

## **Current-Voltage Characteristics of Single InGaN/GaN Nanowire LEDs**

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InGaN/GaN nanowire heterostructures have attracted considerable attention for applications in solid-state lighting. To date, however, there still lacks a detailed understanding of the surface states, defects and band-bending on the performance, including the electrical efficiency of such nanoscale LEDs. In this work, we have studied the current-voltage characteristics of single InGaN/GaN nanowires, wherein self-organized InGaN quantum dots are incorporated in the active region to achieve white-light emission. A significant enhancement of the current under forward bias is observed when the nanowire is illuminated under 405nm laser excitation, which is explained by leakage of photo-generated carriers from the dots and the reduction of the depletion region width of nanowires.

Catalyst-free, vertically aligned InGaN/GaN dot-in-a-wire heterostructures were first grown on Si(111) substrates by radio frequency plasma-assisted molecular beam epitaxy under nitrogen rich conditions. The active region contains 10 vertically coupled InGaN/GaN quantum dots. The In compositions of the dots are varied from ~ 15% to 50% to achieve white-light emission. The nanowire diameter is ~100 nm. The nanowires were dispersed on pre-patterned substrate, and single-nanowire devices were fabricated using e-beam lithography and contact metallization. Their current-voltage characteristics were measured at various temperatures. Under optical excitation, a significant enhancement of the current, up to a factor of ~150 for a forward bias of 8 V at 300 K was measured. The photocurrent enhancement becomes more pronounced with decreasing temperature. Detailed studies confirm that the current enhancement is not due to photovoltaic effect. Photo-generated carriers in the InGaN dots may escape from the dots and therefore lead to reduced depletion region width across the nanowire lateral dimension. Consequently, the current is significantly enhanced under forward biasing conditions. This study provides a unique approach for examining the carrier leakage process in nanowire devices and for probing the effect of surface electronic properties on the performance of nanowire LEDs. The optical performance of single-nanowire white LEDs is being investigated and will be reported.

ABSTRACT EXTENSION:

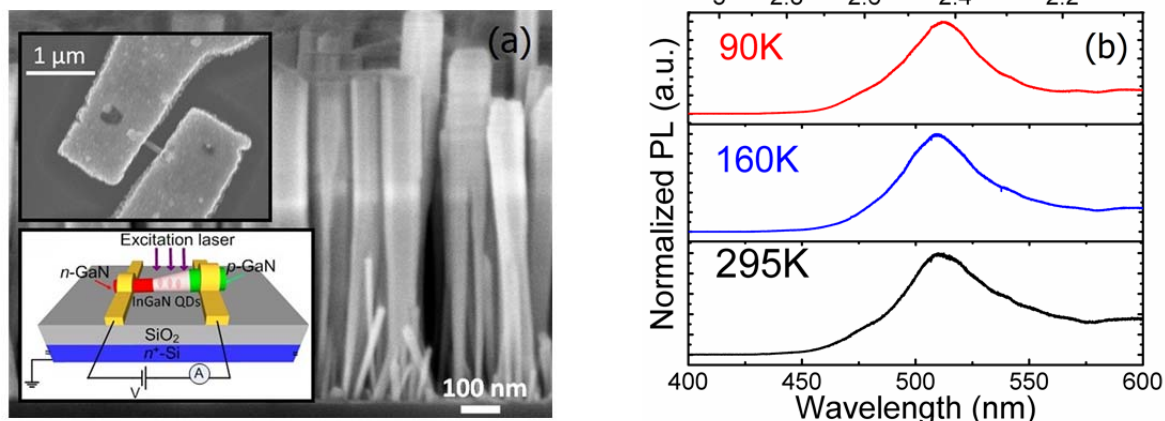


Figure 1. (a) Scanning electron microscopy image showing the morphology of the InGaN/GaN dot-in-a-wire heterostructures grown on a Si(111) substrate by molecular beam epitaxy. Inset: SEM image of a single InGaN/GaN dot-in-a-wire LED device with Ni/Au contact electrodes on both *n*- and *p*-GaN; Schematic illustration of the experimental setup used for measuring the photocurrent under forward biased condition. (b) Temperature dependent normalized photoluminescence spectra of single NW device with peak emission wavelengths of ~510 nm.

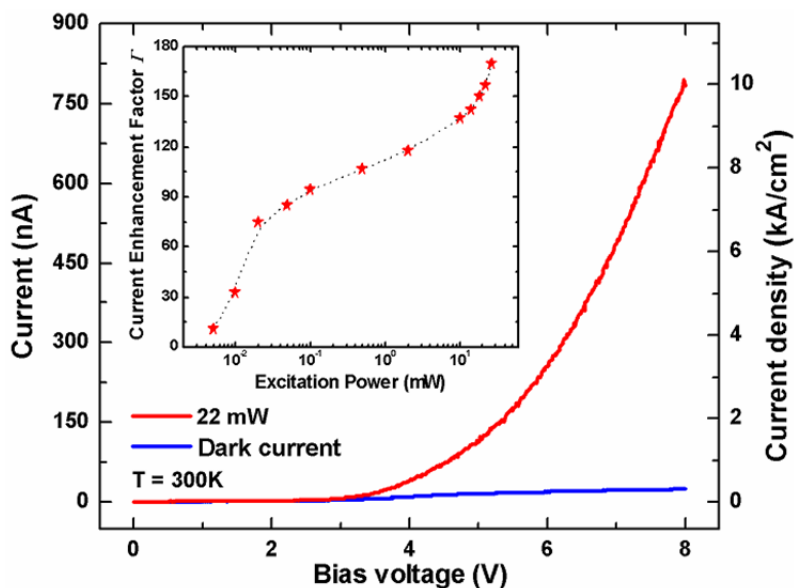


Figure 2. Dark and photocurrent of the single-nanowire based devices as a function of illumination density measured at 300 K. Inset: Semilog plot of enhancement factor  $\Gamma = I_{ph}/I_{dark}$  measured at 300 K, under 8 V bias and excitation power of 22 mW.

# B: Optical Devices, Visible

\* Invited paper

SESSION B1: Vis LEDs on Si  
Chair: Nathan Gardner  
Monday Afternoon, August 26, 2013  
National Harbor 4-5

## 1:30 PM \*B1.01

**High Performance InGaN/GaN based Blue LEDs Fabricated from 8-inch Diameter Si(111) Substrates** Youngjo Tak, Jun-Youn Kim, Joosung Kim, Jaekyun Kim, Suhee Chae and Youngsoo Park; Compound Device Lab, Samsung Advanced Institute of Technology (SAIT), Yongin, Korea, Republic of.

## 2:00 PM \*B1.02

**GaN on Silicon Substrates for Solid State Lighting: Strain Compensation, Dislocation Mechanisms and Device Results** Martin Albrecht<sup>1</sup>, T. Markurt<sup>1</sup>, T. Schulz<sup>1</sup>, L. Lymperakis<sup>2</sup>, A. Duff<sup>2</sup>, J. Neugebauer<sup>2</sup>, P. Drechsel<sup>3</sup> and P. Stauss<sup>3</sup>; <sup>1</sup>Elektronenmikroskopie, Leibniz-Institut fuer Kristallzuechtung, Berlin, Germany; <sup>2</sup>Max-Planck-Institute fuer Iesenforschung, Dusseldorf, Germany; <sup>3</sup>OSRAM Opto Semiconductors, Regensburg, Germany.

## 2:30 PM B1.03

**Micro-Pixelated InGaN/GaN Light Emitting Diodes on Si Substrates** Pengfei Tian<sup>1</sup>, Jonathan J. McKendry<sup>1</sup>, Zheng Gong<sup>1</sup>, Shuailong Zhang<sup>1</sup>, Scott Watson<sup>2</sup>, Dandan Zhu<sup>3</sup>, Ian M. Watson<sup>1</sup>, Erdan Gu<sup>1</sup>, Anthony E. Kelly<sup>2</sup>, Colin J. Humphreys<sup>3</sup> and Martin D. Dawson<sup>1</sup>; <sup>1</sup>Institute of Photonics, University of Strathclyde, Glasgow, United Kingdom; <sup>2</sup>School of Engineering, University of Glasgow, Glasgow, United Kingdom; <sup>3</sup>Department of Materials Science and Metallurgy, University of Cambridge, Cambridge, United Kingdom.

## 2:45 PM B1.04

**Excellent Uniformity on Large Diameter GaN on Silicon LED Wafer** Andrea Pinos, Lars Groh, Atsushi Nishikawa, Ashay Chitnis, WeiSin Tan, Chengyu Hu, Saad Murad and Stephan Lutgen; Technology Department, AZZURRO Semiconductors AG, Dresden, Germany.

## 3:00 PM BREAK

SESSION B2: Nano LEDs and Lasers  
Chair: C. C. Yang  
Monday Afternoon, August 26, 2013  
National Harbor 4-5

## 3:30 PM \*B2.01

**High-Performance Nanowire III-N LEDs** Nathan F. Gardner, P. Svensson, S. Yi, O. Kryliouk, Y. Chang, L. Romano, B. Herner, V. Robbins, D. Thompson, F. Patterson, R. Kancshiro and L. Samuelson; Glo USA, Inc., Sunnyvale, California.

## 4:00 PM B2.02

**High Efficiency Non-Radiative Energy Transfer in Novel White Light Emitting Hybrid Organic/Inorganic Structures Using InGaN/GaN Nanorod Arrays** Rick M. Smith, Bin Liu, Jie Bai and Tao Wang; Electronic and Electrical Engineering, The University of Sheffield, Sheffield, South Yorkshire, United Kingdom.

## 4:15 PM B2.03

**Electro-Optical Characterization of Single InGaN/GaN Core-Shell LED Structures** Johannes Ledig, Xue Wang, Jana Hartmann, Lorenzo Caccamo, Hergo-H. Wehmann and Andreas Waag; Institut für Halbleitertechnik, TU Braunschweig, Braunschweig, Germany.

## 4:30 PM B2.04

**Fabrication and Characterization of Axial and Radial III-Nitride Nanowire LEDs** George T. Wang, Qiming Li, Jonathan J. Wierer, Daniel D. Koleske and Jeffrey J. Figiel; Sandia National Laboratories, Albuquerque, New Mexico.

## 4:45 PM B2.05

**Regularly Patterned Core-Shell InGaN/GaN Quantum-Well Nanorod Light-Emitting Diode Arrays** Che-Hao Liao, Yu-Feng Yao, Horng-Shyang Chen, Chang-Gan Tu, Chia-Ying Su, Wen-Ming Chang, Hao-Tsung Chen, Yean-Woei Kiang and Chih-Chung (C. C.) Yang; Institute of Photonics and Optoelectronics, National Taiwan

University, Taipei, Taiwan.

## 5:00 PM B2.06

**Factors Affecting the Directionality of InGaN/GaN Nanorod LED Arrays** S. Lis, S. E. O'Kane, C. J. Lewins, S. A. Fox, Y. D. Zhuang, J. Sarma and D. W. Allsopp; Electronic and Electrical Engineering, University of Bath, Bath, Avon, United Kingdom.

## 5:15 PM B2.07

**Mode and Polarization Control in Gallium Nitride Nanowire Lasers** Huiwen Xu<sup>1</sup>, Jeremy B. Wright<sup>2</sup>, Antonio Hurtado<sup>1</sup>, Ting-Shan Luk<sup>2</sup>, Jeffrey J. Figiel<sup>2</sup>, Luke F. Lester<sup>1</sup>, Igal Brnec<sup>2</sup>, Qiming Li<sup>2</sup> and George T. Wang<sup>2</sup>; <sup>1</sup>Center for High Technology Materials, The University of New Mexico, Albuquerque, New Hampshire; <sup>2</sup>Sandia National Laboratories, Albuquerque, New Mexico.

SESSION BP1: Poster Session: Optical Devices, Visible  
Monday Evening, August 26, 2013  
6:00 PM

Potomac C/D & 1-6

## BP1.01

**Optical Characterization of Semipolar InGaN Single Quantum Well Grown on GaN Micro-Pyramids** Weijie Chen, Guoheng Hu, Minggang Liu, Yibin Yang, Peng Xiang, Gangwei Hu, Yunqian Wang, Yuan Ren, Yan Lin, Xiaobiao Han, Jianliang Jiang, Zhisheng Wu, Yang Liu and Baijun Zhang; State Key Laboratory of Optoelectronic Materials and Technologies, School of Physics and Engineering, Sun Yat-sen University, Guangzhou, China.

## BP1.02

**Optical Absorption of c-plane and Semipolar InGaN/GaN Quantum Wells** Junjun Wang<sup>1</sup>, Benjamin Neusch<sup>2</sup>, Tobias Meisch<sup>1</sup>, Klaus Thonke<sup>2</sup> and Ferdinand Scholz<sup>1</sup>; <sup>1</sup>Institute of Optoelectronics, Ulm, Germany; <sup>2</sup>Institute of Quantum Matter, Semiconductor Physics Group, Ulm, Germany.

## BP1.03

**GaN-Based LED Grown on ECO-GaN Template with an AlN/Patterned SiO<sub>2</sub> Sacrificial Layer for Chemical Lift-Off Application** Ray Hua Horng, Hsu-Hung Hsueh, Sin-Liang Ou and Dong-Sing Wu; National Chung Hsing University, Taichung, Taiwan.

## BP1.04

**Growth, Structural, and Optical Properties of the Rare Earth (Yb<sup>3+</sup> and Er<sup>3+</sup>) Doped In<sub>1-x</sub>Ga<sub>x</sub>N Thin films** Kiran Dasari<sup>1</sup>, Maxime Guinel<sup>1</sup>, J. Wang<sup>2</sup>, W. M. Jadwisieniczak<sup>2</sup>, H. Huhtinen<sup>3</sup>, A. K. Pradhan<sup>4</sup> and R. Palai<sup>1</sup>; <sup>1</sup>Department of Physics, University of Puerto Rico, San Juan, Puerto Rico; <sup>2</sup>School of EECS, Ohio University, Athens, Ohio; <sup>3</sup>Department of Physics, University of Turku, Turku, Finland; <sup>4</sup>Center for Materials Research, Norfolk State University, Norfolk, Virginia.

## BP1.05

**Carrier Competitions in Novel Sandwiched Structure InGaN Quantum Wells** Ding Li, Juan He, Kamran Rajabil, Wei Yang, Wenyu Cao, Qingbin Ji and Xiaodong Hu; The Research Center for Wide-Gap Semiconductor, School of Physics, Peking University, Beijing, China.

## BP1.06

**Large-Scale Fabrication and Luminescence Properties of GaN Nanostructures by Soft Ultraviolet Nanoimprint Lithography Technology** Zhuang Zhe<sup>1,3</sup>, Zhang Guogang<sup>1,3</sup>, Guo Xu<sup>2,3</sup>, Liu Bin<sup>1,3</sup>, Zhang Rong<sup>1,3</sup>, Zhi Ting<sup>1,3</sup>, Tao Tao<sup>1,3</sup>, Ge Haixiong<sup>2,3</sup>, Ren Fangfang<sup>1,3</sup>, Xie Zili<sup>1,3</sup>, Zhao Hong<sup>1,3</sup>, Chen Peng<sup>1,3</sup>, Xiu Xiangqian<sup>1,3</sup>, Han Ping<sup>1,3</sup> and Zheng Youdou<sup>1,3</sup>; <sup>1</sup>Jiangsu Provincial Key Laboratory of Advanced Photonic and Electronic Materials, School of Electronic Science and Engineering, Nanjing University, Nanjing 210093, P. R. China, Nanjing, Jiangsu Province, China; <sup>2</sup>School of Engineering and Applied Sciences, Nanjing University, Nanjing 210093, P. R. China, Nanjing, Jiangsu Province, China; <sup>3</sup>Nanjing National Laboratory of Microstructures, Nanjing University, Nanjing 210093, P. R. China, Nanjing, Jiangsu Province, China.

## BP1.07

**Interplays of Point Defects, Extended Defects, and Localization on the External Quantum Efficiency Droop in InGaN Light-Emitting Diodes** Yue Lin<sup>1,2,4</sup>, Yong Zhang<sup>1</sup>, Zhiqiang Liu<sup>3</sup>, Jihong Zhang<sup>4</sup>, Liqing Su<sup>1</sup>, Tongbo Wei<sup>3</sup> and Zhong Chen<sup>4</sup>; <sup>1</sup>Electrical and Computer Engineering Department, University of North Carolina at Charlotte, Charlotte, North Carolina; <sup>2</sup>Fujian Institute of Research on the Structure of Matter, Chinese Academy of Sciences, Fuzhou, China; <sup>3</sup>R&D Center for Semiconductor Lighting,

Chinese Academy of Sciences, Beijing, China; <sup>4</sup>Department of Electronic Science and Fujian Engineering Research Center for Solid-State Lighting, Xiamen University, Xiamen, China.

