

# **2021 34th International Vacuum Nanoelectronics Conference (IVNC 2021)**

**Lyon, France  
5 – 9 July 2021**



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# 34<sup>th</sup> International Vacuum Nanoelectronics Conference

## Schedule

Monday, 5th July, 2021

Time (Lyon)	
12:40-13:00	Opening comments from the two Chairmen

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Chair - tbd

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13:45-14:30 Tutorial M1.2	<b>Ion sources and optical charged particles dedicated to FIB technology today. Current trends and challenges in semiconductors, failure analysis and HR SIMS</b> <u>Arnaud Houël</u> , Anne Delobbe, Justine Renaud, Matthieu Vitteau Orsay Physics	32

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Chair – Richard Forbes

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15:45-16:30 Tutorial M2.2	<b>Electron emission calculations beyond the classical equations: finite size, space charge and thermal effects in sharp emitters</b> <u>Andreas Kyritsakis</u> University of Tartu, Estonia	NA

16:30-16:45	Pause
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Tutorial M3.1	<b><u>Soichiro Tsujino</u></b> Paul Scherrer Institut, Switzerland	
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17:30-17:45	Pause
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Chair S. Purcell and J.-P. Mazellier

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	<b>We wish to thank our industriel sponsors Orsay Physics, Kashiyama Europe GMBH, Hamamatsu France and Slide Pack who all will be available in the poster sessions. Three will present flashes.</b>	
17:50	<b>Orsay Physics</b>	
17:52	<b>Hamamatsu France</b>	
17:54	<b>Slide Pack</b>	
<b>Microscopy + Spectroscopy</b>		
17:58	<b>Electron energy analysis in Scanning Field Emission Microscopy using a Bessel box energy analyzer</b> <b><u>M. Bodik</u></b> , M. Demydenko, C.G.H. Walker, T. Bähler, T. Michlmayr, A.-K. Thamm, U. Ramsperger, A. Pratt, S.P. Tear, M.M. El Gomati, D. Pescia ETH Zürich, Switzerland	128
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18:02	<b>Collector dependence of field emission in the Scanning Field Emission Microscopy</b> <b><u>H.J. Gotsis</u></b> , N.C. Bacalis, and J.P. Xanthakis	132
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18:42	<b>Silicon Field Emitter Arrays Fabricated Using a Layout-Independent Process</b> <b>Nedeljko Karaulac</b> , Winston Chern, Girish Rughoobur, and Akintunde I. Akinwande, Massachusetts Institute of Technology, USA	171
18:44	<b>Current dependent performance test used on different types of silicon field emitter arrays</b> <b>Andreas Schels</b> , Simon Edler, Walter Hansch, Michael Bachmann, Florian Herdl, Felix Düsberg, Magdalena Eder, Manuel Meyer, Markus Dudek, Rupert Schreiner Universität der Bundeswehr München, Germany	173
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18:48	<b>Carbon Nanotube Fiber Cathodes and Saturation of their Field Emission Current</b> <b>Evgenii P. Sheshin</b> , Ilya N. Kosarev, Bulat I. Masnaviev and D. I. Ozol Moscow Institute of Physics and Technology, Russian Federation	176

18:50	<p><b>Field emission properties of sharp tungsten cathodes coated with a thin resilient oxide barrier</b></p> <p><b>Daniel Burda</b>, Mohammad M. Allaham, Alexandr Knápek, Dinara Sobola, Marwan Suleiman Mousa  Institute of Scientific Instruments of the CAS, Czech Republic</p>	178
18:54	<p><b>Using High Aspect Ratio AFM Probe for Digital Twin Development of SiC FEA</b></p> <p><b>Konstantin Nikiforov</b>, Nikolay Egorov, Ivan Sokolov, Valery Strebko, Vladimir Mikhailovskiy, Denis Danilov, Vladimir Golubkov, Vladimir Ilyin, and Alexey Ivanov  Saint Petersburg State University, Russia</p>	180
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## Tuesday, 6th July, 2021

