRONICS TECHNICAL COMMITTEE

Plenary Talks

- PL.5:** "Much Ado About Nothing": Electron Sources and Transport in Vacuum (Page 13)
Kevin L. Jensen (*U.S. Naval Research Laboratory*)

Session 3: Scandate Cathodes

Session Chair: Bernard Vancil (*e-Beam, Inc.*)

- 3.1:** Development of Scandate Cathode and its Prospect_ a review (Page 41)
Yiman Wang (*Beijing University of Technology*),
Jinshu Wang (*Beijing University of Technology*),
Wei Liu (*Beijing University of Technology*)
- 3.2:** Scandia Doped Impregnated Cathode Prepared with Hollow Tungsten Spheres (Page 43)
Jinshu Wang (*Beijing University of Technology*),
Yuntao Cui (*Beijing University of Technology*),
Wei Liu (*Beijing University of Technology*),
Xi Wang (*Beijing University of Technology*),
Yiman Wang (*Beijing University of Technology*),
Meiling Zhou (*Beijing University of Technology*)
- 3.5:** 100A/cm² High Emission Current Density Oxide Cathode (Page 49)
Xiaoxia Wang (*Chinese Academy of Sciences*),
Min Zhang (*Chinese Academy of Sciences*),
Xianheng Liao (*Chinese Academy of Sciences*),
Jirun Luo (*Chinese Academy of Sciences*),
Qinglan Zhao (*Chinese Academy of Sciences*),
Yun Li (*Chinese Academy of Sciences*),
Qi Zhang (*Chinese Academy of Sciences*)

Poster Session I

- P1.11:** RF Circuit Design of a Multi-gap W-band Sheet Beam Klystron (Page 69)
Guo Liu (*University of Electronic Science and Technology of China*),
Yong Luo (*University of Electronic Science and Technology of China*),
Jian-xun Wang (*University of Electronic Science and Technology of China*)
- P1.23:** Ultra Wide Band UHF Chaotic Impulse Generator (Page 91)
Boris Savelevich Dmitriev (*Saratov State University*),
Jury Dmitrievich Zharkov (*Saratov State University*),
Valentin Nikolaevich Skorokhodov (*Saratov State University*),
Sergei Alexandrovich Sadovnikov (*Saratov State University*)
- P1.24:** The Vacuum-sealed Micro-focus X-ray Tube with CNT Field Emitters (Page 93)
Jin-Woo Jeong (*Electronics and Telecommunications Research Institute*),
Jae-Woo Kim (*University of Science & Technology*),
Sungyool Choi (*Electronics and Telecommunications Research Institute*),
Jun-Tae Kang (*Electronics and Telecommunications Research Institute*),
Yoon-Ho Song (*Electronics and Telecommunications Research Institute & University of Science & Technology*)

- P1.25: Synthesize Carbon Nanotube Field Emitters by Local Heating Chemical Vapor Deposition (Page 95)**
 Feng Gao (*Southeast University*),
 Mei Xiao (*Southeast University*),
 Xiaobing Zhang (*Southeast University*)
- P1.26: Enhanced Field Emission from ZnO-CNTs Composite Emitters with CsI Nanoparticle (Page 97)**
 Zhuoya Zhu (*Southeast University*),
 Xiaofei Hao (*Southeast University*),
 Wei Lei (*Southeast University*),
 Xiaobing Zhang (*Southeast University*),
 Huan Feng (*Southeast University*),
 Yajun Sun (*Southeast University*)
- P1.29: The Design and Fabrication of CNT Field Emitters for a Vacuum-sealed X-ray Tube (Page 103)**
 Jae-Woo Kim (*University of Science & Technology & ETRI*),
 Jun-Tae Kang (*Electronics and Telecommunications Research Institute*),
 Jin-Woo Jeong (*Electronics and Telecommunications Research Institute*),
 Sungyool Choi (*Electronics and Telecommunications Research Institute*),
 Dae-Jun Kim (*Vacuum Science/Instrument*),
 Yoon-ho Song (*Electronics and Telecommunications Research Institute*)

Session 6: Cold Cathodes I

Session Chair: Jonathan Shaw (*U.S. Naval Research Laboratory*)