#### **BP1.08**

**Characteristics of Less Strained LED Grown on Sapphire Substrate with SiO<sub>2</sub> Backside Deposition** JongHak Kim<sup>1</sup>, Seunghyun Moon<sup>2</sup>, Kisu Joo<sup>2</sup>, Yoon-Kyu Song<sup>2</sup>, Youngbo Moon<sup>4</sup>, Yongjo Park<sup>4</sup> and Euijoon Yoon<sup>1,3,4</sup>; <sup>1</sup>Department of Materials Science and Engineering, Seoul National University, Seoul, Korea, Republic of; <sup>2</sup>Department of Nano Science and Technology, Graduate School of Convergence Science and Technology, Seoul National University, Suwon, Korea, Republic of; <sup>3</sup>WCU Hybrid Materials Program, Department of Materials Science and Engineering, Seoul National University, Seoul, Korea, Republic of; <sup>4</sup>Energy Semiconductor Research Center, Advanced Institutes of Convergence Technology, Seoul National University, Suwon, Korea, Republic of.

#### **BP1.09**

**Effect of Piezoelectric Field in (Al)GaN/InGaN Heterostructures on Efficiency of Direct Photoelectrolysis of Water** Yu-Tong Chen<sup>1,2</sup>, Jinn-Kong Sheu<sup>1,2</sup>, Yu-Hsiang Yeh<sup>1,2</sup>, Ming-Lun Lee<sup>3</sup> and Wei-Chih Lai<sup>1,2</sup>; <sup>1</sup>Department of Photonics & Advanced Optoelectronic Technology Center, National Cheng Kung University, Tainan, Taiwan; <sup>2</sup>Research Center for Energy Technology and Strategy & Center for Micro/Nano Science and Technology, National Cheng Kung University, Tainan, Taiwan; <sup>3</sup>Department of Electro-Optical Engineering, Southern Taiwan University of Science and Technology, Tainan, Taiwan.

#### **BP1.10**

**Performance Improvement of Gallium Nitride-Based Vertical Light Emitting Diodes Using Transparent and Conducting Carbon Nanotube Network Films** Kyeong Hoon Kim, Su Jin Kim, Jae Hoon Lee, Suk Won Kim, Byeong Ryong Lee, Kie Young Woo, Ho-Myoung An and Tae Geun Kim; Department of Electrical Engineering, Korea University, Seoul, Korea, Republic of.

#### **BP1.11**

**Effects of an InGaN Prelayer on the Properties of InGaN/GaN Quantum Well Structures** M. J. Davies<sup>1</sup>, F. C. Massabuau<sup>2</sup>, P. Dawson<sup>1</sup>, R. A. Oliver<sup>2</sup>, M. J. Kappers<sup>2</sup> and C. J. Humphreys<sup>2</sup>; <sup>1</sup>School of Physics and Astronomy, Photon Science Institute, University of Manchester, Manchester, United Kingdom; <sup>2</sup>Department of Materials Science and Metallurgy, University of Cambridge, Cambridge, United Kingdom.

#### **BP1.12**

**GaN-Based Intermediate Band Solar Cells Realized via the Yellow-Emitting Impurity Level** Jen-Hsiung Liao, Kun-Yu A. Lai, Lung-Chieh Cheng, Hsueh-Hsing Liu, Jen-Inn Chyi and Hsiao-Wei Huang; Department of Optics and Photonics, National Central University, Chung-Li, Taiwan.

#### **BP1.13**

**Enhanced Indium Incorporation and Emission Efficiency of InGaN/GaN Multiple Quantum Wells Grown on Porous GaN Templates** Chew Beng Soh<sup>1,2</sup>, Ian Peiyuan Seetoh<sup>3</sup>, Rayson Jen Ngee Tan<sup>2</sup>, kwadwo K. Ansah-Antwi<sup>2,4</sup>, Chuan Beng Tay<sup>5</sup>, Agam P. Vajpeyi<sup>3</sup> and Soo Jin Chua<sup>2,3,4</sup>; <sup>1</sup>Engineering and Applied Science, Singapore Institute of Technology, Singapore, Singapore; <sup>2</sup>Institute of Materials Research and Engineering, Singapore, Singapore; <sup>3</sup>Singapore-MIT Alliance, National University of Singapore, Singapore, Singapore; <sup>4</sup>Department of Electrical and Computer Engineering, National University of Singapore, Singapore, Singapore; <sup>5</sup>NUSNNI, National University of Singapore, Singapore, Singapore.

#### **BP1.14**

**Temperature-Dependent AC Current-Voltage-Capacitance Characteristics of GaN-Based Blue Light-Emitting Diodes at Forward Bias** Wei Yang<sup>1</sup>, Ding Li<sup>1</sup>, Cunda Wang<sup>1,2</sup> and Xiaodong Hu<sup>1</sup>; <sup>1</sup>School of Physics, Peking University, State Key Laboratory for Artificial Microstructure and Mesoscopic Physics, Beijing, China; <sup>2</sup>Department of Applied Physics, Tianjin University, Tianjin, China.

#### **BP1.15**

**Space- and Time-Resolved Spectroscopic Study of InGaN/GaN Quantum Wells Coupled with the Localized Surface Plasmons in Metal Nanoparticles** Saulius Nargelas<sup>1</sup>, Darius Dobrovolskas<sup>1</sup>, Juras Mickevicius<sup>1</sup>, Mikas Vengris<sup>3</sup>, Ramunas Aleksiejunas<sup>2</sup>, Gintautas Tamulaitis<sup>1</sup>, Horng-Shyang Chen<sup>4</sup>, Chia-Feng Chen<sup>4</sup>, Chih-Yen Chen<sup>4</sup>, Che-Hao Liao<sup>4</sup> and C. C. Yang<sup>4</sup>; <sup>1</sup>Semiconductors Physics Department, Vilnius University, Vilnius, Lithuania; <sup>2</sup>Institute of Applied Research, Vilnius University, Vilnius, Lithuania; <sup>3</sup>Department of Quantum Electronics, Vilnius University, Vilnius, Lithuania; <sup>4</sup>Institute of Photonics and Optoelectronics,

National Taiwan University, Taipei, Taiwan.

#### **BP1.16**

**Comparison of Light Extraction Efficiency between the Vertical Light-Emitting Diodes with Surfaces of Periodic and Rough Structures** Chun-Han Lin, Charng-Gan Tu, Horng-Shyang Chen, Chieh Hsieh, Chih-Yen Chen, Che-Hao Liao, Yean-Woei Kiang and Chih-Chung (C. C.) Yang; Institute of Photonics and Optoelectronics, National Taiwan University, Taipei, Taiwan.

#### **BP1.17**

**Dependence of the Coupling Strength on the Distance between Quantum Wells and Metal Nanostructures in Surface Plasmon Coupled Light-Emitting Diodes** Horng-Shyang Chen, Yang Kuo, Chia-Feng Chen, Wang-Hsien Chou, Ming-Hsen Chiou, Wen-Ming Chang, Pei-Ying Shih, Chih-Yen Chen, Chieh Hsieh, Yean-Woei Kiang and Chih-Chung (C. C.) Yang; Institute of Photonics and Optoelectronics, National Taiwan University, Taipei, Taiwan.

#### **BP1.18**

**Freestanding Guided-Mode Resonant GaN Gratings at Visible Range** Shumin He<sup>1</sup>, Zheng Shi<sup>1</sup>, Xin Li<sup>1</sup>, Qinglong Yu<sup>1</sup>, Xumin Gao<sup>1</sup>, Zhenhai Wang<sup>1</sup>, Miao Zhang<sup>2</sup> and Yongjin Wang<sup>1</sup>; <sup>1</sup>Nanjing University of Posts and Telecommunications, Nanjing, China; <sup>2</sup>State Key Laboratory of Functional Materials for Informatics, Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, Shanghai, China.

#### **BP1.19**

**Fabrication of Two-Dimensional InGaN / GaN Photonic Crystalline Structures Using a Novel Lift-Off Technique** Modestos Athanasiou, Taeki Kim, Bin Liu, Richard Smith and Tao Wang; University of Sheffield, Sheffield, United Kingdom.

#### **BP1.20**

**88-Fold Enhancement in Internal Quantum Efficiency of InGaN/GaN Nanodisk Array Structure in the Green Spectral Region due to Nano-Cavity Effect** Taeki Kim, Bin Liu, Rick M. Smith, Modestos Athanasiou, YiPin Gong and Tao Wang; Electronic and Electrical Engineering, The University of Sheffield, Sheffield, South Yorkshire, United Kingdom.

#### **BP1.21**

**Correlation between Internal Quantum Efficiency and Degree of Localization in InGaN Nanowires** Hideaki Murotani<sup>1</sup>, Hiroya Andoh<sup>1</sup>, Takehiko Tsukamoto<sup>1</sup>, Toko Sugiura<sup>1</sup>, Yoichi Yamada<sup>2</sup>, Takuya Tabata<sup>3</sup>, Yoshio Honda<sup>3</sup>, Masahito Yamaguchi<sup>3</sup> and Hiroshi Amano<sup>3</sup>; <sup>1</sup>Toyota National College of Technology, Toyota, Japan; <sup>2</sup>Yamaguchi University, Ube, Japan; <sup>3</sup>Nagoya University, Nagoya, Japan.

#### **BP1.22**

**Effects of Enhanced Lateral Transport on InGaN/GaN Light Emitting Diodes via n-type AlGaIn/GaN Superlattices** Hooyoung Song, Ki-Seong Jeon, Jin Hyoun Joe, Seonock Kim, Minwoo Lee, Eun Ah Lee, Hwanjoon Choi, Junho Sung, Mingu Kang, Yoon-Ho Choi and Jeong Soo Lee; Materials & Components Laboratory, LG electronics, Seoul, Korea, Republic of.

#### **BP1.23**

**GaInN/GaN Multiple Quantum Well Solar Cells under Concentrated Illumination and Elevated Temperature** Liang Zhao<sup>1,2</sup>, Wenting Hou<sup>1,2</sup>, Theeradetch Detchprohm<sup>1,2</sup> and Christian Wetzel<sup>1,2</sup>; <sup>1</sup>Future Chips Constellation, Rensselaer, Troy, New York; <sup>2</sup>Department of Physics, Applied Physics, and Astronomy, Rensselaer, Troy, New York.

#### **BP1.24**

**Characteristics of Blue Light Emitting Diode with Varing Si-Doping on InGaN Layers below Quantum Wells** Kyusang Kim<sup>1</sup>, Dong-Pyo Han<sup>2</sup>, Joo-Sun Yun<sup>2</sup>, Il-Gyun Choi<sup>2</sup>, Min-Gu Kang<sup>2</sup>, Hyun-Sung Kim<sup>2</sup>, Chan-Hyoung Oh<sup>2</sup>, Dong-Soo Shin<sup>3</sup> and Jong-In Shim<sup>2</sup>; <sup>1</sup>Dept. of Applied Physics and Electronics, Sangji University, Wonju, Korea, Republic of; <sup>2</sup>Dept. of Electronics & Communication Engineering, Hanyang University, Ansan, Korea, Republic of; <sup>3</sup>Dept. of Applied Physics, Hanyang University, Ansan, Korea, Republic of.

#### **BP1.25**

**Measurement of Low Temperature Current Spill-Over and Its Effects on the Efficiency Droop in InGaN/GaN Multiple Quantum Wells** Tae-Soo Kim<sup>1</sup>, Ki-Nam Park<sup>1</sup>, Jin-Gyu Lee<sup>1</sup>, Yong-Hyun Kim<sup>1</sup>, Soon-Ku Hong<sup>2</sup>, Youngbo Moon<sup>3</sup> and Jung-Hoon Song<sup>1</sup>; <sup>1</sup>Kongju National University, Gongju, Chungnam, Korea, Republic of; <sup>2</sup>Chungnam National University, Daejeon, Chungnam,

Korea, Republic of; <sup>3</sup>THELEDS Ltd., Gwangju, Korea, Republic of.

#### **BP1.26**

**Investigation into Low-Temperature Photoluminescence Internal Quantum Efficiency and Defect-Recombination in InGaN Light-Emitting Diodes** Xiaoli Ji, Jun Ma, Xuecheng Wei, Ruifei Duan, Junxi Wang, Xiaoyan Yi, Yiping Zeng, Guohong Wang, Fuhua Yang and Jinmin Li; Institute of Semiconductors, Chinese Academy of Sciences, Beijing, China.

#### **BP1.27**

**Numerical Simulation of InGaN-Based p-i-n Solar Cells Grown on Ga- and N-Polar GaN** Der-Yuh Lin, Chen-Chan Kao, Bo-Yuan Hu and Wei-Zhi Chen; Department of Electronics Engineering, National Changhua University of Education, Changhua, Taiwan.

#### **BP1.28**

**Enhancement of Light Extraction Efficiency and Reduction of Dislocation Density on GaN-Based Light-Emitting Diodes Using Two-Direction Stripe-Patterned Sapphire Substrate** Koji Okuno<sup>1,2</sup>, Takahide Oshio<sup>2</sup>, Naoki Shibata<sup>2</sup>, Yoshio Honda<sup>1</sup>, Masahito Yamaguchi<sup>1</sup> and Hiroshi Amano<sup>1</sup>; <sup>1</sup>Department of Electrical Engineering and Computer Science, Graduate School of Engineering, Nagoya University, C3-1, Chikusa-ku, Nagoya, Aichi, Japan; <sup>2</sup>Optoelectronics Business Unit, Toyoda Gosei Co., Ltd., 710, Origuchi, Shimomiyake, Heiwa, Inazawa, Aichi, Japan.

#### **BP1.29**

**The Effects of Mg Doping on Dislocation Core Structures in GaN Films** Sneha Rhode<sup>1</sup>, S. L. Sahonta<sup>1</sup>, M. K. Horton<sup>2</sup>, M. J. Kappers<sup>1</sup>, C. J. Humphreys<sup>1</sup>, R. O. Dusanc<sup>3</sup> and M. A. Moram<sup>2</sup>; <sup>1</sup>Department of Materials Science & Metallurgy, University of Cambridge, Cambridge, United Kingdom; <sup>2</sup>Department of Materials, Imperial College London, London, United Kingdom; <sup>3</sup>Department of Metallurgical Engineering and Materials Science, Indian Institute of Technology Bombay, Mumbai, India.

#### **BP1.30**

**Separation of the Effects of Piezoelectric Fields from In Localization on the Emission Properties in InGaN/GaN Light Emitting Diodes Studied by Temperature and Excitation Power Dependent Emission Spectroscopy** Ki-Nam Park<sup>1</sup>, Tae-Soo Kim<sup>1</sup>, Jin-Gyu Lee<sup>1</sup>, Hye-Jung Yu<sup>1</sup>, Nan-Cho Oh<sup>1</sup>, Jung-Hoon Song<sup>1</sup> and Young-Boo Moon<sup>2</sup>; <sup>1</sup>Kongju National University, Gongju, Korea, Republic of; <sup>2</sup>THELEDS Ltd., Gwangju, Korea, Republic of.

#### **BP1.31**

**Thermal Resistivity of InGaN Laser Diodes and Arrays** Szymon Stanczyk<sup>1</sup>, Anna Kafar<sup>1</sup>, Grzegorz Targowski<sup>2</sup>, Przemek Wisniewski<sup>1,2</sup>, Irina Makarowa<sup>2</sup>, Tadeusz Suski<sup>1</sup> and Piotr Perlin<sup>1,2</sup>; <sup>1</sup>Institute of High Pressure Physics, Warsaw, Poland; <sup>2</sup>TopGaN Ltd., Warsaw, Poland.

#### **BP1.32**

**Three Different Wavelengths by the Effect of Air-Gaps on Stress Relaxation for Light-Emitting Diodes** Young Jae Park, Hyun Kyu Kim, Yashpal S. Katharria, Nam Han, Min Han, Kang Bok Ko, Jong Han Yang, Young Tack Kim and Chang-Hee Hong; Chonbuk National University, Jeonju, Korea, Republic of.

#### **BP1.33**

**Improved Performance of GaN-Based Light-Emitting Diodes Grown on Nano-Porous GaN Layer** Kwang Jac Lee, Jae-Joon Kim, Sang-Jo Kim, Ho Yeon Kim and Seong-Ju Park; Gwangju Institute of Science and Technology, Gwangju, Korea, Republic of.

#### **BP1.34**

**Enhanced Optical Output Power of InGaN/GaN Vertical Light-Emitting Diodes Using ZnO Nanorods on Surface with Varied Stoichiometry** Young Chul Leem<sup>1</sup>, Na-Yeong Kim<sup>1</sup>, Wan-Tae Yim<sup>2</sup>, Sung-Tae Kim<sup>2</sup> and Seong-Ju Park<sup>1</sup>; <sup>1</sup>School of Materials Science and Engineering, Gwangju Institute of Science and Technology, Gwangju, Korea, Republic of; <sup>2</sup>Samsung Electronics Co. Ltd., Suwon, Korea, Republic of.

#### **BP1.35**

**Enhanced Performance of Vertical GaN-Based Light-Emitting Diodes Using Electrical Forming Process in Wide-Bandgap Transparent Conductive Electrodes** Su Jin Kim, Hee-Dong Kim, Sang Young Park, Kyeong Heon Kim, Suk Won Kim, Byeong Ryong Lee, Kie Young Woo, Ho-Myoung An and Tae Geun Kim; School of Electrical Engineering, Korea University, Seoul, Korea, Republic of.

#### **BP1.36**

**Enhanced Optical Output Power of InGaN/GaN Multiple Quantum Well Light-Emitting Diodes by Magnetic Field** Jae-Joon Kim, Young-Chul Leem, Jang-Won Kang and Seong-Ju Park; Gwangju Institute of Science and Technology, Gwangju, Korea, Republic of.