Time (Lyon)	
12:40-13:00	Opening comments from the two Chairmen

### Tu1 - Ultrafast, Ultra-intense Laser Excitation of Free and Bound Electrons

Chairs - Anthony Ayari

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14:15-14:30	Pause
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14:30-14:45 Oral Tu1.3	<b>Emission of electrons from a metal tip irradiated by femtosecond IR lasers at wavelengths of 800 and 1240 nm</b> A.V. Ovchinnikov, O.V. Chefonov, M.B. Agranat, N.A. Abramovskii, S.B. Bodrov, A.M. Kiselev, A.A. Murzanev, A.V. Romashkin, <b><u>A.N. Stepanov</u></b> Russian Academy of Sciences (IAP RAS), Russia	42
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15:15-15:45	Pause
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Chair Alizera Nojeh

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16:15-16:45 Invited Tu2.2	<b><u>Longitudinal and transverse modulation of electron wave function with light, and its application to electron microscopy</u></b> <b><u>Ivan Madan</u></b> , Giovanni Vanacore, Gabriele Berruto, Enrico Pomarico, Javier García de Abajo, Ido Kaminer, Fabrizio Carbone École Polytechnique Fédérale de Lausanne, Switzerland	48
16:45-17:00 Oral Tu2.3	<b><u>Voltage-controlled three-electron-beam interference by a three-element Boersch phase shifter with top and bottom shielding electrodes</u></b> <b><u>P. Thakkar</u></b> , V.A. Guzenko, P-H. Lu, R.E. Dunin-Borkowski, J.P. Abrahams and S. Tsujino Paul Scherrer Institut, Switzerland	50
17:00-17:30 Invited Tu2.4	<b><u>A standing molecule as a coherent single-electron field emitter</u></b> Taner Esat, Marvin Knol, Philipp Leinen, Matthew F. B. Green, Malte Esders, Niklas Friedrich, Michael Maiworm, Nicola Ferri, Pawel Chmielniak, Sidra Sarwar, Torsten Deilmann, Peter Krüger, Hadi H. Arefi, Daniel Corken, James Gardner, Kristof T. Schütt, Jeff Rawson, Paul Kögerler, Michael Rohlfing, Rolf Findeisen, Alexandre Tkatchenko, Klaus-Robert Müller, Reinhard J. Maurer, Christian Wagner, Ruslan Temirov & <b><u>F. Stefan Tautz</u></b> Peter Grünberg Institut, Germany	52
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Chair tbd

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## Wednesday, 7th July, 2021

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Chair S. Purcell, J.-P. Mazellier

Time(Lyon)	Title and Authors (speaker bold underlined, institute of speaker only)	Page
	<b>Industriel Sponsors</b>	
	<b>We wish to thank our industriel sponsors Orsay Physics, Kashiyama Europe GMBH, Hamamatsu France and Slide Pack who all will be available in the poster sessions. Three will present flashes.</b>	
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10:52	<b>Hamamatsu France</b>	
10:54	<b>Slide Pack</b>	
	<b>Applications</b>	
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11:02	<b>Cold Cathode X-Ray Flat Panel Detector Based on Ga2O3 Thin Film Photoconductor</b> <b>Haojian Huang</b> , Manni Chen, Zhipeng Zhang, Juncong She, Shaozhi Deng, Ningsheng Xu, Jun Chen Sun Yat-sen University, China	187
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11:52	<b>Degradation of an emitter based on VACNT made by DC-PECVD during field emission</b> <b><u>M.A. Chumak</u></b> , A.A. Rokacheva, L.A. Filatov, I.S. Bizyaev, E.O. Popov, S.V. Filippov, A.G. Kolosko Peter the Great St.-Petersburg Polytechnical University, Russia	237
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## W2 - Novel Emission Mechanisms 1

Chair- Arya Fallahi

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14:00-14:30 Invited W2.3	<b>Planar type electron emission device using atomic layered materials and it applications</b> <b><u>Katsuhisa Murakami</u></b> , Naoyuki Matsumoto, Yukino Kameda, Yoshinori Takao, Yoichiro Neo, Yoichi Yamada, Kazutaka Mitsuishi, Masahiro Sasaki, Hidenori Mimura, and Masayoshi Nagao National Institute of Advanced Industrial Science and Technology, Japan	60
14:30-14:45 Oral	<b>Mechanism of electron emission from graphene/hexagonal boron nitride heterostructure: Implication on MIM planar cathode</b>	NA