- 6.1: Hafnium Carbide CFE, TFE, and Schottky Electron Sources (Page 129)**
 William A. Mackie (*Applied Physics Technologies, Inc.*),
 Josh M. Lovell (*Applied Physics Technologies, Inc.*),
 Gerald G. Magera (*Applied Physics Technologies, Inc.*)
- 6.4: Stable Field Emission from Nanoporous Silicon Carbide (Page 135)**
 Myung-Gyu Kang (*University of Maryland*),
 Henri J. Lezec (*The Center for Nanoscale Science and Technology*),
 Raymond L. Kallaher (*The Center for Nanoscale Science and Technology*),
 Fred Sharifi (*The Center for Nanoscale Science and Technology*)

Session 9: Dispenser Cathodes

Session Chair: Louis Falce (*Consultant for Calabazas Creek Research, Inc.*)

- 9.1: Implementation of High Current Density Cathodes in High Frequency RF Sources (Page 159)**
 Lawrence Ives (*Calabazas Creek Research, Inc.*),
 Lou Falce (*Calabazas Creek Research, Inc.*),
 Michael Read (*Calabazas Creek Research, Inc.*),
 George Collins (*Calabazas Creek Research, Inc.*),
 Zhigang Pan (*University of Maryland*),
 David Marsden (*Calabazas Creek Research, Inc.*)
- 9.2: Modeling the Quantum Efficiency of Controlled Porosity Dispenser Photocathodes (Page NA)**
 Zhigang Pan (*U.S. Naval Research Laboratory*),
 Kevin Lynn Jensen (*U.S. Naval Research Laboratory*),
 Patrick Gerard O'Shea (*University of Maryland*)
- 9.3: Reservoir Cathode for Ion Thrusters (Page 161)**
 Bernard K. Vancil (*e-Beam, Inc.*),
 Wayne Ohlinger (*Private Consultant*),
 James Polk (*California Institute of Technology*),
 Victor Schmidt (*e-Beam, Inc.*)
- 9.5: Synthesis and Characterization of High Purity Barium Calcium Aluminates for TWT Impregnated Cathodes (Page 165)**
 Frank F. Sene (*Nuclear and Energy Research Institute*),
 Vinicius O. Santos (*University of Sao Paulo*),
 Claudio C. Motta (*University of Sao Paulo*)

Poster Session II

- P2.6: Metal Alloy Cathodes for Application in Vacuum Microwave Devices (Page 177)**
 Boris Cheslavovich Djubua (*FSUE Istok*),
 Oleg Konstantinovich Kultashev (*FSUE Istok*),
 Anatoly Pavlovich Makarov (*FSUE Istok*),
 Olga Valentinovna Polivnikova (*FSUE Istok*),
 Evgeny Mikhailovich Zemchikhin (*FSUE Istok*)
- P2.8: Fabrication and Characterization of Pressed Y₂O₃ Doped Ba-W Dispenser Cathode (Page 181)**
 Fan Yang (*Beijing University of Technology*),
 Jinshu Wang (*Beijing University of Technology*),
 Wei Liu (*Beijing University of Technology*),
 Yiman Wang (*Beijing University of Technology*)

P2.9: Development and Characterization of the Porous Tungsten Matrix Obtaining Process for Dispenser Thermionic Cathode (Page 183)

Frank F. Sene (*Nuclear and Energy Research Institute*),
Artur G. L. Silva (*University of Sao Paulo*),
Claudio C. Motta (*University of Sao Paulo*)

P2.10: DC Emission Characteristic of Sc- doped Impregnated Dispenser Cathodes (Page 185)

Xi Wang (*Beijing University of Technology*),
Wei Liu (*Beijing University of Technology*),
Yiman Wang (*Beijing University of Technology*),
Yuntao Cui (*Beijing University of Technology*),
Jinshu Wang (*Beijing University of Technology*)

P2.11: Investigation of Influence of Surface Activator Element to Scandate Cathodes Work Function (Page 187)

Xizhu Zhang (*Beijing University of Technology*),
Jinshu Wang (*Beijing University of Technology*),
Yiman Wang (*Beijing University of Technology*),
Wei Liu (*Beijing University of Technology*),
Meiling Zhou (*Beijing University of Technology*)

P2.22: 527 GHz Gyrotron for DNP-NMR Spectroscopy (Page 205)