#### **BP1.37**

**Fabrication of Low-Temperature-Dependent Light-Emitting Diodes Using Eu and Mg Codoped GaN** Hiroto Sekiguchi<sup>1</sup>, Ryota Matsumura<sup>1</sup>, Tatsuki Otani<sup>1</sup>, Yasufumi Takagi<sup>2</sup>, Hiroshi Okada<sup>1</sup> and Akihiro Wakahara<sup>1</sup>; <sup>1</sup>Toyohashi University of Technology, Toyohashi, Japan; <sup>2</sup>Hamamatsu Photonics K. K., Hamamatsu, Japan.

#### **BP1.38**

**Emission Wavelength Dependence of Characteristic Temperature of InGaN Laser Diodes** Agata Bojarska<sup>1</sup>, Jakub Goss<sup>1</sup>, Lucja Marona<sup>1</sup>, Anna Kafar<sup>1</sup>, Szymon Stanczyk<sup>1</sup>, Irina Makarowa<sup>2</sup>, Grzegorz Targowski<sup>2</sup>, Tadek Suski<sup>1</sup> and Piotr Perlin<sup>1,2</sup>; <sup>1</sup>Institute of High Pressure Physics, Warsaw, Poland; <sup>2</sup>TopGaN Limited, Warsaw, Poland.

#### **BP1.39**

**Polarization-Induced Tunnel Junctions for the Design of Light-Emitting Diodes with Reduced Droop** Miao-Chan Tsai<sup>1</sup>, Benjamin Leung<sup>2</sup>, Lien Wei Chieh<sup>3</sup>, Ta-Cheng Hsu<sup>4</sup> and Yen-Kuang Kuo<sup>5</sup>; <sup>1</sup>Institute of Photonics, National Changhua University of Education, Changhua, Taiwan; <sup>2</sup>Department of Electrical Engineering, Yale University, New Haven, Connecticut; <sup>3</sup>R&D Center, Epistar Co., Ltd., Chunan, Taiwan; <sup>4</sup>R&D Center, Epistar Co., Ltd., Hsinchu, Taiwan; <sup>5</sup>Department of Physics, National Changhua University of Education, Changhua, Taiwan.

#### **BP1.40**

**Improving Carrier Injection and Efficiency Droop in InGaN/GaN Light-Emitting Diodes with Step-Stage Multiple-Quantum-Well Structure and Hole Blocking Barriers** Zhiyuan Zheng, Zimin Chen, Yingda Chen, Hualong Wu, Shanjin Huang, Bingfeng Fan, Zhisheng Wu, Gang Wang and Hao Jiang; School of Physics and Engineering, Sun Yat-sen University, Guangzhou, Guangdong, China.

#### **BP1.41**

**Atom Probe Tomography Analysis of a Gallium-Nitride-Based Commercial Light-Emitting Diode** Ty J. Prosa<sup>1</sup>, D. Olson<sup>1</sup>, A. D. Giddings<sup>1</sup>, W. Lefebvre<sup>2</sup>, P. H. Clifton<sup>1</sup> and D. J. Larson<sup>1</sup>; <sup>1</sup>CAMECA Instruments, Inc., Madison, Wisconsin; <sup>2</sup>Universite de Rouen, Saint Etienne du Rouvray, France.

#### **BP1.42**

**Monolithic III-Nitride Multi-Color Laser Arrays** Jeremy B. Wright<sup>1,2,4</sup>, Sheng Liu<sup>1,2</sup>, George T. Wang<sup>1</sup>, Qiming Li<sup>1</sup>, Alexander Benz<sup>1,2</sup>, Daniel D. Koleske<sup>1</sup>, Ping Lu<sup>1</sup>, Huiwen Xu<sup>2,4</sup>, Luke Lester<sup>2,4</sup>, Ting S. Luk<sup>1,3</sup>, Igal Brener<sup>1,3</sup> and Ganapathi S. Subramania<sup>1,4</sup>; <sup>1</sup>Sandia National Laboratories, Albuquerque, New Mexico; <sup>2</sup>Center for High Technology Materials, The University of New Mexico, Albuquerque, New Mexico; <sup>3</sup>Center for Integrated Nanotechnology, Sandia National Laboratories, Albuquerque, New Mexico; <sup>4</sup>Electrical and Computer Engineering, The University of New Mexico, Albuquerque, New Mexico.

#### **BP1.43**

**Growth Morphology and Emission Characteristics of Single InGaN Quantum Wells on Misoriented Nonpolar m-Plane Bulk GaN Substrates** Kathryn M. Kelchner<sup>1</sup>, Leah Y. Kuritzky<sup>1</sup>, Kenji Fujito<sup>2</sup>, Shuji Nakamura<sup>1,3</sup>, Steven P. DenBaars<sup>1,3</sup> and James S. Speck<sup>3</sup>; <sup>1</sup>Materials Department, University of California, Santa Barbara, Santa Barbara, California; <sup>2</sup>Optoelectronics Laboratory, Mitsubishi Chemical Corporation, Ushiku, Ibaraki, Japan; <sup>3</sup>Department of Electrical and Computer Engineering, University of California, Santa Barbara, California.

#### **BP1.44**

**Coincident Cathodoluminescence and Electron Channelling Contrast Imaging of Threading Dislocations in GaN** Jochen Bruckbauer<sup>1</sup>, G. Naresh-Kumar<sup>1</sup>, Nouf Allehiani<sup>1</sup>, Paul R. Edwards<sup>1</sup>, Simon Krausel<sup>1</sup>, Ben Hourahine<sup>1</sup>, Stephen Lovelock<sup>2</sup>, Menno J. Kappers<sup>2</sup>, Colin J. Humphreys<sup>2</sup>, Michelle A. Moram<sup>2,3</sup>, Rachel A. Oliver<sup>2</sup>, Robert W. Martin<sup>1</sup> and Carol Trager-Cowan<sup>1</sup>; <sup>1</sup>Department of Physics, SUPA, University of Strathclyde, Glasgow, United Kingdom; <sup>2</sup>Department of Materials Science and Metallurgy, University of Cambridge, Cambridge, United Kingdom; <sup>3</sup>Department of Materials, Imperial College London, London, United Kingdom.

**BP1.45****MOVPE of Columnar Ga-Polar GaN Core-Shell LEDs**Xuc Wang<sup>1</sup>, Jana Hartmann<sup>1</sup>, Johannes Ledig<sup>1</sup>, Martin S.Mohajjerani<sup>1</sup>, Hergo Wehmann<sup>1</sup>, Martin Mandl<sup>1,2</sup>, Martin Strassburg<sup>2</sup>, Ian Griffiths<sup>3</sup>, David Cherns<sup>3</sup>, Uwe Jahn<sup>4</sup> and Andreas Waag<sup>1</sup>; <sup>1</sup>Institute of Semiconductor Technology, Braunschweig University of Technology, Braunschweig, Germany; <sup>2</sup>Osram Opto Semiconductors GmbH, Regensburg, Germany; <sup>3</sup>School of Physics, H H Wills Physics Laboratory, University of Bristol, Bristol, United Kingdom; <sup>4</sup>Paul-Drude-Institut fuer Festkoerperelektronik, Berlin, Germany.**BP1.46****Characterisation of Semi-Polar (11-22) InGaN/GaN Multi-Quantum Wells Grown on ELOG GaN Templates**Danny Sutherland<sup>1</sup>, Fabrice Oehler<sup>2</sup>, Tongtong Zhu<sup>2</sup>, JamesGriffiths<sup>2</sup>, Tom Badcock<sup>1</sup>, Dmytro Kundys<sup>1</sup>, Phil Dawson<sup>1</sup>, Menno Kappers<sup>2</sup>, Rachel Oliver<sup>2</sup> and Colin Humphreys<sup>2</sup>; <sup>1</sup>School of Physics and Astronomy, Photon Science Institute, University of Manchester, Manchester, United Kingdom; <sup>2</sup>Department of Materials Science and Metallurgy, University of Cambridge, Cambridge, United Kingdom.**BP1.47****High-Efficiency GaN-Based Light-Emitting Diodes Fabricated with Identical Ag Contact on Both n- and p-layers**Munsik Oh<sup>1</sup>, Seongjun Kim<sup>1</sup>, Eunjin Jung<sup>1</sup>, Hyunsoo Kim<sup>1</sup>, Seongnam Lee<sup>2</sup> and Yunju Choi<sup>3</sup>; <sup>1</sup>Chonbuk National University, Jeonju, Korea, Republic of; <sup>2</sup>Korea Polytechnic University, Siheung, Korea, Republic of; <sup>3</sup>Korea Basic Science Institute, Suncheon, Korea, Republic of.

SESSION B3: High Brightness/Efficiency Visible LEDs

Chair: Werner Goetz

Tuesday Morning, August 27, 2013

National Harbor 4-5

**8:30 AM \*B3.01****Status of GaN/SiC-based LEDs and their Application in Solid State Lighting** Hua-Shuang Kong, Cree, Inc., Durham, North Carolina.**9:00 AM B3.02****High-Efficiency Yellow Light-Emitting Diodes Grown on (0001) Sapphire Substrate** Rei Hashimoto, Jongil Hwang, Shinji Saito and Shinya Nunou; Corporate R&D Center, Toshiba Corporation, Kawasaki-si, Kanagawa-ken, Japan.**9:15 AM B3.03****Influence of Waveguide Geometry on Parameters of J-Shaped Violet and Blue-Violet InGaN Superluminescent Diodes**Anna Kafar<sup>1</sup>, Szymon Stanczyk<sup>1</sup>, Grzegorz Targowski<sup>2</sup>, Robert Czernecki<sup>2</sup>, Przemek Wisniewski<sup>1</sup>, Mike Leszczynski<sup>1,2</sup>, Tadek Suski<sup>1</sup> and Piotr Perlin<sup>1,2</sup>; <sup>1</sup>Institute of High Pressure Physics PAS, Warsaw, Poland; <sup>2</sup>TopGaN Ltd., Warsaw, Poland.**9:30 AM B3.04****Ray Tracing Simulations of Light Extraction for High Efficiency LEDs** Leah Kuritzky<sup>1</sup>, Christopher Lalau Keraly<sup>1</sup>,Martin Cochet<sup>1</sup>, James Speck<sup>1</sup> and Claude Weisbuch<sup>1,2</sup>; <sup>1</sup>Materials, University of California, Santa Barbara, Santa Barbara, California; <sup>2</sup>Laboratoire de Physique de la Matière Condensée, CNRS-Ecole Polytechnique, Palaiseau, France.**9:45 AM B3.05****In Incorporation of InGaN Based LEDs on GaN Substrates with Various Planes** Rika Shimma<sup>1</sup>, Yaxin Wang<sup>1</sup>, TomohiroYamamoto<sup>1</sup>, Hideki Hayashi<sup>1</sup>, Ken-ichi Shiohama<sup>1</sup>, Kaori Kurihara<sup>2</sup>, Ryuichi Hasegawa<sup>3</sup> and Kazuhiro Ohkawa<sup>1</sup>; <sup>1</sup>Dept. of Applied Physics, Tokyo University of Science, Tokyo, Japan; <sup>2</sup>Mitsubishi Chemical Corporation, Ibaraki, Japan; <sup>3</sup>Mitsubishi Chemical Group, Science and Technology Research Center, Yokohama, Japan.**10:00 AM BREAK**

SESSION B4: Visible LED Physics and

Characterization

Chair: Martin Albrecht

Tuesday Morning, August 27, 2013

National Harbor 4-5

**10:30 AM B4.01****Suppression of Auger-Stimulated Efficiency Droop in Nitride-Based Light Emitting Diodes** Roman Vaxenburg<sup>1</sup>, EfratLifshitz<sup>1</sup> and Alexander L. Efros<sup>2</sup>; <sup>1</sup>Technion - Israel Institute ofTechnology, Haifa, Israel; <sup>2</sup>Naval Research Laboratory, Washington, District of Columbia.**10:45 AM B4.02****Correlation between the Onset of High Injection and the****Onset of Efficiency Droop in GaInN Light-Emitting Diodes** David S. Meyaard<sup>1</sup>, Guan-Bo Lin<sup>1</sup>, Jaehye Cho<sup>1</sup>, E. Fred Schubert<sup>1</sup>, Hyunwook Shim<sup>2</sup>, Sang-Heon Han<sup>2</sup>, Min-Ho Kim<sup>2</sup>, Young Sun Kim<sup>2</sup> and Cheolsoo Sone<sup>2</sup>; <sup>1</sup>Rensselaer Polytechnic Institute, Troy, New York; <sup>2</sup>LED Business, Samsung Electronics, Yongin, Korea, Republic of.**11:00 AM B4.03****Role of p-InxGa1-xN Layer in Enhancing Hole Transport and Distribution in InGaN/GaN Multiple Quantum Wells of****Visible III-Nitride Light-Emitting Diodes** Jeomoh Kim<sup>1</sup>, Mi-Hee Ji<sup>1</sup>, Md. M. Satter<sup>1</sup>, Jac-Hyun Ryou<sup>1,2</sup>, P. D. Yoder<sup>1</sup>, Theeradetch Detchprohm<sup>1</sup>, Russell D. Dupuis<sup>1</sup>, Reid Juday<sup>3</sup>, Alec Fischer<sup>3</sup> and Fernando Ponce<sup>3</sup>; <sup>1</sup>Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, Georgia; <sup>2</sup>Department of Mechanical Engineering, University of Houston, Houston, Texas; <sup>3</sup>Department of Physics, Arizona State University, Tempe, Arizona.**11:15 AM B4.04****Distribution of Deep Level Defects in InGaN/GaN Light Emitting Diodes and Their Dependence on Indium Alloying**

Andrew Armstrong, Mary H. Crawford and Daniel D. Koleske; Sandia National Labs, Albuquerque, New Mexico.

**11:30 AM B4.05****Determination of Small Current Internal Quantum Efficiency of Blue (AlInGa)N Light-Emitting Diodes from Purely****Electrically Derived Parameters** Michael Binder<sup>1</sup>, Bastian Galler<sup>1</sup>, Michael Furitsch<sup>1</sup>, Juergen Off<sup>1</sup>, Hans-Joachim Wagner<sup>2</sup>, Roland Zeisel<sup>1</sup> and Simeon Katz<sup>1</sup>; <sup>1</sup>OSRAM Opto Semiconductors GmbH, Regensburg, Germany; <sup>2</sup>Fraunhofer-Institut für Angewandte Festkörperphysik, Freiburg, Germany.**11:45 AM B4.06****Atomistic Simulations of InGaN/GaN LEDs Including Random Alloy Effects** Marco Ulises Lopez Diaz<sup>1</sup>, AlessandroPecchia<sup>2</sup>, Matthias Auf der Maur<sup>1</sup>, Fabio Sacconi<sup>3</sup>, Gabriele Penazzi<sup>4</sup> and Aldo Di Carlo<sup>1</sup>; <sup>1</sup>Electronic Engineering, University of Rome Tor Vergata, Rome, Lazio, Italy; <sup>2</sup>CNR-ISMN, Monterotondo, Rome, Lazio, Italy; <sup>3</sup>Tiberlab Srl, Rome, Lazio, Italy; <sup>4</sup>Bremen Center for Computational Materials Science, Universität Bremen, Bremen, Germany.

SESSION B5: Visible LED Fabrication and Integration

Chair: Tae-Yeon Seong

Tuesday Afternoon, August 27, 2013

National Harbor 4-5

**1:30 PM B5.01****Fabrication of N-Polar InGaN LEDs by Pulsed Sputtering**Eiji Kishikawa<sup>1</sup>, Kohei Ueno<sup>2</sup>, Shigeru Inoue<sup>1</sup>, Jitsuo Ohta<sup>1</sup> and Hiroshi Fujioka<sup>1,3</sup>; <sup>1</sup>IIS, The University of Tokyo, Tokyo, Japan; <sup>2</sup>Department of Appl. Chem., The University of Tokyo, Tokyo, Japan; <sup>3</sup>JST-CREST, Tokyo, Japan.**1:45 PM B5.02****Flexible, Compliant GaN Nanomembranes for Photonic****Applications** Danti Chen, Jie Song, Ge Yuan, Kanglin Xiong and Jung Han; Electrical Engineering, Yale University, New Haven, Connecticut.**2:00 PM B5.03****Monolithic Cool White Light Emitting Diodes Based on AlN Islands** Manish Mathew<sup>1</sup>, Hassanet Sodabanlu<sup>1</sup>, MasakazuSugiyama<sup>2,3</sup> and Yoshiaki Nakano<sup>1,2</sup>; <sup>1</sup>Research Center for Advanced Science and Technology, The University of Tokyo, Tokyo, Japan; <sup>2</sup>Department of Electrical Engineering & Information Systems, The University of Tokyo, Tokyo, Japan; <sup>3</sup>Institute of Engineering Innovation, The University of Tokyo, Tokyo, Japan.**2:15 PM B5.04****An Low-Cost Method for Parallel Multiple-Wafer Ltoff of Patterned Sapphire Substrates with Photoelectrochemical****Process** Chieh Hsieh, Zhan Hui Liu, Chun-Han Lin, Chih-Yen Chen, Horng-Shyang Chen, Che-Hao Liao and Chih-Chung (C. C.) Yang; Institute of Photonics and Optoelectronics, National Taiwan University, Taipei, Taiwan.**2:30 PM B5.05****A Dual-Character GaN/InGaN Multiple Quantum Well**

**Device for Electroluminescence and Photovoltaic Absorption of Near-Mutually Exclusive Wavelengths** Jian Wei Ho<sup>1,2,3</sup>, Surani-bin Dolmanan<sup>3</sup>, Qixun Wee<sup>4,3</sup>, Chuan Beng Tay<sup>5</sup>, Andrew A. O. Tay<sup>6</sup> and Soo-Jin Chua<sup>2,4,7</sup>; <sup>1</sup>NUS Graduate School for Integrative Sciences and Engineering, National University of Singapore, Singapore, Singapore; <sup>2</sup>Department of Electrical and Computer Engineering, National University of Singapore, Singapore, Singapore; <sup>3</sup>A\*STAR Institute of Materials Research and Engineering, Singapore, Singapore; <sup>4</sup>Singapore-MIT Alliance, National University of Singapore, Singapore, Singapore; <sup>5</sup>Nanoscience & Nanotech Initiative, National University of Singapore, Singapore, Singapore; <sup>6</sup>Department of Mechanical Engineering, National University of Singapore, Singapore, Singapore; <sup>7</sup>Singapore-MIT Alliance for Research and Technology Centre, Singapore, Singapore.