W2.4	<b><u>Yicong Chen</u></b> , Zhibing Li, Jun Chen Sun Yat-sen University, China	
14:45-15:00 Oral W2.5	<b>Oxygen Resistance Investigation of Graphene-Oxide-Semiconductor Planar-Type Electron Sources for Low Earth Orbit Applications</b> <b><u>Naoyuki Matsumoto</u></b> , Yoshinori Takao, Masayoshi Nagao, and Katsuhisa Murakami Yokohama National University, Japan	64

14:45-15:15	Pause
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### W3 - Novel Emission Mechanisms 2

Chair: Jun Chen

Time(Lyon)	Title and Authors (speaker bold underlined, institute of speaker only)	Page
15:15-15:45 Invited W3.1	<b>Development of highly spin-polarized field emitter using Heusler alloy Co<sub>2</sub>MnGa</b> <b><u>Shigekazu Nagai</u></b> Mie University, Japan	66
15:45-16:00 Oral W3.2	<b>A HfC nanowire field emission point electron source</b> <b><u>Shuai Tang</u></b> , Jie Tang, Ta-Wei Chiu, Wataru Hayami, Lu-Chang Qin National Institute for Materials Science, Tsukuba, Japan	68
16:00-16:15 Oral W3.3	<b>Field Emission from Genuine Graphene: An Experimental Study</b> <b><u>Philippe Poncharal</u></b> , Anthony Ayari, Pascal Vincent, Sorin Perisanu, Stephen T. Purcell University Claude Bernard Lyon 1 / CNRS, France	70
16:15-16:30 Oral W3.4	<b>Combined effect of single-electron charging and quantum confinement on field electron emission from heterostructured nanotips</b> <b><u>Victor I. Kleshch</u></b> Moscow State University, Russia	72
16:30-16:45 Oral	<b>Negative Differential Resistance in Laser-Assisted Field Emission from Si Nanowires</b> M. Choueib, A. Derouet, P. Vincent, A. Ayari, P. Poncharal, C. S. Cojocaru, <b><u>R. Martel</u></b> , S.T. Purcell Université de Montréal, Canada	74

16:45-17:00	Pause
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### W4- Vacuum Nano/Micro Devices

Chair: Rupert Schreiner

17:00-17:30 Invited W4.1	<b>Vertical Si Nano Vacuum Channel Transistors: Building Blocks for Empty State Electronics</b> <b><u>Akintunde I. Akinwande</u></b> , Girish Rughoobur, Nedeljko Karaulac, Winston Chern and Olusoji O. Ilori	76
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	Massachusetts Institute of Technology, USA	
17:30-17:45 Oral W4.2	<b>Ion-Atomic clocks with Spindt type Field Emitter Array</b> <b>John D. Prestage</b> , Christopher Holland, Thai Hoang, Sang Chung, Thanh Le, Nan Yu Jet Propulsion Laboratory, USA	NA
17:45-18:00 Oral W4.3	<b>Investigation on the Emission Behaviour of p-doped Silicon Field Emission Arrays with Individually Controllable Single Tips</b> <b>Philipp Buchner</b> , Vitali Bomke, Matthias Hausladen, Simon Edler, Michael Bachmann, Rupert Schreiner Ostbayerische Technische Hochschule (OTH) Regensburg, Germany	78
18:00-18:15 Oral W4.4	<b>Failure Mode of Si Field Emission Arrays based on Emission pattern analysis</b> <b>Reza Farsad Asadi</b> , Tao Zheng, Jaime da Silva, Girish Rughoobur, Akintunde I Akinwande, Bruce Gnade Massachusetts Institute of Technology, USA	80
18:15-18:30 Oral W4.5	<b>Field Emission Arrays from Graphite Fabricated by Laser Micromachining</b> <b>Robert Lawrowski</b> , Michael Bachmann and Rupert Schreiner Ostbayerische Technische Hochschule (OTH) Regensburg, Germany	82
Oral 18:30-18:45 W4.6	<b>Effects of Ultra Violet Light Exposure on Gated Silicon Field Emitter Arrays</b> <b>Ranajoy Bhattacharya</b> , Mason Canon, Nedeljko Karaulac, Girish Rughoobur, Winston Chern, Akintunde I. Akinwande and Jim Browning Boise State University, USA	84
18:45-19:00 Oral W4.7	<b>Emission Behavior of Planar Nano-Vacuum Field Emitters</b> <b>Marco Turchetti</b> , Yujia Yang, Mina R. Bionta, Alberto Nardi, Luca Daniel, Karl K. Berggren, Philip D. Keathley Massachusetts Institute of Technology, USA	86