Sudheer K. Jawla (*Massachusetts Institute of Technology*),
Michael A. Shapiro (*Massachusetts Institute of Technology*),
William C. Guss (*Massachusetts Institute of Technology*),
Richard J. Temkin (*Massachusetts Institute of Technology*)

Session 12: Basic Emission Physics I

Session Chair: Joan Yater (*U.S. Naval Research Laboratory*)

12.2: Correlation Between Single Crystal LaB₆ Cathode Optical and Emission Images (Page 247)

Victor Katsap (*NuFlare Technology*),
Chising Lai (*NuFlare Technology*)

12.3: Scattering and the Prediction of Quantum Efficiency and Response Time Characteristics (Page 249)

Kevin Lynn Jensen (*U.S. Naval Research Laboratory*),
Joan E. Yater (*U.S. Naval Research Laboratory*),
Jonathan L. Shaw (*U.S. Naval Research Laboratory*),
Brad B. Pate (*U.S. Naval Research Laboratory*),
Eric J. Montgomery (*University of Maryland*),
Donald W. Feldman (*University of Maryland*),
Patrick G. O'Shea (*University of Maryland*),
John J. Petillo (*Science Applications International Corporation*)

12.4: Ab initio Model of Intrinsic Defects in Sc₂O₃ for Thermionic Cathode Systems (Page 251)

Ryan M. Jacobs (*University of Wisconsin*),
Dane Morgan (*University of Wisconsin*),
John H. Booske (*University of Wisconsin*)

12.5: The Exchange-Correlation Potential Correction to the Vacuum Potential Barrier of Graphene Edge (Page 253)

Weiliang Wang (*Sun Yat-sen University*),
Junwen Shao (*Sun Yat-sen University*),
Zhibing Li (*Sun Yat-sen University*)

Poster Session III

P3.27: Hafnium Carbide Thermal Sources in O₂, CO and CO₂ Environments (Page 303)

Josh M. Lovell (*Applied Physics Technologies, Inc.*),
William A. Mackie (*Applied Physics Technologies, Inc.*),
Gerald G. Magera (*Applied Physics Technologies, Inc.*)

P3.28: Investigation of Lift-off Layer in Spindt Cathode Fabrication (Page 305)

Xinghui Li (*Beijing Vacuum Electronics Research Institute*),
Guodong Bai (*Beijing Vacuum Electronics Research Institute*),
Hanyan Li (*Beijing Vacuum Electronics Research Institute*),
Mingqing Ding (*Beijing Vacuum Electronics Research Institute*),
Jinjun Feng (*Beijing Vacuum Electronics Research Institute*),
Fujiang Liao (*Beijing Vacuum Electronics Research Institute*)

P3.29: Field Emission from Mechanical Pencil Lead and Graphite Edges (Page 307)

Toshihiro Endo (*University of Tsukuba*),
Toshiharu Higuchi (*University of Tsukuba*),
Yoichi Yamada (*University of Tsukuba*),
Masahiro Sasaki (*University of Tsukuba*)

P3.30: Impact of Spacers on the Uniformity of a Large-area Field Emission Display (Page 309)

Zheng Hu (*Southeast University*),
Zhuoya Zhu (*Southeast University*)

Wei Lei (*Southeast University*),
Xiaobing Zhang (*Southeast University*),
Huan Feng (*Southeast University*),
Yajun Sun (*Southeast University*),
Linhu Zheng (*Southeast University*)

P3.32: Investigations of Secondary Electron Emission from Boron doped Diamond Films Grown by MPCVD (Page 313)

Ming Q Ding (*Beijing Vacuum Electronics Research Institute*),
Lili Li (*Beijing Vacuum Electronics Research Institute*),
Jinjun Feng (*Beijing Vacuum Electronics Research Institute*),
Yujuan Gao (*Beijing Vacuum Electronics Research Institute*),
Qilue Chen (*Beijing Vacuum Electronics Research Institute*),
Wensheng Shao (*Beijing Vacuum Electronics Research Institute*)

Session 15: Cathode Simulation

Session Chair: Kevin Jensen (*U.S. Naval Research Laboratory*)

15.1: SOURCE Software for the Simulation and Design of Electron Guns (Page 339)