#### 2:45 PM B5.06

**GaN Thin Film Lift-Off by Selective Lateral Electrochemical Etching of a InGaN/AlGaN Superlattice Layer** Heonsu Jeon<sup>1,2</sup>, Hojun Chang<sup>1</sup>, Hyungrae Cha<sup>2</sup> and Seong-Ran Jeon<sup>3</sup>; <sup>1</sup>Department of Physics and Astronomy, Seoul National University, Seoul, Korea, Republic of; <sup>2</sup>Department of Biophysics and Chemical Biology (WCU), Seoul National University, Seoul, Korea, Republic of; <sup>3</sup>Korea Photonics Technology Institute, Gwangju, Korea, Republic of.

#### 3:00 PM BREAK

SESSION B6: Solar Cells  
Chair: James Speck  
Tuesday Afternoon, August 27, 2013  
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#### 3:30 PM \*B6.01

**Realization of the High Conversion Efficiency Solar Cells using Nitride Semiconductors** Motoaki Iwaya<sup>1</sup>, Yasushi Kurokawa<sup>1</sup>, Yosuke Katsu<sup>1</sup>, Taiji Yamamoto<sup>1</sup>, Tetsuya Takeuchi<sup>1</sup>, Satoshi Kamiyama<sup>1</sup>, Isamu Akasaki<sup>1,2</sup> and Hiroshi Amano<sup>2,3</sup>; <sup>1</sup>Faculty of Science and Technology, Meijo University, Nagoya, Japan; <sup>2</sup>Akasaki Research Center, Nagoya University, Nagoya, Japan; <sup>3</sup>Graduate School of Engineering, Nagoya University, Nagoya, Japan.

#### 4:00 PM B6.02

**Advances in Nitride Growth Technology for InGaN-Based Solar Cells** Chloé A. Fabien<sup>1</sup>, Brendan Gunning<sup>1</sup>, Michael Mosley<sup>1</sup>, W. Alan Doolittle<sup>1</sup>, Alec M. Fischer<sup>2</sup>, Yong Wei<sup>2</sup> and Fernando A. Ponce<sup>2</sup>; <sup>1</sup>School of Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, Georgia; <sup>2</sup>Department of Physics, Arizona State University, Tempe, Arizona.

#### 4:15 PM B6.03

**Assessment of Factors Controlling Conversion Efficiency of Single-Junction III-Nitride Solar Cells** Sergey Y. Karpov and Kirill A. Bulashevich; STR Group - Soft-Impact, Ltd., St.Petersburg, Russian Federation.

#### 4:30 PM B6.04

**Multilevel Intermediate-Band Solar Cells Based on III-Nitrides** Liwen Sang<sup>1,2</sup>, Meiyong Liao<sup>1</sup>, Qifeng Liang<sup>1</sup>, Masaki Takeguchi<sup>1</sup>, Benjamin Dierre<sup>1</sup>, Takashi Sekiguchi<sup>1</sup>, Yasuo Koide<sup>1</sup> and Masatomo Sumiya<sup>1</sup>; <sup>1</sup>National Institute for Materials Science, Tsukuba, Japan; <sup>2</sup>JST-PRESTO, Japan Science and Technology Agency, Tokyo, Japan.

#### 4:45 PM B6.05

**Solar Hydrogen Generation Using p-(In,Ga)N Nanowire Photocathodes** Jumpei Kamimura<sup>1</sup>, Peter Bogdanoff<sup>2</sup>, Jonas Laehnemann<sup>1</sup>, Christian Hauswald<sup>1</sup>, Lutz Geelhaar<sup>1</sup>, Sebastian Fiechter<sup>2</sup> and Henning Riechert<sup>1</sup>; <sup>1</sup>Paul-Drude-Institut, Berlin, Germany; <sup>2</sup>Helmholtz-Zentrum Berlin, Berlin, Germany.

#### 5:00 PM B6.06

**Fabrication of Nitride/Si Hybrid Tandem Cell Structures with Low Environmental Burden by Surface Activated Bonding** Naoteru Shigekawa<sup>1</sup>, Jianbo Liang<sup>1</sup>, Noriyuki Watanabe<sup>2</sup> and Akio Yamamoto<sup>3</sup>; <sup>1</sup>Osaka City University, Osaka, Japan; <sup>2</sup>NTT Photonics Labs., Nippon Telegraph and Telephone Corporation, Atugi, Japan; <sup>3</sup>University of Fukui, Fukui, Japan.

#### 5:15 PM B6.07

**Obtaining a High Open-Circuit Voltage in GaInN-Based Solar Cells** Kurokawa Hironori<sup>1</sup>, Kondo Shinichiro<sup>1</sup>, Mori Mikiko<sup>1</sup>, Iwaya Motoaki<sup>1</sup>, Takeuchi Tetsuya<sup>1</sup>, Kamiyama Satoshi<sup>1</sup>, Akasaki Isamu<sup>1,2</sup> and Amano Hiroshi<sup>2,3</sup>; <sup>1</sup>Faculty of Science and Technology, Meijo University, Nagoya, Japan; <sup>2</sup>Akasaki Research Center, Nagoya University, Nagoya, Japan; <sup>3</sup>Graduate School of Engineering, Nagoya University, Nagoya, Japan.

SESSION B7: Visible Nanostructures  
Chair: Axel Hoffman  
Tuesday Afternoon, August 27, 2013  
Chesapeake 1-3

#### 3:30 PM B7.01

**Monolithic Integration of Different Emission Colors in Two-Dimensionally Arranged InGaN-Based Nanocolumn Array Units of Micrometer Length-Scale Areas** Atsushi Takahashi<sup>1</sup>, Shunsuke Ishizawa<sup>2</sup> and Katsumi Kishino<sup>1,2</sup>; <sup>1</sup>Department of Engineering and Applied Science, Sophia University, Tokyo, Japan; <sup>2</sup>Nanotechnology Research Center, Sophia University, Tokyo, Japan.

#### 3:45 PM B7.02

**GaN Nanotubes with Coaxial GaInN Quantum Wells** Dominik Heinz<sup>1</sup>, Mohamed Fikry<sup>1</sup>, Timo Aschenbrenner<sup>2,3</sup>, Marco Schowalter<sup>4</sup>, Andreas Rosenauer<sup>4</sup>, Manfred Madel<sup>5</sup>, Ingo Tischer<sup>5</sup>, Detlef Hommel<sup>2</sup>, Klaus Thonke<sup>5</sup> and Ferdinand Scholz<sup>1</sup>; <sup>1</sup>Institute of Optoelectronics, Ulm University, Ulm, Germany; <sup>2</sup>Institute of Solid State Physics / Semiconductor Epitaxy, University of Bremen, Bremen, Germany; <sup>3</sup>Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany; <sup>4</sup>Institute of Solid State Physics / Electron Microscopy, University of Bremen, Bremen, Germany; <sup>5</sup>Institute of Quantum Matter / Semiconductor Physics Group, Ulm University, Ulm, Germany.

#### 4:00 PM B7.03

**Nanoscale Correlation of Structural, Electrical, and Optical Properties in GaN and InGaN Nanorods** Xiang Zhou<sup>1</sup>, Ming-Yen Lu<sup>2</sup>, Yu-Jung Lu<sup>3</sup>, Shangjr Gwo<sup>3</sup> and Silvija Gradecak<sup>1</sup>; <sup>1</sup>Department of Materials Science and Engineering, MIT, Cambridge, Massachusetts; <sup>2</sup>Graduate Institute of Opto-mechatronics Engineering, Chia-Yi, Taiwan; <sup>3</sup>Department of Physics, National Tsing Hua University, Hsinchu, Taiwan.

#### 4:15 PM B7.04

**Photonic Crystal Effects in Regular Arrays of Core Shell and Quantum Disc InGaN/GaN Nanorods** Christopher J. Lewins<sup>1</sup>, Emmanuel D. Le Boulbar<sup>1</sup>, Paul R. Edwards<sup>2</sup>, Szymon M. Lis<sup>1</sup>, Wang N. Wang<sup>1</sup>, Robert W. Martin<sup>2</sup>, Philip A. Shields<sup>1</sup> and Duncan W. Allsopp<sup>1</sup>; <sup>1</sup>Electrical & Electronic Engineering, University of Bath, Bath, United Kingdom; <sup>2</sup>Physics, University of Strathclyde, Glasgow, United Kingdom.

#### 4:30 PM B7.05

**GaN Nanostructures and Nanowires with Exceptional Lengths and Great Optical and Crystallographic Properties Grown by Hydride Vapor Phase Epitaxy (HVPE)** Yamina Andre<sup>1,2</sup>, Agnes Trassoudain<sup>1,2</sup>, Geoffrey Avit<sup>1,2</sup>, Evlync Gil<sup>1,2</sup>, Kaddour Lekhal<sup>1,2</sup>, Catherine Bougerol<sup>3</sup>, Francois Reveret<sup>1,2</sup>, Joel Leymarie<sup>1,2</sup>, Christelle Varenne<sup>1,2</sup>, Guillaume Monier<sup>1,2</sup> and Dominique Castelluci<sup>1,2</sup>; <sup>1</sup>Clermont Université, Université Blaise Pascal, Institut Pascal, F-63000 Clermont-Ferrand. 2CNRS, UMR 6602., Aubiere, France; <sup>2</sup>CNRS UMR 6602, Aubiere, France; <sup>3</sup>CEA-CNRS-UJF group jNanophysique et Semiconducteursj, Institut Néel CNRS, 25 avenue des Martyrs., Grenoble, France.

#### 4:45 PM B7.06

**Recombination Dynamics and Internal Quantum Efficiency of InGaN Nanowires** Hideaki Murotani<sup>1</sup>, Hiroya Andoh<sup>1</sup>, Takehiko Tsukamoto<sup>1</sup>, Toko Sugiura<sup>1</sup>, Yoichi Yamada<sup>2</sup>, Takuya Tabata<sup>3</sup>, Yoshio Honda<sup>3</sup>, Masahito Yamaguchi<sup>3</sup> and Hiroshi Amano<sup>3</sup>; <sup>1</sup>Toyota National College of Technology, Toyota, Japan; <sup>2</sup>Yamaguchi University, Ube, Japan; <sup>3</sup>Nagoya University, Nagoya, Japan.

#### 5:00 PM B7.07

**Selective Area Growth of In(Ga)N/GaN Nanocolumns by Molecular Beam Epitaxy on Si(111): from Ultraviolet to Infrared Emission** Steven Albert<sup>1</sup>, Ana M. Bengoechea Encabo<sup>1</sup>, Zarko Gacevic<sup>1</sup>, Miguel A. Sanchez-Garcia<sup>1</sup>, Enrique Calleja<sup>1</sup> and Achim Trampert<sup>2</sup>; <sup>1</sup>Instituto de Sistemas Optoelectrónicos y Microtecnología, Universidad Politécnica de Madrid, Madrid, Spain; <sup>2</sup>Paul-Drude-Institut, Berlin, Germany.

#### 5:15 PM B7.08

**Correlated Optical and Structural Characterization of Nanowire Array LEDs** James R. Riley<sup>1</sup>, Qiming Li<sup>2</sup>, George Wang<sup>2</sup> and Lincoln Lauhon<sup>1</sup>; <sup>1</sup>Materials Science and Engineering, Northwestern University, Evanston, Illinois; <sup>2</sup>Sandia National Laboratories, Albuquerque, New Mexico.

**BP2.01**

**Temperature-Dependent Kelvin Probe Studies on GaN from 80 to 600 K** Joy McNamara, Alison Baski and Michael Reshchikov; Physics, Virginia Commonwealth University, Richmond, Virginia.

**BP2.02**

**High-Power and High-Efficiency Blue Light-Emitting Diode with 4 W Output Power Achieved in a Single-Chip Package** Tak Jeong<sup>1</sup>, Hyung Jo Park<sup>1</sup>, Jong Hyeob Baek<sup>1</sup>, Jun-Seok Ha<sup>2</sup> and Han-Youl Ryu<sup>3</sup>; <sup>1</sup>LED Device Research Center, Korea Photonics Technology Institute, Gwangju, Korea, Republic of; <sup>2</sup>Dept. of Applied Chemical Engineering, Chonnam National University, Gwangju, Korea, Republic of; <sup>3</sup>Dept. of Physics, Inha University, Incheon, Korea, Republic of.

**BP2.03**

**Current-Voltage Characteristics of Single InGaN/GaN Nanowire LEDs** Binh H. Le, Nhung H. Tran, Shamsul Ariffin, Hieu P. Nguyen and Zetian Mi; Electrical and Computer Engineering, McGill University, Montreal, Quebec, Canada.

**BP2.04**

**Enhanced Luminous Efficacy in Phosphor-Converted White Vertical Light-Emitting Diodes Using Low Index Layer** Hyung-Jo Park<sup>1,2</sup>, Jun Beom Park<sup>1,2</sup>, Seung Hwan Kim<sup>1,3</sup>, Tak Jeong<sup>1</sup>, Jun Seok Ha<sup>2</sup>, Ja Yoon Kim<sup>1</sup>, Sang Hern Lee<sup>1</sup> and Jong Hyeob Baek<sup>1</sup>; <sup>1</sup>LED Research & Business Division, Korea Photonics Technology Institute, Gwangju, Korea, Republic of; <sup>2</sup>Department of Advanced Chemical and Engineering, Chonnam National University, Gwangju, Korea, Republic of; <sup>3</sup>School of Semiconductor and Chemical Engineering, Chonbuk National University, Jeonju, Korea, Republic of.

**BP2.05**

**High Efficiency Blue and Green LEDs Grown on Si with 5  $\mu$ m Thick GaN Buffer** Xinbo Zou, Wing Cheung Chong, Ka Ming Wong, Jun Ma and Kei May Lau; ECE, The Hong Kong University of Science & Technology, Hong Kong, Hong Kong.

**BP2.06**

**High Performance of GaN LEDs with Ga-Doped ZnO Transparent Conductive Layers Prepared Using MOCVD** Dong-Sing Wu<sup>1,4</sup>, Ray-Hua Horng<sup>2,3</sup>, Kun-Ching Shen<sup>1</sup>, Chen-Yang Yin<sup>3</sup> and Chiung-Yi Huang<sup>1</sup>; <sup>1</sup>Department of Materials Science and Engineering, National Chung Hsing University, Taichung, Taiwan; <sup>2</sup>Graduate Institute of Precision Engineering, National Chung Hsing University, Taichung, Taiwan; <sup>3</sup>Department of Photonics, National Cheng Kung University, Taiwan, Taiwan; <sup>4</sup>Department of Materials Science and Engineering, Da-Yeh University, Changhua, Taiwan.

**BP2.07**

**Improvement of Light Extraction Efficiency of InGaN/GaN Based LED by Using Plasma Damage-Free Sputtering** Min Joo Park, Kwang Jeong Son and Joon Seop Kwak; Dept. of Printed Electronics Engineering, Suncheon National University, Suncheon, Jeonnam, Korea, Republic of.