## Thursday, 8th July, 2021

### Th1– Poster Session Time Zone B

Chair tbd

Time(Lyon)		
9:45 11:45	Following the W1 - Poster Flashes Time Zone B.	

### Th2 – Shoulder Gray Spicndt Award

Chairman: tbd

Time(Lyon)		
11:45 12:00	Heinz Busta announces SGS award winner.	

### Th3 – Presentation IVNC 2022 South Korea

Chair tbd

Time(Lyon)		
12:00 12:30	Professor Park : South Korea attributes for the IVNC 2022	

12:30-13:00	Pause	
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### Th4 - High frequency EM radiation from Electron Beams

Chair: Peter Hommelhoff

13:00-13:45 Plenary Th4.1	<b>Evolution of traveling wave tubes towards sub-THz frequency</b> <u>Claudio Paoloni</u> Lancaster University, UK	NA
13:45-14:15 Invited Th4.2	<b>Terahertz Acceleration Technology Towards Compact Light Sources</b> <u>Arya Fallahi</u> , ETH Zurich, Switzerland	89

14:15-14:45	Pause	
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### Th5 – Applications and their modelisation

Chair: tbd

Time(Lyon)	Title and Authors (speaker bold underlined, institute of speaker only)	Page
14:45-15:15 Invited Th5.1	<b>High performance cold cathode CNT x-ray tube</b> Sang Heon Lee, Jun Soo Han, Han Bin Go, Si Eun Han and <u>Cheol Jin Lee</u> Korea University, South Korea	NA
15:15-15:30 Oral Th5.2	<b>Direct-Conversion X-Ray Detectors Based on ZnO Nanowire Field Emitters Grown on Ga2O3 Photoconductors</b> <u>Zhipeng Zhang</u> , Manni Chen, Xinpeng Bai, Huanjun Chen, Shaozhi Deng, Jun Chen Sun Yat-sen University, China	NA



15:30-15:45 Oral Th5.3	<b>A novel current dependent field emission performance test</b> <b><u>Florian Herdl</u></b> , Michael Bachmann, Dominik Wohlfartsstätter, Felix Düsberg, Markus Dudeck, Magdalena Eder, Manuel Meyer, Andreas Pahlke, Simon Edler, Andreas Schels, Walter Hansch, Rupert Schreiner KETEK GmbH, Germany	95
15:45-16:00 Oral Th5.4	<b>Designing Micro-gap Thermionic Energy Harvesters</b> <b>Ehsanur Rahman</b> and Alireza Nojeh University of British Columbia, Canada	97
16:00-16:15 Oral Th5.5	<b><u>Proposal for a Negative Capacitance Vacuum Field Effect Transistors with sub-60mV/dec Subthreshold Swing</u></b> <b><u>N. Hernandez</u></b> , M. Cahay, J. Ludwick, and T. Back University of Cincinnati, Cincinnati, USA	99

16:15-16:30	Pause
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### Th6 - Nano-Micro Emitters (Nanotubes, Nanowires, Spindt and micro cathodes, etc.)