John Andrew Rouse (*Munro's Electron Beam Software Ltd*),
Haoning Liu (*Munro's Electron Beam Software Ltd*),
Xieqing Zhu (*Munro's Electron Beam Software Ltd*),
Eric Munro (*Munro's Electron Beam Software Ltd*)

15.3: Simulation of Thermionic Dispenser Cathodes (Page 343)

Meduri Ravi (*Defence Research & Development Organization*),
K.S. Bhat (*Defence Research & Development Organization*)

15.4: Characterization of Multi-Beam Cathode using Thermionic Emission Microscope (Page 345)

Sushil Kumar Shukla (*CSIR-Central Electronics Engineering Research Institute*),
Suryanarayana Raju Ruddarraju (*CSIR-Central Electronics Engineering Research Institute*),
Rahul Prajesh (*CSIR-Central Electronics Engineering Research Institute*),
Niharika Rajoriya (*Banasthali University*)

15.5: Electron Beam Emitter Characterization and its performance Analysis (Page NA)

Junaid Zafar (*COMSATS, Lahore*),
Haroon Zafar (*TOMI Research Group, National University*),
Khalid Masood (*INMOL, Pakistan Atomic Energy Commission*)

Session 18: Basic Emission Physics II

Session Chair: Ivor Brodie (*University of California*)

18.1: A Transit Time Model of Space Charge and Its Comparison to Experimental Data (Page 363)

Kevin L. Jensen (*U.S. Naval Research Laboratory*),
Y.Y. Lau (*U.S. Naval Research Laboratory*),
Joel L. Lebowitz (*Rutgers University*),
John W. Luginsland (*U.S. Air Force Office of Scientific Research*)

18.5: Theoretical Analysis for Different PDP Protective Layer Materials (Page 371)

Qiaofen Li (*Southeast University*),
Yan Tu (*Southeast University*),
Lanlan Yang (*Southeast University*),
Harm. Tolner (*Southeast University*)

Poster Session IV

P4.3: Enhanced Field Emission Density Current of a Planar Triode Structure with Double Cathodes (Page 377)

Linhu Zheng (*Southeast University*),
Zhuoya Zhu (*Southeast University*),
Wei Lei (*Southeast University*),
Xiaobing Zhang (*Southeast University*),
Huan Feng (*Southeast University*),
Yajun Sun (*Southeast University*),
Zheng Hu (*Southeast University*)

P4.6: Design of Injector for the Next Generation FEL X-ray (Page NA)

Zhiqiang Yu (*Beijing Vacuum Electronics Research Institute*)

P4.7: First-principles Study of Interaction of lithium Atoms with H-adsorbed (3, 3) Single-walled Carbon Nanotube (Page 383)

Zhi-Jun Jia (*Ocean University of China*),
Lin-Peng Li (*Qingdao Institute of Technology*),
Shun-Fu Xu (*Ocean University of China*),
Guang Yuan (*Ocean University of China*)

Session 21: Photo/Secondary Emission

Session Chair: Martin Kordesch (*Ohio University*)

- 21.3: Development of Biased Diamond Current Amplifier (Page 439)**
 Joan E. Yater (*U.S. Naval Research Laboratory*),
 Jonathan L. Shaw (*U.S. Naval Research Laboratory*),
 Kevin L. Jensen (*U.S. Naval Research Laboratory*),
 Frank Wood (*U.S. Naval Research Laboratory*),
 Tatyana Feygelson (*Science Applications International Corporation*),
 Jeremy Hanna (*Beam-Wave Research, Inc.*),
 Bradford B. Pate (*U.S. Naval Research Laboratory*)
- 21.4: Diamond Bonding and Metallization for Electron Transmission Cathodes (Page 441)**
 Jonathan L. Shaw (*U.S. Naval Research Laboratory*),
 Franklin N. Wood (*U.S. Naval Research Laboratory*),
 Joan E. Yater (*U.S. Naval Research Laboratory*),
 Kevin L. Jensen (*U.S. Naval Research Laboratory*),
 Bradford B. Pate (*U.S. Naval Research Laboratory*),
 Jeremy M. Hanna (*Beam-Wave Research, Inc.*),
 Robert E. Myers (*Beam-Wave Research, Inc.*),
 Tatyana I. Feygelson (*Science Applications International Corporation*)

Session 24: Thermionic Cathodes

Session Chair: Michael Green (*Varian Medical Systems*)