**BP2.08**

**Less Strained and More Efficient GaN Light-Emitting Diodes with Embedded Silica Hollow Nanospheres** JongHak Kim<sup>1</sup>, Hecje Woo<sup>2</sup>, Kisu Joo<sup>3</sup>, Sungwon Tac<sup>4</sup>, Jinsub Park<sup>5</sup>, Dacyoung Moon<sup>4</sup>, Sung Hyun Park<sup>1</sup>, Junghwan Jang<sup>4</sup>, Yigil Cho<sup>6</sup>, Juchool Park<sup>1</sup>, Hwankuk Yuh<sup>1</sup>, Gun-Do Lee<sup>1</sup>, In-Suk Choi<sup>6</sup>, Yasushi Nanishi<sup>1,7</sup>, Heung Nam Han<sup>1</sup>, Kookheon Char<sup>2,8</sup> and Euijoon Yoon<sup>1,4,9</sup>; <sup>1</sup>Department of Materials Science and Engineering, Seoul National University, Seoul, Korea, Republic of; <sup>2</sup>School of Chemical and Biological Engineering, Seoul National University, Seoul, Korea, Republic of; <sup>3</sup>Nano Science and Technology Program, Graduate School Convergence Science and Technology, Seoul National University, Seoul, Korea, Republic of; <sup>4</sup>WCU Hybrid Materials Program, Department of Materials Science and Engineering, Seoul National University, Seoul, Korea, Republic of; <sup>5</sup>Department of Electronic Engineering, Hanyang University, Seoul, Korea, Republic of; <sup>6</sup>High Temperature Energy Materials Research Center, Korea Institute of Science and Technology, Seoul, Korea, Republic of; <sup>7</sup>Department of Photonics, Ritsumeikan University, Kusatsu, Shiga, Japan; <sup>8</sup>The National Creative Research Center for Intelligent Hybrids and The WCU Program of Chemical Convergence for Energy & Environment, Seoul National University, Seoul, Korea, Republic of; <sup>9</sup>Energy Semiconductor Research Center, Advanced Institutes of Convergence Technology, Seoul National University, Suwon, Korea, Republic of.

**BP2.09**

**Fabrication of III-Nitride Nanorods Photovoltaics on Silicon Grown by PA-MBE** Ching-Wen Chang<sup>1</sup>, Paritosh Wadekar<sup>1</sup>, Hui-Chun Huang<sup>2</sup>, Chen-Yu Lin<sup>1</sup>, Yuan-Fu Hsu<sup>1</sup>, Chen-Yu He<sup>1</sup> and Li-Wei Tu<sup>1</sup>; <sup>1</sup>Physics, National Sun Yat-sen University, Kaohsiung, Taiwan; <sup>2</sup>Materials and Opto-Electronic Science, National Sun Yat-sen University, Kaohsiung, Taiwan.

**BP2.10**

**Verification of Internal Field Presence in InGaN/GaN Semipolar Quantum Wells by Means of Photoluminescence Studied under High Pressure** Grzegorz Staszczak<sup>1</sup>, Tadeusz Suski<sup>1</sup>, Piotr Perlin<sup>1,2</sup>, Mitsuru Funato<sup>3</sup> and Yoichi Kawakami<sup>3</sup>; <sup>1</sup>Institute of High Pressure Physics "UNIPRESS", PAS, Warsaw, Poland; <sup>2</sup>TopGaN, Warsaw, Poland; <sup>3</sup>Department of Electronic Science and Engineering, Kyoto University, Kyoto, Japan.

**BP2.11**

**Defects in Polar, Semipolar and Nonpolar (In)GaN - A Comparison** Lukas Schade<sup>1,2</sup>, Tim Wernicke<sup>3</sup>, Jens Rasmussen<sup>3</sup>, Simon Ploch<sup>3</sup>, Meena A. Karunakaran<sup>2</sup>, Katarzyna Holc<sup>1</sup>, Markus Weyers<sup>4</sup>, Michael Knciss<sup>3,4</sup> and Ulrich T. Schwarz<sup>1,2</sup>; <sup>1</sup>Optoelectronic Modules, Fraunhofer Institute for Applied Physics, Freiburg, Germany; <sup>2</sup>Optoelectronics, IMTEK, University Freiburg, Freiburg, Germany; <sup>3</sup>Institute of Solid State Physics, Technical University Berlin, Berlin, Germany; <sup>4</sup>Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Berlin, Germany.

**BP2.12**

**Improved Efficiency Droop in GaN-Based Light-Emitting Diodes with Trapezoidal Quantum Barriers** Kim Sang-Jo, Sang-Jun Lee, Kwang Jae Lee and Seong-Ju Park; Department of Nanobio Materials and Electronics, Gwangju Institute of Science and Technology, Gwangju, Korea, Republic of.

**BP2.13**

**Stable Balance of Emission Intensities from Two Active Regions in Nitride Semiconductor-Based Light Emitting Diodes** Kenjo Matsui<sup>1</sup>, Koji Yamashita<sup>1</sup>, Mitsuru Kaga<sup>1</sup>, Takatoshi Morita<sup>1</sup>, Yuka Kuwano<sup>1</sup>, Tomoyuki Suzuki<sup>1</sup>, Tetsuya Takeuchi<sup>1</sup>, Satoshi Kamiyama<sup>1</sup>, Motoaki Iwaya<sup>1</sup> and Isamu Akasaki<sup>1,2</sup>; <sup>1</sup>Faculty of Science and Technology, Meijo University, Nagoya, Japan; <sup>2</sup>Electrical Engineering and Computer Science, Akasaki Research Center, Nagoya University, Nagoya, Japan.

**BP2.14**

**InGaN/GaN Light Emitting Diodes with Graphene Directly Grown by Plasma Enhanced Chemical Vapor Deposition** Kisu Joo<sup>1,2</sup>, Yong Seung Kim<sup>3,4</sup>, Sahng-Kyoon Jerng<sup>3,4</sup>, Jae Hong Lee<sup>3,4</sup>, Seung-Hyun Chun<sup>3,4</sup> and Euijoon Yoon<sup>2,5</sup>; <sup>1</sup>Department of Nano Science and Technology, Graduate School of Convergence Science and Technology, Seoul National University, Suwon, Korea, Republic of; <sup>2</sup>Energy Semiconductor Research Center, Advanced Institutes of Convergence Technology, Seoul National University, Suwon, Korea, Republic of; <sup>3</sup>Graphene Research Institute, Sejong University, Seoul, Korea, Republic of; <sup>4</sup>Department of Physics, Sejong University, Seoul, Korea, Republic of; <sup>5</sup>Department of Materials Science and Engineering, Seoul National University, Seoul, Korea, Republic of.

**BP2.15**

**Transport and Emission Properties of Nb-Doped  $n^{++}$ -type (001) Anatase-TiO<sub>2</sub> / Mg-Doped  $p$ -type (0001) GaN Heteroepitaxial Structures** Masahiro Yamagishi<sup>1</sup>, Kouji Hazu<sup>1</sup>, Tomomi Ohtomo<sup>1</sup>, Youichi Ishikawa<sup>1</sup>, Kentaro Furusawa<sup>1</sup>, Tokuyuki Nakayama<sup>2</sup> and Shigefusa F. Chichibu<sup>1</sup>; <sup>1</sup>Tohoku Univ., Sendai, Japan; <sup>2</sup>Sumitomo Metal Mining Co. Ltd., Tokyo, Japan.

**BP2.16**

**Structural and Chemical Characterization of the InGaN/GaN Multi-Quantum Wells Using HR-XRD Pattern, XPS and AES Spectroscopy** Ewa Grzanka<sup>1,2</sup>, Marcin Pisarek<sup>3</sup>, Wojciech Lisowski<sup>3</sup>, Robert Czernecki<sup>1,2</sup>, Michal Leszczynski<sup>1,2</sup>, Piotr Perlin<sup>1,2</sup>, Andrzej Jablonski<sup>3</sup> and Tadeusz Suski<sup>1</sup>; <sup>1</sup>Institute of High Pressure Physics PAS, Warsaw, Poland; <sup>2</sup>Institute of Physical Chemistry PAS, Warsaw, Poland; <sup>3</sup>TopGaN, Warsaw, Poland.

**BP2.17**

**Numerical Study of Polarization Dependent Quantum Efficiency of Ag/SiO<sub>2</sub> Core-Shell-Nanoparticle Coated InGaN/GaN Light Emitting Diodes** Seul-kee Moon and Jin-Kyu Yang; Kongju National University, Kongju-si, Chungchungnam-do, Korea, Republic of.



### **BP2.18**

**MOVPE Growth and Characterization of Position-Controlled InGaN / GaN Core-Shell Nano- and Microrods** Martin Mandl<sup>1,2</sup>, Tilman Schimpke<sup>1</sup>, Michael Binder<sup>1</sup>, Xue Wang<sup>2</sup>, Andreas Waag<sup>3</sup>, Xiang Kong<sup>3</sup>, Achim Trampert<sup>3</sup>, Frank Bertram<sup>4</sup>, Juergen Christen<sup>4</sup>, Hans-Juergen Lugauer<sup>1</sup> and Martin Strassburg<sup>1</sup>; <sup>1</sup>OSRAM Opto Semiconductors GmbH, Regensburg, Germany; <sup>2</sup>Institute of Semiconductor Technology, Braunschweig University of Technology, Braunschweig, Germany; <sup>3</sup>Paul-Drude-Institute for Solid State Electronics, Berlin, Germany; <sup>4</sup>Otto von Guericke University Magdeburg, Magdeburg, Germany.

### **BP2.19**

**Fabrication Characterization and Comparison of GaN NanoLEDs by both Selective Area MOVPE Growth and Etching** Shunfeng Li<sup>1</sup>, Qianqian Jiao<sup>2</sup>, Zhizhong Chen<sup>2</sup>, Xue Wang<sup>3</sup>, Soenke Fuending<sup>3</sup>, Milena Erenburg<sup>3</sup>, Jiandong Wei<sup>3</sup>, Hergo-Heinrich Wehmann<sup>3</sup>, Andreas Waag<sup>3</sup> and Guoyi Zhang<sup>1,2</sup>; <sup>1</sup>Peking University, Dongguan Institute of Optoelectronics, Dongguan, China; <sup>2</sup>State Key Laboratory for Artificial Microstructures and Mesoscopic Physics, Peking University, Beijing, China; <sup>3</sup>Institute of Semiconductor Technology, TU-Braunschweig, Braunschweig, Germany.

### **BP2.20**

**Advances in ITO – Current Spreading Layers** Silvia Schwyn Thoeny<sup>1</sup>, Hanspeter Friedli<sup>1</sup>, Marco Padrun<sup>1</sup>, Antonino Castiglia<sup>2</sup>, Gatién Cosendey<sup>2</sup> and Nicolas Grandjean<sup>2</sup>; <sup>1</sup>Evattec AG, Flums, Switzerland; <sup>2</sup>LASPE, ICMP, École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland.

### **BP2.21**

**Simultaneous Mapping of the Cathodoluminescence and Electron Beam Induced Current from InGaN LEDs with Different Barrier Growth Temperatures** Michael J. Wallace<sup>1</sup>, Paul R. Edwards<sup>1</sup>, Fabrice Oehler<sup>2</sup>, Menno J. Kappers<sup>2</sup>, Margaret Hopkins<sup>3</sup>, Sivapathasundaram Sivaraya<sup>3</sup>, Rachel A. Oliver<sup>2</sup>, Colin J. Humphreys<sup>2</sup>, Duncan W. Allsopp<sup>3</sup> and Robert W. Martin<sup>1</sup>; <sup>1</sup>Physics, University of Strathclyde, Glasgow, United Kingdom; <sup>2</sup>Materials Science and Metallurgy, University of Cambridge, Cambridge, United Kingdom; <sup>3</sup>Electronic and Electrical Engineering, University of Bath, Bath, United Kingdom.

### **BP2.22**

**Enhancement of External Quantum Efficiency of InGaN-Based Light-Emitting Diodes Grown on Al<sub>2</sub>O<sub>3</sub> and Si (111) with Co-Doped ZnO Film** Yen-Hsiang Fang<sup>1</sup>, Rong Xuan<sup>1</sup>, Chia-Lung Tsai<sup>1</sup> and Jung-Chun-Andrew Huang<sup>2</sup>; <sup>1</sup>Industrial Technology Research Institute/Electronics and Optoelectronics Research Laboratories, Hsinchu, Taiwan; <sup>2</sup>Department of Physics, National Cheng Kung University, Tainan 701, Taiwan, R. O. C., Tainan, Taiwan.

### **BP2.23**

**Displacement Current in Current-Voltage Characteristics of Metal/Low-Mg-Doped p-GaN Interfaces** Kenji Shiojima<sup>1</sup>, Toshichika Aoki<sup>1</sup>, Naoki Kaneda<sup>2,1</sup> and Tomoyoshi Mishima<sup>2</sup>; <sup>1</sup>Graduate School of Electrical and Electronics Engineering, University of Fukui, Fukui, Japan; <sup>2</sup>Corporate Advanced Technology Group, Hitachi Cable Ltd., Tsuchiura, Ibaraki, Japan.

### **BP2.24**

**Spectrally Resolved Carrier Dynamics in Highly Excited LED Structures with Different Barrier Design** Ramunas Aleksiejunas<sup>1</sup>, Kristina Gelzinyte<sup>1</sup>, Kazimieras Nomeika<sup>1</sup>, Saulius Nargelas<sup>1</sup>, Mikas Vengris<sup>1</sup>, Kestutis Jarasiunas<sup>1</sup>, Sirdal Okur<sup>2</sup>, Fan Zhang<sup>2</sup>, Vitaliy Avrutin<sup>2</sup>, Hadis Morkoc<sup>2</sup> and Umit Ozgur<sup>2</sup>; <sup>1</sup>Institute of Applied Research, Vilnius University, Vilnius, Lithuania; <sup>2</sup>Department of Electrical and Computer Engineering, Virginia Commonwealth University, Richmond, Virginia.

### **BP2.25**

**Cavity – Free Lasing in InGaN Heterostructures** Agata Bojarska<sup>1</sup>, Alexander Khachapuridze<sup>1</sup>, Robert Czernacki<sup>1,2</sup>, Tadek Suski<sup>1</sup> and Piotr Perlin<sup>1,2</sup>; <sup>1</sup>Institute of High Pressure Physics, Warsaw, Poland; <sup>2</sup>TopGaN Limited, Warsaw, Poland.

### **BP2.26**

**Structure and Optical Properties of Staggered InGaN Quantum Wells** Tobias Schulz<sup>1</sup>, Toni Markurt<sup>1</sup>, Thilo Remmele<sup>1</sup>, Christian Nennstiel<sup>2</sup>, Felix Nippert<sup>2</sup>, Axel Hoffmann<sup>2</sup>, Tadek Suski<sup>3</sup> and Martin Albrecht<sup>1</sup>; <sup>1</sup>Elektronenmikroskopie, Leibniz-Institut fuer Kristallzuechtung, Berlin, Germany; <sup>2</sup>Institut für Festkörperphysik, Technische Universität Berlin, Berlin, Germany; <sup>3</sup>Semiconductors, Institute für High Pressure Physics, Polish Academy of Sciences, Warsaw, Poland.

### **BP2.27**

**AlN Buffer Layer Optimization for the MOVPE Growth of GaN Nanowire-Based LEDs on Silicon (111)** Robert Koester, Claudia Schmidt, Gregor Keller, Werner Probst and Franz-Josef Tegude; Solid-State Electronics Department - ZHO, University of Duisburg-Essen, Duisburg, Germany.

### **BP2.28**

**Improved Properties of (11-20) Nonpolar InGaN/GaN Light Emitting Diodes Using SiNx Interlayers and Hemispherically Patterned Sapphire Substrate** Dachong Min, Geunho Yoo, Jongjin Jang, Seunghwan Moon, Jeahwan Kim, Sooryong Chae and Okhyun Nam; Korea Polytechnic University, Siheung, Korea, Republic of.

### **BP2.29**

**Improved Uniformity for the Epitaxy of Laser Diodes on Pre-Patterned Substrates** Lise Lahourcade<sup>1</sup>, Marco Rossetti<sup>2</sup>, Antonino Castiglia<sup>1</sup>, Jean-Michel Lamy<sup>1</sup>, Denis Martin<sup>1</sup>, Marcus Duell<sup>2</sup>, Christian Velez<sup>2</sup> and Nicolas Grandjean<sup>1</sup>; <sup>1</sup>SB ICMP LASPE, EPFL, Lausanne, Switzerland; <sup>2</sup>EXALOS AG, Schlieren, Switzerland.

### **BP2.30**

**Damage Morphology Study of GaN Structures by Electron Beam Induced Current** Tomas Grinys<sup>1</sup>, Arunas Kadys<sup>1</sup>, Tadas Malinauskas<sup>1</sup>, Mindaugas Sciuka<sup>2</sup>, Andrius Melninkaitis<sup>2</sup> and Roland Tomasianus<sup>1</sup>; <sup>1</sup>Institute of Applied Research, Vilnius University, Vilnius, Lithuania; <sup>2</sup>Laser Research Center, Vilnius University, Vilnius, Lithuania.

### **BP2.31**

**White Light Emission from InGaN/GaN LEDs and Nanorods Using a Novel Organic Compound for Colour Conversion** Jochen Bruckbauer<sup>1</sup>, Neil J. Findlay<sup>2</sup>, Hugh A. McMullen<sup>2</sup>, Anto R. Inigo<sup>2</sup>, Paul R. Edwards<sup>1</sup>, Jie Bai<sup>3</sup>, Tao Wang<sup>3</sup>, Fabrice Oehler<sup>4</sup>, Menno J. Kappers<sup>4</sup>, Colin J. Humphreys<sup>4</sup>, Rachel A. Oliver<sup>1</sup>, Margaret Hopkins<sup>5</sup>, Duncan W. Allsopp<sup>5</sup>, Peter J. Skabara<sup>2</sup> and Robert W. Martin<sup>1</sup>; <sup>1</sup>Department of Physics, SUPA, University of Strathclyde, Glasgow, United Kingdom; <sup>2</sup>Department of Pure and Applied Chemistry, WestCHEM, University of Strathclyde, Glasgow, United Kingdom; <sup>3</sup>Department of Electronic and Electrical Engineering, University of Sheffield, Sheffield, United Kingdom; <sup>4</sup>Department of Materials Science and Metallurgy, University of Cambridge, Cambridge, United Kingdom; <sup>5</sup>Department of Electronic and Electrical Engineering, University of Bath, Bath, United Kingdom.