Chair: Alizera Nojeh

Time(Lyon)	Title and Authors (speaker bold underlined, institute of speaker only)	Page
16:30-16:45 Oral Th6.1 NME2.1	<b>Direct in situ Electron Microscope Synthesis of CNTs with Applied Electric Field and Field Emission</b> <b><u>P. Vincent</u></b> , F. Panciera, I. Florea, M. Ezzedine, M.-R. Zamfir, S. Perisanu, C. Cojocar, N. Blanchard, D. Pribat, S.T. Purcell, P. Legagneux University Claude Bernard Lyon 1 / CNRS, France	101
16:45-17:00 Oral Th6.2 NME 2.2	<b>Effect of Substrate Conductivity on Si Self-Assembled Field Emission Arrays</b> <b><u>Shabnam Ghotbi</u></b> , Saeed Mohammadi Purdue University, USA	103
17:00-17:15 Oral Th6.4 NME 2.4	<b>Strongly anisotropic field emission from highly aligned carbon nanotube films</b> <b><u>S. B. Fairchild</u></b> , T. A. de Assis, J. H. Park, M. Cahay, J. Bulmer, D.E. Tsentalovich, Y. S. Ang, L. K. Ang, J. Ludwick, P.T. Murray, Y. Zhou, P. Zhang Wright-Patterson Air Force Base, USA	NA
17:15-17:30 Oral Th6.5	<b>A Universal Multiscale Method for Rapid Determination of Local Emission Current Density from Nanoscale Emitters</b> <b><u>J. Ludwick</u></b> and T. C. Back, M. Cahay, N. Hernandez, H. Hall, J. O'Mara, K. L. Jensen, J. H. B. Deane, R. G. Forbes Air Force Research Laboratory, USA	NA

## Friday, 9th July, 2021

### F1 Theory of Emission : Ab Initio

Chair: Thiago A. de Assis

Time(Lyon)	Title and Authors (speaker bold underlined, institute of speaker only)	Page
13:00-13:30 Invited F1.1	<b>Field emitters at atomic scale – insights from order-N density functional theory</b> <b><u>C. J. Edgcombe</u></b> University of Cambridge, United Kingdom	109
13:30-13:45 Oral F1.2	<b>Thermal-Field Electron Emission from Three-Dimensional Cd<sub>3</sub>As<sub>2</sub></b> <b><u>Wei Jie Chan</u></b> , Yee Sin Ang, and L. K. Ang Singapore University of Design and Technology, Singapore	111
13:45-14:00 Oral F1.3	<b>Field emission from two dimensional materials:a quantum mechanical model and its application to graphene</b> <b><u>Bruno Lepetit</u></b> Université Toulouse III Paul Sabatier / CNRS, France	113
14:00-14:15 Oral F1.4	<b>Tunneling Delay and the Modeling of Electron Emission</b> <b><u>Kevin L. Jensen</u></b> , Joel L. Lebowitz, Jeanne M. Riga, Andrew Shabaev, Donald A. Shier, Rebecca Seviour Naval Research Laboratory, USA	NA
14:15-14:30 Oral F1.5	<b>Theoretical analysis of efficiency of plasmonic photoemission from single silver nanospheres</b> <b><u>Shisong Luo</u></b> , Yicong Chen, Zhibing, Jun Chen Sun Yat-sen University, China	NA

14:30-15:00	Pause
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### Theory of Emission : Classic Quantum Tunneling

Chair: John Xanthakis

Time(Lyon)	Title and Authors (speaker bold underlined, institute of speaker only)	Page
15:00-15:15 Oral F2.1	<b>General scaling laws of space charge effects in field Emission</b> <b><u>A. Kyritsakis</u></b> , M. Veske, V. Zadin and F. Djurabekova University of Tartu, Estonia	117
15:15-15:30 Oral F2.2	<b>Absence of space-charge-limited current from field emission due to non-FN law</b> <b><u>Cherq Chua</u></b> , Chun Yun Kee, Yee Sin Ang, Lay Kee Ang Singapore University of Technology and Design, Singapore	119
15:30-15:45 Oral F2.3	<b>Behavior of notional cap-area efficiency (gn) for hemisphere-on-plane and related field emitters</b> <b><u>S.V. Filippov</u></b> , A.G. Kolosko, E.O. Popov, Richard G. Forbes Ioffe Institute, Russia	121

15:45-16:00 Oral F2.4	<b>Does a banal tungsten field emitter obey the field emission theory?</b> <b><u>Anthony Ayari</u></b> , Pascal Vincent, Sorin Perisanu, Philippe Poncharal, Stephen T. Purcell University Lyon1/CNRS, France	123
16:00-16:15 Oral F2.5	<b>A Generalized Formula for Barrier Strength (Gamow Factor), applicable to various field ion and electron emission contexts</b> <b><u>Richard G. Forbes</u></b> University of Surrey, UK	125
16:15-???	Closing statements	