- 24.1: Brightness and Energy Spread Measurements for an I-cathode (Page 463)**
 Leon van Kouwen (*Delft University of Technology*),
 Marco van der Heijden (*Delft University of Technology*),
 Pieter Kruit (*Delft University of Technology*)
- 24.2: Improved Electron Emission from W-Ir Dispenser Cathodes (Page 465)**
 Meduri Ravi (*Defence Research & Development Organization*),
 K. Santosh Kumar (*Defence Research & Development Organization*),
 P. Durga Devi (*Defence Research & Development Organization*),
 K.S. Bhat (*Defence Research & Development Organization*),
 Lalit Kumar (*Defence Research & Development Organization*)
- 24.3: Emission Mechanism and technical progresses for M-type cathodes (Page 467)**
 Shengyi Yin (*Institute of Electronics, Chinese Academy of Science*),
 Yongqing Zhang (*Institute of Electronics, Chinese Academy of Science*)
- 24.4: Modeling of Emission Slump by Ion Bombardment of a Ba-Dispenser Cathode in an Electron Tube (Page 469)**
 Toshiharu Higuchi (*University of Tsukuba*),
 Masahiro Sasaki (*University of Tsukuba*),
 Shuji Matsumoto (*Accelerator Laboratory, High Energy Accelerator Research Organization*),
 Shigeki Fukuda (*Accelerator Laboratory, High Energy Accelerator Research Organization*)
- 24.5: A Study of Tungstate Formation in Dispenser Cathodes (Page 471)**
 William G. Tighe (*L-3 Communications Electron Technologies, Inc.*),
 Russell H. Martin (*L-3 Communications Electron Technologies, Inc.*)

Poster Session V

- P5.1: Cathode Manufacturing: Relational Database and Process Control System (Page 473)**
 Michael Effgen (*Semicon Associates*),
 Lindsey Wolverton (*Semicon Associates*)
- P5.3: Variations in Properties of Mo-Re Sheet Effects on Dispenser Cathode Fabrication (Page 477)**
 James O. Tarter (*Semicon Associates*),
 Phillip Swartzentruber (*University of Kentucky*),
 John Balk (*University of Kentucky*),
 Alex Fryman (*University of Kentucky*),
 Cheryl Rabek (*University of Kentucky*),
 Andrew Batts (*University of Kentucky*)
- P5.4: Moving Toward Sustainability In Cathode Manufacturing Process (Page 479)**
 Scott Roberts (*Semicon Associates*),
 Michael Effgen (*Semicon Associates*)
- P5.5: The Effects and Cost Reduction with Lower Rhenium Content in MoRe Alloys (Page 481)**
 Lindsey Wolverton (*Semicon Associates*),
 Todd Leonhardt (*Rhenium Alloys*)
- P5.7: Mechanical Properties of Nanoparticles Reinforced Mo-Ni Braze for a Dispenser Cathode Application (Page 485)**
 Daniel Busbaher (*Semicon Associates*),
 Wen Liu (*University of Kentucky*),
 Dusan P. Sekulic (*University of Kentucky*)

P5.8: Research on Sintering and Fabrication of Advanced Cathodes (Page 487)

Lou Falce (*Calabazas Creek Research, Inc.*),
R. Lawrence Ives (*Calabazas Creek Research, Inc.*),
George Collins (*Calabazas Creek Research, Inc.*),
David Marsden (*Calabazas Creek Research, Inc.*)

Session 27: Cold Cathodes II

Session Chair: William Mackie (*Applied Physics Technologies, Inc.*)

27.1: Field Emission Display with Printable Planar Triode (Page 555)

Wei Lei (*Southeast University*),
Xiaobing Zhang (*Southeast University*),
Baoping Wang (*Southeast University*)

27.4: Effect of Outgassing on the Field Emission Property of Screen-printed CNTs (Page 561)

Nicolai Bushuev (*Federal State Unitary Enterprise, NPP Almaz*),
Yunkang Cui (*Nanjing Institute of Technology & Southeast University*),
Xiaobing Zhang (*Southeast University*),
Wei Lei (*Southeast University*),
Yunsong Di (*Nanjing Normal University*),
Jing Chen (*Southeast University*),
Qilong Wang (*Southeast University*)