### **BP2.32**

**Nano-Scale Characterization of Extended Defects within GaN Nanocolumns by Scanning Transmission Electron Microscopy Cathodoluminescence** Marcus Mueller<sup>1</sup>, Gordon Schmidt<sup>1</sup>, Peter Veit<sup>1</sup>, Frank Bertram<sup>1</sup>, Juergen Christen<sup>1</sup>, Arne Urban<sup>2</sup>, Joerg Malindretos<sup>2</sup> and Angela Rizzi<sup>2</sup>; <sup>1</sup>Institute of Experimental Physics, Otto-von-Guericke Universität Magdeburg, Magdeburg, Sachsen-Anhalt, Germany; <sup>2</sup>IV. Physikalisches Institut, Georg-August-Universität Göttingen, Göttingen, Niedersachsen, Germany.

### **BP2.33**

**Photoluminescence and Electroluminescence Improvement through Optimization of Multi Quantum Well Active Region Growth at High Pressure by MOCVD** Ronald A. Arif, Erkan A. Berkman, Dan Byrnes, Soo Min Lee and George D. Papanoulitios; Veeco Instruments, Somerset, New Jersey.

### **BP2.34**

**Dynamics of Carrier Redistribution Processes in InGaN/GaN Quantum Well Structures** Tom Badcock<sup>1</sup>, Matthew Davies<sup>1</sup>, Phil Dawson<sup>1</sup>, Menno Kappers<sup>2</sup>, Rachel Oliver<sup>2</sup> and Colin Humphreys<sup>2</sup>; <sup>1</sup>Physics & Astronomy, University of Manchester, Manchester, United Kingdom; <sup>2</sup>Materials Science and Metallurgy, University of Cambridge, Cambridge, United Kingdom.

### **BP2.35**

**Characterisation of Defects at Non-Polar GaN/InGaN Junctions in Novel Materials for Application in Light Emitting Diodes** Jack Severs<sup>1</sup>, Juan G. Lozano<sup>1</sup>, Stewart Hooper<sup>2</sup> and Peter D. Nellist<sup>1</sup>; <sup>1</sup>Oxford Materials, University of Oxford, Oxford, United Kingdom; <sup>2</sup>Sharp Laboratories of Europe, Oxford, United Kingdom.

### **BP2.36**

**Embedding Nanopillar Arrays into InGaN Light-Emitting Diodes** Kwai Hei Li<sup>1</sup>, Keyan Zang<sup>2</sup>, Soo Jin Chua<sup>2,3</sup> and Hoi Wai Choi<sup>1</sup>; <sup>1</sup>Electrical and Electronic Engineering, The University of Hong Kong, Hong Kong, Hong Kong; <sup>2</sup>Institute of

**BP2.37**

**Influence of Quantum Well Number on the Bandwidth of High Speed Green Light-Emitting Diodes** Pleun Maaskant<sup>1</sup>, Grzegorz Kozłowski<sup>1</sup>, Haymen Shams<sup>1</sup>, Mahbub Akhter<sup>1</sup>, Brendan Roycroft<sup>1</sup>, Silvino Presa<sup>1</sup>, Menno Kappers<sup>2</sup>, Colin Humphreys<sup>2</sup> and Brian Corbett<sup>1</sup>; <sup>1</sup>Tyndall National Institute, University College Cork, Cork, Ireland; <sup>2</sup>Materials Science and Metallurgy, University of Cambridge, Cambridge, United Kingdom.

**BP2.38**

**Growth Properties and Electrochemical Characterization of InGaN Photoanodes with Different In Concentrations** Matthias Finken<sup>1,3</sup>, Ada Wille<sup>1,3</sup>, Benjamin Reuters<sup>1,3</sup>, Bernd Hollaender<sup>2,3</sup>, Michael Heuken<sup>1,4</sup>, Holger Kalisch<sup>1,3</sup> and Andrei Vescan<sup>1,3</sup>; <sup>1</sup>GaNBE, RWTH Aachen University, Aachen, Germany; <sup>2</sup>PGI9-IT, Forschungszentrum Jülich GmbH, Jülich, Germany; <sup>3</sup>JARA-Fundamentals of Future Information Technologies, Jülich, Germany; <sup>4</sup>AIXTRON SE, Herzogenrath, Germany.

**BP2.39**

**The MOVPE Control of InGaN/GaN MQWs Covering on GaN Wires Grown on Si(111) Substrate** Damien Salomon<sup>1,2</sup>, Amelie Dussaigne<sup>2</sup>, Christophe Durand<sup>1</sup>, Pierre Ferret<sup>2</sup> and Joel Eymer<sup>1</sup>; <sup>1</sup>Equipe mixte CEA-CNRS-UJF "Nanophysique et semiconducteurs", SP2M, UMR-E CEA / UJF-Grenoble I, INAC, Grenoble, France; <sup>2</sup>CEA - LETI, Grenoble, France.

**BP2.40**

**Tuning of Wavelength and Emitted Power from Violet InGaN/GaN Laser Diode for Resonant Excitation of Solid State Converters** Alexander Khachapuridze<sup>1</sup>, Tadeusz Suski<sup>1</sup>, Lucja Marona<sup>1</sup>, Piotr Perlin<sup>1,2</sup>, Marek Berkowski<sup>3</sup> and Witold Ryba-Romanowski<sup>4</sup>; <sup>1</sup>Institute of High Pressure Physics, "Unipress", PAS, Warsaw, Poland; <sup>2</sup>TopGaN Limited, Warsaw, Poland; <sup>3</sup>Institute of Physics, PAS, Warsaw, Poland; <sup>4</sup>Institute of Low Temperature and Structure Research, PAS, Wrocław, Poland.

**BP2.41**

**Numerical Study on the Optimization of a GaN-Based Dual Color Light-Emitting Diode with P-Type Insertion Layer for Balancing Two-Color Intensities** Shu-Ting Yeh<sup>1</sup>, Kai-Lun Chi<sup>2</sup>, Jin-Wei Shi<sup>2</sup> and Yuh-Renn Wu<sup>1</sup>; <sup>1</sup>Institute of Photonics and Optoelectronics and Department of Electrical Engineering, National Taiwan University, Taipei, Taiwan; <sup>2</sup>Department of Electrical Engineering, National Central University, Taoyuan, Taiwan.

**BP2.42**

**A Simple Method to Model Bragg Reflectors with Transient Layers Formed at the Interfaces** Zarko Gacevic<sup>1</sup>, Nenad Vukmirovic<sup>2</sup> and Enrique Calleja<sup>1</sup>; <sup>1</sup>ISOM, Universidad Politécnica de Madrid, Madrid, Spain; <sup>2</sup>Scientific Computing Laboratory, Institute of Physics Belgrade, University of Belgrade, 11080 Belgrade, Serbia.

**BP2.43**

**The Structure of Polar, Nonpolar, and Semipolar InGaN Quantum Wells Characterized by Atom Probe Tomography** James R. Riley<sup>1</sup>, Theeradetch Detchprohm<sup>2</sup>, Christian Wetzel<sup>2</sup> and Lincoln Lauhon<sup>1</sup>; <sup>1</sup>Materials Science and Engineering, Northwestern University, Evanston, Illinois; <sup>2</sup>Smart Lighting Research Center, Future Chips Constellation, Department of Physics, Applied Physics, and Astronomy, Rensselaer Polytechnic Institute, Troy, New York.

**BP2.44**

**The Effects of Varying Threading Dislocation Density on the Optical Properties of InGaN/GaN Quantum Wells** M. J. Davics<sup>1</sup>, P. Dawson<sup>1</sup>, F. C. Massabuau<sup>2</sup>, F. Ochler<sup>2</sup>, R. A. Oliver<sup>2</sup>, M. J. Kappers<sup>2</sup>, T. J. Badcock<sup>1</sup> and C. J. Humphreys<sup>2</sup>; <sup>1</sup>School of Physics and Astronomy, Photon Science Institute, University of Manchester, Manchester, United Kingdom; <sup>2</sup>Department of Materials Science and Metallurgy, University of Cambridge, Cambridge, United Kingdom.

**BP2.45**

**Growth Kinetics of N-polar GaN Columns by Selective Area MOVPE** Xue Wang<sup>1</sup>, Jana Hartmann<sup>1</sup>, Martin S. Mohajerani<sup>1</sup>, Hergo Wehmann<sup>1</sup>, Martin Mandl<sup>1,2</sup>, Martin Strassburg<sup>2</sup>, Eva Raj<sup>3</sup>, Zbigniew Lisik<sup>3</sup> and Andreas Waag<sup>1</sup>; <sup>1</sup>Institute of Semiconductor Technology, Braunschweig University of Technology, Braunschweig, Germany; <sup>2</sup>Osram Opto Semiconductors GmbH, Regensburg, Germany; <sup>3</sup>Department of semiconductor and optoelectronics devices, Technical University of Lodz, Lodz, Poland.

**8:30 AM B8.01**

**Modulation Characteristics of pnp AlGaIn/InGaIn/GaN Light-Emitting Transistors** Kazuhide Kumakura, Hideki Yamamoto and Toshiki Makimoto; NTT Basic Research Labs., Atsugi-shi, Kanagawa, Japan.

**8:45 AM B8.02**

**Tunnel Injection of Holes in GaN Using GdN/GaN Heterojunction** Sriram Krishnamoorthy<sup>1</sup>, Oscar Restrepo<sup>2</sup>, Rohan Mishra<sup>3</sup>, Jing Yang<sup>2</sup>, Roberto Myers<sup>2,1</sup>, Wolfgang Windl<sup>2</sup> and Siddharth Rajan<sup>1,2</sup>; <sup>1</sup>Electrical and Computer Engineering, The Ohio State University, Columbus, Ohio; <sup>2</sup>Materials Science and Engineering, The Ohio State University, Columbus, Ohio; <sup>3</sup>Materials Science and Technology Division, Oak Ridge National Laboratory, Oak Ridge, Ohio.

**9:00 AM B8.03**

**10- $\mu$ m-Square Micro LED Array with Tunnel Junction** Masahiro Watanabe<sup>1</sup>, Mitsuru Kaga<sup>1</sup>, Koji Yamashita<sup>1</sup>, Tomoyuki Suzuki<sup>1</sup>, Daichi Minamikawa<sup>1</sup>, Yuka Kuwano<sup>1</sup>, Tetsuya Takeuchi<sup>1</sup>, Satoshi Kamiyama<sup>1</sup>, Motoaki Iwaya<sup>1</sup> and Isamu Akasaki<sup>1,2</sup>; <sup>1</sup>Meijo University, Nagoya, Japan; <sup>2</sup>Akasaki Research Center, Nagoya University, Nagoya, Japan.

**9:15 AM B8.04**

**GaN Double-Doped with Mg and Eu: Beyond the Light Emitting Diode Limit** Kevin O'Donnell<sup>1</sup>, Vyacheslav Kachkanov<sup>2</sup>, Katharina Lorenz<sup>3</sup> and Michal Bockowski<sup>4</sup>; <sup>1</sup>Strathclyde University, Glasgow, United Kingdom; <sup>2</sup>Diamond Light Source Ltd, Chilton, United Kingdom; <sup>3</sup>Instituto Superior Técnico, Campus Tecnológico e Nuclear,, Sacavem, Portugal; <sup>4</sup>Unipress, Warsaw, Poland.

**9:30 AM B8.05**

**Flexible InGaIn/GaN Quantum-Well Light-Emitting Diode** Hornq-Shyang Chen, Chun-Han Lin, Chih-Yen Chen, Chieh Hsieh, Wang-Hsien Chou, Yean-Woci Kiang and Chih-Chung (C. C.) Yang; Institute of Photonics and Optoelectronics, National Taiwan University, Taipei, Taiwan.

**9:45 AM B8.06**

**Using an Inversion Layer for Achieving p-type GaN for LEDs Grown by MOCVD on Planar N-polar GaN and Semi-Polar Facets of Wet Etched N-polar GaN** Dennis M. Van Den Broeck<sup>1</sup>, Aadhithya M. Hosalli<sup>1</sup>, Deon Bharrat<sup>2</sup>, Salah Bedair<sup>1</sup> and Nadia El-Masry<sup>2</sup>; <sup>1</sup>Electrical Engineering, North Carolina State University, Raleigh, North Carolina; <sup>2</sup>Materials Science and Engineering, North Carolina State University, Raleigh, North Carolina.

**10:00 AM BREAK**

SESSION B9: Visible Lasers  
Chair: Mike Krames  
Wednesday Morning, August 28, 2013  
National Harbor 4-5

**10:30 AM \*B9.01**

**Recent Developments in Green and Blue Laser Diodes** Adrian Avramescu, OSRAM Opto-Semiconductors GmbH, Regensburg, Germany.

**11:00 AM B9.02**

**True Green InGaIn-Based Semipolar Laser Diodes Using Limited Area Epitaxy** Matthew T. Hardy, Shuji Nakamura, James S. Speck and Steven P. DenBaars; Materials, University of California, Santa Barbara, Santa Barbara, California.

**11:15 AM B9.03**

**True-Blue Laser Diodes Grown by Plasma Assisted MBE on Bulk GaN Substrates** Grzegorz Muziol<sup>1</sup>, Henryk Turski<sup>1</sup>, Marcin Siskacz<sup>1,2</sup>, Marta Sawicka<sup>1,2</sup>, Szymon Grzanka<sup>1,2</sup>, Piotr Perlin<sup>1,2</sup>, Sylwester Porowski<sup>1</sup> and Czesław Skierbiszewski<sup>1,2</sup>; <sup>1</sup>Institute of High Pressure Physics Polish Academy of Sciences, Warsaw, Poland; <sup>2</sup>TopGaN Ltd, Warsaw, Poland.

**11:30 AM B9.04**

**Violet Vertical-Cavity Surface-Emitting Laser Structures Based on an AlInN/GaN Distributed Bragg Reflector** Christoph Berger, Juergen Blaesing, Gordon Schmidt, Marcus Mueller, Peter Veit, Thomas Hempel, Frank Bertram, Armin Dadgar, Juergen Christen and Alois Krost; Institute of Experimental Physics,

**11:45 AM B9.05**

**InGaN Laser Diodes with Very Thin AlGaIn Cladding Layer Grown on GaN Plasmonic Substrate** Szymon Stanczyk<sup>1</sup>, Tomasz Czyszanowski<sup>2</sup>, Anna Kafar<sup>1</sup>, Robert Czernecki<sup>3</sup>, Grzegorz Targowski<sup>3</sup>, Mike Leszczynski<sup>1,3</sup>, Tadeusz Suski<sup>1</sup> and Piotr Perlin<sup>1,3</sup>;  
<sup>1</sup>Institute of High Pressure Physics, Warsaw, Poland; <sup>2</sup>Institute of Physics, Lodz University of Technology, Lodz, Poland; <sup>3</sup>TopGaN Ltd., Warsaw, Poland.

**12:00 PM B9.06**

**Gallium Nitride Laser Diodes with Integrated Absorber: On the Dynamics of Self-Pulsation** Katarzyna Holc<sup>1</sup>, Gerrit Luekens<sup>1</sup>, Thomas Weig<sup>1</sup>, Klaus Koehler<sup>1</sup>, Joachim Wagner<sup>1</sup> and Ulrich Schwarz<sup>1,2</sup>; <sup>1</sup>Fraunhofer IAF, Freiburg, Germany; <sup>2</sup>IMTEK, Freiburg University, Freiburg, Germany.

**12:15 PM B9.07**

**The Potential of III-Nitride Laser Diodes for Solid-State Lighting** Jonathan J. Wierer<sup>1</sup>, Jeffrey Y. Tsao<sup>1</sup> and Dmitry S. Sizov<sup>2</sup>; <sup>1</sup>Sandia National Laboratories, Albuquerque, New Mexico; <sup>2</sup>Corning Incorporated, Corning, New York.

SESSION BP3: Poster Session: Optical Devices, Visible  
Wednesday Afternoon, August 28, 2013  
1:00 PM  
Potomac C/D & 1-6

**BP3.01**

**Plasmonically-Enhanced Emission from an Inverted III-Nitride Light Emitting Diode** Michael Mastro, US Naval Research Lab, Washington, District of Columbia.

**BP3.02**

**Strain Relief Mechanisms and Growth Behavior of Superlattice Distributed Bragg Reflectors** Ada Wille<sup>1</sup>, Benjamin Reuters<sup>1</sup>, Matthias Finken<sup>1</sup>, Frank Heyroth<sup>2</sup>, Georg Schmidt<sup>2,3</sup>, Michael Heuken<sup>1,4</sup>, Holger Kalisch<sup>1</sup> and Andrei Vescan<sup>1</sup>; <sup>1</sup>GaN-BET, RWTH Aachen University, Aachen, Germany; <sup>2</sup>Interdisciplinary Center for Materials Science, Martin-Luther-University Halle, Halle, Germany; <sup>3</sup>Department of Physics, Martin-Luther-University Halle, Halle, Germany; <sup>4</sup>AIXTRON SE, Herzogenrath, Germany.

**BP3.03**

**Transparent Conductive Silver Nanowire Electrode in GaN Based Light Emitting Diodes** Pan-Ju Choi<sup>1</sup>, Yong-Jin Kang<sup>1,2</sup>, Seung-Jong Oh<sup>1</sup>, Ja-Yeon Kim<sup>2</sup> and Min-Ki Kwon<sup>1</sup>; <sup>1</sup>Phononic Engineering, Chosun University, Gwangju, Korea, Republic of; <sup>2</sup>Korea Photonics Technology Institute, Gwangju, Korea, Republic of.

**BP3.04**

**Optical Signature of Thermal Degradation of Indium-Rich InGaIn Quantum Wells** Nils A. Kaufmann, Lise Lahourcade, Georg Rossbach, Denis Martin and Nicolas Grandjean; SB ICMP LASPE, EPFL, Lausanne, Switzerland.

**BP3.05**

**Growth of GaN on Nano-Patterned Thermal Oxidized (111) and (100) Si** Wenting Hou, Theeradetch Detchprohm, Xiaoli Wang and Christian Wetzel; Physics, Rensselaer, Troy, New York.

**BP3.06**

**Impact of QD Shape and Coulomb Interaction on the Electronic and Optical Properties of a-plane GaN/AlN QDs** Stefan Schulz<sup>1</sup>, Miguel A. Caro<sup>1,2</sup> and Eoin P. O'Reilly<sup>1,2</sup>;  
<sup>1</sup>Photonics Theory Group, Tyndall National Institute, Cork, Ireland; <sup>2</sup>Department of Physics, University College Cork, Cork, Ireland.

**BP3.07**

**Localized Emission from the Apex of GaN/(In,Ga)N/GaN Pyramidal-Top Nanocolumns Grown in Ordered Arrays** Noemi Garcia-Lepetit, Zarko Gacevic, Steven Albert, Ana Bengochea-Encabo, Miguel Angel Sanchez-Garcia and Enrique Calleja; ISOM (Instituto de Sistemas Optoelectrónicos y Microtecnología), Madrid, Spain.

**BP3.08**

**A 2-D Hole Gas is Confirmed for Super-Luminescent n-In<sub>0.30</sub>Ga<sub>0.70</sub>N/p-GaN Single Heterostructures Grown by the Migration Enhanced Afterglow Technique** K. Scott Butcher<sup>1,2</sup>, Rositsa Gergova<sup>2</sup>, Dimiter Alexandrov<sup>1,2</sup>, Vasil Georgiev<sup>1,2</sup>, Dimka Georgieva<sup>2</sup>, Penka Terziyska<sup>2</sup>, Peter W. Binsted<sup>2</sup> and Greg Togatema<sup>2</sup>;  
<sup>1</sup>Meaglow Ltd, Thunder Bay, Ontario, Canada; <sup>2</sup>Semiconductor

**BP3.09**

**The Potential of X-Ray Diffraction for Characterization of Self-Assembled and Selective-Area Grown III-Nitride Nanocolumns on Si(111)** Zarko Gacevic, Steven Albert, Ana Bengochea-Encabo, Miguel Angel Sanchez-Garcia and Enrique Calleja; ISOM, Universidad Politécnic de Madrid, Madrid, Spain.

**BP3.10**

**Investigation of InGaIn Layers with Different In Concentration for Photo-Electrochemical Hydrogen Generation** Tadas Malinauskas<sup>1</sup>, Arunas Kadys<sup>1</sup>, Edgaras Jelmakas<sup>1</sup>, Tomas Grinys<sup>1</sup>, Mantas Dmukauskas<sup>1</sup>, Benjaminas Sebekas<sup>2</sup>, Irena Savickaja<sup>2</sup>, Jurga Juodkazyte<sup>2</sup> and Saulius Juodkazis<sup>1</sup>;  
<sup>1</sup>Vilnius University, Vilnius, Lithuania; <sup>2</sup>Center for Physical Sciences and Technology, Vilnius, Lithuania.

**BP3.11**

**Nano-Layers of Nitride Semiconductors Grown by MEAGlow Epitaxial Technology and Their Nano-Dimensional Optical Properties** Dimiter Alexandrov<sup>1,2</sup>, Scott Butcher<sup>2,1</sup>, Penka Terziyska<sup>1</sup>, Rositsa Gergova<sup>1</sup>, Peter Binsted<sup>1</sup>, Dimka Georgieva<sup>1</sup> and Vasil Georgiev<sup>1,2</sup>; <sup>1</sup>Electrical Engineering, Lakehead University, Thunder Bay, Ontario, Canada; <sup>2</sup>Meaglow Ltd., Thunder Bay, Ontario, Canada.

**BP3.12**

**Statistical Analysis of InGaIn Quantum Dots** Tyler Hill<sup>1</sup>, Lei Zhang<sup>1</sup>, Chu-hsiang Teng<sup>2</sup>, Brandon Demory<sup>2</sup>, Pei-Cheng Ku<sup>2</sup> and Hui Deng<sup>1</sup>; <sup>1</sup>Physics, University of Michigan, Ann Arbor, Michigan; <sup>2</sup>Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, Michigan.

**BP3.13**

**Stark-Effect Versus Indium Fluctuations in Green-Light Emitting InGaIn Quantum Wells** Lucja Marona<sup>1</sup>, Agata Bojarska<sup>1</sup>, Grzegorz Staszczak<sup>1</sup>, Ewa Grzanka<sup>1</sup>, Robert Czernecki<sup>2</sup>, Tadeusz Suski<sup>1</sup> and Piotr Perlin<sup>1</sup>; <sup>1</sup>Institute of High Pressure Physics, Warsaw, Poland; <sup>2</sup>TopGaN, Warsaw, Poland.

**BP3.14**

**InGaIn/GaN Microcolumn LEDs with Sidewall Metal Contact Arrays** Duk-jo Kong, Si-Young Bae, Chang-Mo Kang and Dong-Seon Lee; School of Information and Communications, Gwangju Institute of Science and Technology (GIST), Gwangju, Korea, Republic of.

**BP3.15**

**The Reliability of GaN Superluminescent Diodes and Laser Diodes** Marco Rossotti<sup>1</sup>, Marcus Duck<sup>1</sup>, Christian Velcz<sup>1</sup>, Antonino Castiglia<sup>2</sup>, Jean-Michel Lamy<sup>2</sup>, Lise Lahourcade<sup>2</sup>, Denis Martin<sup>2</sup> and Nicolas Grandjean<sup>2</sup>; <sup>1</sup>EXALOS AG, Schlieren, Switzerland; <sup>2</sup>EPFL, Lausanne, Switzerland.

**BP3.16**

**Analysis of Light Extraction Efficiency for GaN-Based Coaxial Microwall Light-Emitting Diodes** Mohsen Nami, Ashwin Rishinaramangalam and Daniel Feezell; University of New Mexico, Albuquerque, New Mexico.

**BP3.17**

**Elemental Distribution of Coaxial InGaIn/GaN Nanowires Grown by Metalorganic Chemical Vapor Deposition** Elconora Secco<sup>1</sup>, Nuria Garro<sup>1</sup>, Andres Cantarero<sup>1</sup>, Manh-Hung Chu<sup>2</sup>, Jaime Segura-Ruiz<sup>2</sup>, Gema Martinez-Criado<sup>2</sup>, Bartosz Foltynski<sup>3</sup>, Hannes Behmenburg<sup>3</sup>, Christoph Giesen<sup>3</sup> and Michael Heuken<sup>3</sup>; <sup>1</sup>Institute of Materials Science (ICMUV), Valencia, Spain; <sup>2</sup>European Synchrotron Radiation Facility (ESRF), Grenoble, France; <sup>3</sup>AIXTRON SE, Herzogenrath, Germany.

**BP3.18**

**Design of Robust AlGaIn/GaN Quantum-Well Heterostructures with Intersubband Transitions in the THz Spectral Region** Mark Beeler<sup>1</sup>, Catherine Bougerol<sup>2</sup>, Edith Bellet-Amalric<sup>1</sup>, Katharina Lorenz<sup>3</sup>, Eduardo Alves<sup>3</sup> and Eva Monroy<sup>1</sup>; <sup>1</sup>Group Nanophysique et Semiconducteurs, INAC-SP2M, CEA-CNRS, Grenoble, France; <sup>2</sup>CEA-CNRS Group Nanophysique et Semiconducteurs, Institut Neel-CNRS, CEA-CNRS, Grenoble, France; <sup>3</sup>Campus Tecnológico e Nuclear, Instituto Superior Técnico, Sacavém, Portugal.

**BP3.19**

**Improvement of Luminescence Efficiency of N-face (000-1) InGaIn Multiple Quantum Wells Using InGaIn Underlying Layers** Chia-Hung Lin, Tetsuya Akasaka and Hideki Yamamoto; NTT

Basic Research Laboratories, Atsugi, Kanagawa, Japan.

#### **BP3.20**

**Optimization of Surface Texture of Vertical Blue LEDs for Enhanced Light Extraction Efficiency** Seonock Kim, Minwoo Lee, Eun Ah Lee, Hwanjoon Choi, Hooyoung Song, Jin Hyoun Joe, Junho Sung, Ki-Seong Jeon, Mingu Kang, Yoon-Ho Choi and Jeong Soo Lee; Materials & Components Laboratory, LG electronics, Seoul, Korea, Republic of.

#### **BP3.21**

**A Comparative Study of the Lasing Dynamics from InGaN/GaN Microdisk Cavities with Embedded InGaN Quantum Dots** Alexander J. Woolf<sup>1</sup>, Timothy Puchtler<sup>2</sup>, Tongtong Zhu<sup>2</sup>, Menno J. Kappers<sup>2</sup>, Rachel Oliver<sup>2</sup> and Evelyn Hu<sup>1</sup>; <sup>1</sup>School of Engineering and Applied Sciences, Harvard University, Cambridge, Massachusetts; <sup>2</sup>Department of Materials Science and Metallurgy, University of Cambridge, Cambridge, United Kingdom.

#### **BP3.22**

**Using Surface States of Gallium Nitride Nanowires for Solar-Driven Photocatalytic Water-Splitting and Hydrogen Fuel Generation** Yuchen Yang<sup>1</sup>, Nicholas J. Borys<sup>1</sup>, Anil Ghimire<sup>1</sup>, Michael Bartl<sup>2</sup>, P. James Schuck<sup>3</sup>, Shaul Aloni<sup>3</sup> and Jordan Gerton<sup>1</sup>; <sup>1</sup>Physics & Astronomy, University of Utah, Salt Lake City, Utah; <sup>2</sup>Chemistry, University of Utah, Salt Lake City, Utah; <sup>3</sup>Molecular Foundry, Lawrence Berkeley National Laboratory, Berkeley, California.

#### **BP3.23**

**Quantitative Analysis of Carrier Escape and Recombination Efficiency in GaN-Based Blue Light-Emitting Diodes** SeungHyuk Lim, YangSeok Yoo and YongHoon Cho; Department of Physics and Graduate School of Nanoscience & Technology (WCU), KAIST, Daejeon, Korea, Republic of.

#### **BP3.24**

**Direct Epitaxial Growth of GaN-Based Light-Emitting Diodes on Patterned Graphene Oxide: A Solution for Heat Dissipation Issues** Nam Han, Chonbuk National University, Jeonju, Korea, Republic of.

#### **BP3.25**

**Systematic Analysis of Photocurrent Spectroscopy on InGaN/GaN Blue Light-Emitting Diodes** Dong-Soo Shin<sup>1</sup>, Jong-Ik Lee<sup>2</sup> and Jong-In Shim<sup>2</sup>; <sup>1</sup>Applied Physics, Hanyang University, ERICA Campus, Ansan, Korea, Republic of; <sup>2</sup>Electronics & Communication Eng., Hanyang University, ERICA Campus, Ansan, Korea, Republic of.

#### **BP3.26**

**Thin Film Color-Tunable Micro-Pixelated RGB Light-Emitting Diodes** Zetao Ma, Yuk Fai Cheung and Hoi Wai Choi; Electrical and Electronic Engineering, The University of Hong Kong, Hong Kong, Hong Kong.

#### **BP3.27**

**Advantages of the Moth-Eye Patterned Sapphire Substrate for the High Performance Nitride Based LEDs** Toshiyuki Kondo<sup>1</sup>, Tsukasa Kitano<sup>1</sup>, Atsushi Suzuki<sup>1</sup>, Midori Mori<sup>1</sup>, Koichi Naniwae<sup>1</sup>, Motoaki Iwaya<sup>2</sup>, Tetsuya Takeuchi<sup>2</sup>, Satoshi Kamiyama<sup>2,1</sup> and Isamu Akasaki<sup>2</sup>; <sup>1</sup>EL-SEED Corporation, Nagoya, Japan; <sup>2</sup>Meijo University, Nagoya, Japan.

#### **BP3.28**

**Key Parameters for the Optimization of Yellow Emitting InGaN Multiple Quantum Wells Grown by MOCVD** Kaddour Lekhal, Benjamin Damilano, Sakhawat Hussain, Philippe Vennegues and Philippe De Mierry; CRHEA/CNRS, Nice, France.

#### **BP3.29**

**Analysis of Submicron GaN Based Core-Shell LED Structures Grown by Selective Area MOVPE** Jana Hartmann<sup>1</sup>, Xue Wang<sup>1</sup>, Johannes Ledig<sup>1</sup>, Matin Sadat Mohajerani<sup>1</sup>, Martin Mandl<sup>2</sup>, Stephanie Bley<sup>4</sup>, Kathrin Sebald<sup>4</sup>, Xiang Kong<sup>3</sup>, Achim Trampert<sup>3</sup>, Martin Strassburg<sup>2</sup>, Tobias Voss<sup>4</sup>, Jürgen Gutowski<sup>4</sup>, Hergo-Heinrich Wehmann<sup>1</sup> and Andreas Waag<sup>1</sup>; <sup>1</sup>Institute of Semiconductor Technology, Technical University of Braunschweig, Braunschweig, Germany; <sup>2</sup>Osram Opto Semiconductors GmbH, Regensburg, Germany; <sup>3</sup>Paul-Drude-Institute for Solid State Electronics, Berlin, Germany; <sup>4</sup>University of Bremen, Institute of Solid State Physics, Bremen, Germany.

#### **BP3.30**

**Improvement in Semipolar {11-22} Light-Emitting Diodes Using Combination of InGaN Underlying Layer and Hole**

**Blocking Layer** Kota Nakao, Haziq Muhammad, Keisuke Yamane, Narihito Okada and Kazuyuki Tadatomo; Yamaguchi University, Ube, Japan.

#### **BP3.31**

**Reducing Surface Recombination in InGaN Quantum Dot-in-Wire Structures** Chu-Hsiang Teng<sup>1</sup>, Lei Zhang<sup>2</sup>, Tyler Hill<sup>2</sup>, Brandon Demory<sup>1</sup>, Hui Deng<sup>2</sup> and Pei-Cheng Ku<sup>1</sup>; <sup>1</sup>EECS, University of Michigan, Ann Arbor, Michigan; <sup>2</sup>Physics, University of Michigan, Ann Arbor, Michigan.

#### **BP3.32**

**Luminescence in M-Plane GaN Grown on M-Plane Sapphire by MOCVD** Qing Paduano<sup>1</sup>, David W. Weyburne<sup>1</sup> and David C. Look<sup>2,3</sup>; <sup>1</sup>Air Force Research Lab, Wright-Patterson AFB, Ohio; <sup>2</sup>Semiconductor Research Center, Wright State University, Dayton, Ohio; <sup>3</sup>Wyle Laboratories, Inc, Dayton, Ohio.

#### **BP3.33**

**Junction Leakage Resistance of III-N Solar Cells Grown on GaN Substrates by MBE and MOVPE** Kazuhide Kusakabe<sup>1,2</sup>, Naoki Hashimoto<sup>1</sup> and Akihiko Yoshikawa<sup>1,2,3</sup>; <sup>1</sup>Center for SMART Green Innovation Research, VBL, JST-ALCA: SMART Solar Cell PJ, Chiba University, Chiba, Japan; <sup>2</sup>G-COE, Chiba University, Chiba, Japan; <sup>3</sup>Info. & Comm. Engineering, Kogakuin University, Tokyo, Japan.

#### **BP3.34**

**Prototyping of GaInN LEDs: The Suitable Laser Source for Mesa Definition** Ruediger Moser<sup>1</sup>, Michael Kunzer<sup>1</sup>, Christian Gossler<sup>1</sup>, Klaus Koehler<sup>1</sup>, Wilfried Pletschen<sup>1</sup>, Jens Brunne<sup>2</sup>, Ulrich T. Schwarz<sup>1,3</sup> and Joachim Wagner<sup>1</sup>; <sup>1</sup>Fraunhofer Institute for Applied Solid State Physics IAF, Freiburg, Germany; <sup>2</sup>Laboratory for Microactuators, Institute of Microsystems Engineering (IMTEK), University of Freiburg, Freiburg, Germany; <sup>3</sup>Laboratory for Optoelectronics, Institute of Microsystems Engineering (IMTEK), University of Freiburg, Freiburg, Germany.

#### **BP3.35**

**Investigation of Electron Transport through Unipolar InGaN Quantum Well Structures** David Browne<sup>1</sup>, Yuh-Renn Wu<sup>2</sup> and James S. Speck<sup>1</sup>; <sup>1</sup>Materials, UC Santa Barbara, Santa Barbara, California; <sup>2</sup>Electrical Engineering, National Taiwan University, Taipei, Taiwan.

#### **BP3.36**

**Room Temperature Resonant Energy Transfer between GaN/AlGa Quantum Wells and Polyfluorene** Rahul Jayaprakash<sup>1,2</sup>, Fotis Kalaitzakis<sup>2</sup>, Joel Bleuse<sup>3</sup>, Bruno Gayral<sup>3</sup>, Eva Monroy<sup>3</sup> and Nikos T. Pelekanos<sup>1,2</sup>; <sup>1</sup>Materials Science and Technology, University of Crete, Heraklion, Greece; <sup>2</sup>Microelectronics Research Group, IESL-FORTH, Heraklion, Greece; <sup>3</sup>CEA-CNRS Group of Nanophysics and Semiconductors, CEA/INAC/SP2M, Grenoble, France.

#### **BP3.37**

**Stimulated Emissions in GaN-Based Laser Diodes Far below the Threshold** Ding Li<sup>1</sup>, Wei Yang<sup>1</sup>, Hua Zong<sup>1</sup>, Liefeng Feng<sup>2</sup>, Cunda Wang<sup>1,2</sup>, Guoyi Zhang<sup>1</sup> and Xiaodong Hu<sup>1</sup>; <sup>1</sup>The Research Center for Wide-Gap Semiconductor, School of Physics, Peking University, Beijing, China; <sup>2</sup>Department of Applied Physics, Tianjin University, Tianjin, China.

#### **BP3.38**

**The Origin of Light-Extraction Enhancement of GaN-Based LED Covered with ZnO Nanorods** Hyun Jeong<sup>1</sup>, Doo Jae Park<sup>1</sup>, Yong Hwan Kim<sup>1</sup>, Jae Su Yu<sup>2</sup> and Mun Seok Jeong<sup>1</sup>; <sup>1</sup>Center for Integrated Nanostructure Physics, Institute of Basic Science, Sungkyunkwan University, Suwon, Gyeong Gi-Do, Korea, Republic of; <sup>2</sup>Department of Electronics and Radio Engineering, Kyung Hee University, Suwon, Gyeong Gi-Do, Korea, Republic of.

#### **BP3.39**

**Carrier Dynamics Analysis for Efficiency Droop in GaN-Based Light Emitting Diodes Using Time Resolved Electroluminescence System** YangSeok Yoo<sup>1</sup>, Isnaeni Isnaeni<sup>1</sup>, Jong Ho Na<sup>2</sup> and Yong Hoon Cho<sup>1</sup>; <sup>1</sup>Department of Physics, Graduate School of Nanoscience & Technology (WCU), KAIST Center for LED Research, and KI for the NanoCentury, KAIST, Daejeon, Korea, Republic of; <sup>2</sup>LED Devison, LED R&D Center, LG Innotek, Paju, Korea, Republic of.

SESSION B10: IR Materials and Devices  
Chair: Eva Monroy  
Wednesday Afternoon, August 28, 2013  
National Harbor 4-5

**2:45 PM \*B10.01**

**III-Nitride Photonic Cavities** Nicolas Grandjean, Institute of Condensed Matter Physics (ICMP), Ecole Polytechnique Federale de Lausanne (EPFL), Lausanne, Switzerland.

**3:15 PM B10.02**

**Short Period Polar and Non-Polar InN/nGaN Superlattices** Izabela Gorczyca<sup>1</sup>, Tadek Suski<sup>1</sup>, Grzegorz Staszczak<sup>1</sup>, Xinqiang Wang<sup>2</sup>, Niels Christensen<sup>3</sup>, Axel Svane<sup>3</sup>, Emmanouil Dimakis<sup>4</sup> and Theodore Moustakas<sup>5</sup>; <sup>1</sup>Institute of High Pressure Physics, Warsaw, Poland; <sup>2</sup>State Key Laboratory of Artificial Microstructure and Mesoscopic Physics, Beijing, China; <sup>3</sup>Department of Physics and Astronomy, University of Aarhus, Aarhus, Denmark; <sup>4</sup>Boston University, Boston, Massachusetts.

**3:30 PM B10.03**

**Structure-Properties Relationships in Nitride Intersubband Materials for Infrared Optoelectronic Devices** Oana Malis<sup>1,2</sup>, C. Edmunds<sup>1</sup>, D. Li<sup>1,2</sup>, L. Tang<sup>1,2</sup>, J. Shao<sup>1,2</sup>, G. Gardner<sup>2,4</sup>, A. Grier<sup>3</sup>, Z. Ikonc<sup>3</sup>, P. Harrison<sup>3</sup> and M. J. Manfra<sup>1,4,5</sup>; <sup>1</sup>Physics Dept., Purdue University, West Lafayette, Indiana; <sup>2</sup>Birck Nanotechnology Center, Purdue University, West Lafayette, Indiana; <sup>3</sup>Institute of Microwaves and Photonics, School of Electronic and Electrical Engineering, University of Leeds, Leeds, United Kingdom; <sup>4</sup>School of Materials Engineering, Purdue University, West Lafayette, Indiana; <sup>5</sup>School of Electrical and Computer Engineering, Purdue University, West Lafayette, Indiana.

**3:45 PM B10.04**

**Direct Measurement of Refractive Index Dispersion due to Intersubband Transitions in GaN/AlN MQW** Elad Gross<sup>1</sup>, Amir Nevet<sup>1</sup>, Asaf Pesach<sup>1</sup>, Eva Monroy<sup>2</sup>, Shmuel E. Schacham<sup>3</sup>, Meir Orenstein<sup>1</sup>, Mordechai Segev<sup>4</sup> and Gad Bahir<sup>1</sup>; <sup>1</sup>Electrical Engineering, Technion, Haifa, Israel; <sup>2</sup>Equipe Mixte Nanophysique et Semiconducteurs, CEA-CNRS, Grenoble, France; <sup>3</sup>Electrical Engineering, Ariel University, Ariel, Israel; <sup>4</sup>Physics and Solid State Inst., Technion, Haifa, Israel.

**4:00 PM B10.05**

**Photoreflectance Study of the Temperature Dependence of Excitonic Transitions in Dilute GaAsN Alloys** Wataru Okubo<sup>1</sup>, Shuhei Yagi<sup>1</sup>, Yasuto Hijikata<sup>1</sup>, Kentaro Onabe<sup>2</sup> and Hiroyuki Yaguchi<sup>1</sup>; <sup>1</sup>Graduate School of Science and Engineering, Saitama University, Saitama, Japan; <sup>2</sup>Department of Advanced Materials Science, The University of Tokyo, Kashiwa, Japan.

**4:15 PM B10.06**

**Optical Properties of Nonpolar III-Nitrides for Intersubband Photodetectors** Daniel Feezell, Yagya Sharma and Sanjay Krishna; University of New Mexico, Albuquerque, New Mexico.

SESSION B11: Characterization of Nitrides  
Chair: Fernando Ponce  
Thursday Morning, August 29, 2013  
National Harbor 4-5

**8:30 AM B11.01**

**Direct Mapping of Strain and Charge Reorganization in a Strained InGaN/GaN with Nonpolar Orientation Using Inline Electron Holography** Ja-kyung Lee, Kyung Song, Woo Young Jung, Jong Kyu Kim, Chan Gyung Park and Sang Ho Oh; POSTECH, Pohang, Korea, Republic of.

**8:45 AM B11.02**

**Nanoscale Imaging of Strain, Composition, Polymorphism and Carrier Distribution of InN Segregation Inside a Single InGaN/GaN Quantum Well Vertical Nanorod** Emanuele Poliani<sup>1</sup>, Markus R. Wagner<sup>1,2</sup>, Sebastian J. Reparaz<sup>1,2</sup>, Martin Mandl<sup>3</sup>, Martin Strassburg<sup>3</sup>, Xiang Kong<sup>4</sup>, Achim Trampert<sup>4</sup>, Clivia M. Sotomayor Torres<sup>2</sup>, Axel Hoffmann<sup>1</sup> and Janina Maultzsch<sup>1</sup>; <sup>1</sup>Institut für Festkörperphysik, Technische Universität Berlin, Berlin, Germany; <sup>2</sup>Catalan Institute of Nanotechnology, Bellaterra, Spain; <sup>3</sup>OSRAM Opto Semiconductors GmbH, Regensburg, Germany; <sup>4</sup>Paul Drude Institute, Berlin, Germany.

**9:00 AM B11.03**

**A Combined  $\mu$ -Cathodoluminescence and  $\mu$ -Photoluminescence Investigation of the Degradation of InGaN/GaN Laser Diodes** Matteo Meneghini<sup>1</sup>, Simone Carraro<sup>1</sup>, Simone Vaccari<sup>1</sup>, Nicola Trivellin<sup>1</sup>, Gaudenzio Meneghesso<sup>1</sup>,

Giovanna Mura<sup>2</sup>, Francesca Rossi<sup>3</sup>, Giancarlo Salviati<sup>3</sup>, Katarzyna Holc<sup>4</sup>, Thomas Weig<sup>4</sup>, Lukas Schade<sup>5</sup>, Meena Anu Karunakara<sup>5</sup>, Ulrich T. Schwarz<sup>4,5</sup> and Enrico Zanoni<sup>1</sup>; <sup>1</sup>Department of Information Engineering, University of Padova, Padova, Italy; <sup>2</sup>University of Cagliari, Cagliari, Italy; <sup>3</sup>IMEM-National Council of Research, Parma, Italy, Parma, Italy; <sup>4</sup>Fraunhofer Institute for Applied Solid State Physics IAF, Freiburg, Germany; <sup>5</sup>IMTEK, Freiburg University, Freiburg, Germany.

**9:15 AM B11.04**

**Microscopic Description of the Impact of Alloy Fluctuations on Electronic and Optical properties of c-plane InGaN/GaN QWs** Stefan Schulz<sup>1</sup>, Miguel A. Caro<sup>1,2</sup> and Eoin P. O'Reilly<sup>1,2</sup>; <sup>1</sup>Photonics Theory Group, Tyndall National Institute, Cork, Ireland; <sup>2</sup>Department of Physics, University College Cork, Cork, Ireland.

**9:30 AM B11.05**

**Revisiting the "In-clustering" Question in InGaN by Using Cs-STEM and Low-Loss EELS below the Knock-On Threshold** Kamal H. Baloch<sup>1</sup>, Aaron Johnston-Peck<sup>2</sup>, Kim Kisslinger<sup>2</sup>, Eric Stach<sup>2</sup> and Silvija Gradecak<sup>3,1</sup>; <sup>1</sup>Center for Excitronics, MIT, Cambridge, Massachusetts; <sup>2</sup>Center for Functional Nanomaterials, Brookhaven National Laboratory, Upton, New York; <sup>3</sup>Materials Science and Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts.

**9:45 AM B11.06**

**Gallium Nitride Wire Heterostructures Studied with Synchrotron Radiation** Joel Eymery<sup>1</sup>, Damien Salomon<sup>1,2</sup>, Christophe Durand<sup>1</sup>, Francois Rieutord<sup>1</sup>, Odile Robach<sup>1</sup>, Jean-Sebastien Micha<sup>3</sup>, Manfred Burghammer<sup>4</sup>, Emanuela Di Cola<sup>4</sup>, Michael Reynolds<sup>4</sup>, Marie-Ingrid Richard<sup>5</sup>, Stepane Labat<sup>5</sup>, Olivier Thomas<sup>5</sup> and Vincent Favre-Nicolin<sup>1,6</sup>; <sup>1</sup>INAC, SP2M, CEA, Grenoble, France; <sup>2</sup>Leti, Minatec campus, CEA, Grenoble, France; <sup>3</sup>SPrAM, UMR CEA-CNRS-UJF, Grenoble, France; <sup>4</sup>ESRF, Grenoble, France; <sup>5</sup>IN2MP, UMR 7334 CNRS, Marseille, France; <sup>6</sup>Institut Universitaire de France, Grenoble, France.

**10:00 AM BREAK**

SESSION B12: Optical Properties of Nitrides  
Chair: Martin Kuball  
Thursday Morning, August 29, 2013  
National Harbor 4-5

**10:30 AM B12.01**

**Time-Resolved Electroabsorption Measurement of Carrier Velocity in Inverted Polarity, In<sub>1-x</sub>Ga<sub>x</sub>N/GaN Heterostructures due to Internal Electric Fields** Blair C. Connelly, Chad S. Gallinat, Nathaniel T. Woodward, Ryan W. Enck, Grace D. Metcalfe, Randy Tompkins, Shuai Zhou, Kenneth M. Jones, Hongen Shen and Michael Wraback; US Army Research Laboratory, Adelphi, Maryland.

**10:45 AM B12.02**

**Towards Optical Characterization of Individual Acceptor Centers in GaN** M. S. Mohajerani<sup>1</sup>, M. A. Reshchikov<sup>2</sup>, O. Volciuc<sup>3</sup>, T. Voss<sup>3</sup>, J. Gutowski<sup>3</sup>, X. Wang<sup>1</sup>, A. Bakin<sup>1</sup>, S. Peters<sup>4</sup>, H. Hofer<sup>4</sup>, S. Kueck<sup>4</sup> and A. Waag<sup>1</sup>; <sup>1</sup>Institute of Semiconductor Technology, Braunschweig University of Technology, Braunschweig, Germany; <sup>2</sup>Physics Department, Virginia Commonwealth University, Richmond, Virginia; <sup>3</sup>Institute of Solid State Physics, Semiconductor Optics Group, Bremen University, Bremen, Germany; <sup>4</sup>Physikalisch Technische Bundesanstalt, Braunschweig, Germany.

**11:00 AM B12.03**

**Does Temperature-Induced "S-Shaped" Photoluminescence Peak Shift Directly Indicate Potential Tail?** Takuya Ozaki, Junichi Nishinaka, Mitsuru Funato and Yoichi Kawakami; Electronic Science and Engineering, Kyoto University, Kyoto, Japan.

**11:15 AM B12.04**

**Low Field Magneto-Optical Kerr Effect Study of Excitons in Polar and Non-Polar GaN Films** Ashish Arora, Sandip Ghosh, Nirupam Hatui and Arnab Bhattacharya; Department of Condensed Matter Physics and Materials Science, Tata Institute of Fundamental Research, Mumbai, Maharashtra, India.

**11:30 AM B12.05**

**Anomalous Terahertz Emission in c-plane InN due to In-plane Electric Fields** Nathaniel T. Woodward<sup>1</sup>, Chad Gallinat<sup>1</sup>, Grace D. Metcalfe<sup>1</sup>, Hongen Shen<sup>1</sup>, Michael Wraback<sup>1</sup> and James S. Speck<sup>2</sup>; <sup>1</sup>RDRL-SEE-M, U.S. Army Research Laboratory, Adelphi, Maryland; <sup>2</sup>Materials Department, University of California at Santa Barbara, Santa Barbara, California.

**11:45 AM B12.06**

**Effects of Carrier Transport and Local Lattice Temperature on Nonradiative Recombination processes in InN Films**  
Daichi Imai<sup>1</sup>, Yoshihiro Ishitani<sup>1</sup>, Xinqiang Wang<sup>3</sup>, Kazuhide Kusakabe<sup>2</sup> and Akihiko Yoshikawa<sup>2</sup>; <sup>1</sup>Graduate School of Electronic and Engineering, Chiba Univ., Chiba, Japan; <sup>2</sup>Center for Smart Green Innovation, Chiba Univ., Chiba, Japan; <sup>3</sup>School of Physics, Peking Univ., Beijing, China.

SESSION B13: Optical Properties of Quantum Wells  
Chair: Motoaki Iwaya  
Friday Morning, August 30, 2013  
National Harbor 4-5

**8:30 AM B13.01**

**Radiative and Nonradiative Recombination in GaInN/GaN Quantum Wells at Low and High Carrier Density - Implications for the Validity of ABC Models** Torsten Langer<sup>1</sup>, Alexej Chernikov<sup>2</sup>, Dimitri Kalincev<sup>2</sup>, Marina Gerhard<sup>2</sup>, Uwe Rossow<sup>1</sup>, Martin Koch<sup>2</sup> and Andreas Hangleiter<sup>1</sup>; <sup>1</sup>Institute of Applied Physics, Technische Universität Braunschweig, Braunschweig, Germany; <sup>2</sup>Experimentelle Halbleiterphysik, Philips-Universität Marburg, Marburg, Germany.

**8:45 AM B13.02**

**Efficient Optically Pumped Green Light-Emitting Devices Using GaInN/GaN Multiple Quantum Wells** Michael Binder<sup>1,3</sup>, Dario Schiavon<sup>1,2</sup>, Andreas Loeffler<sup>1</sup>, Thomas Lehnhardt<sup>1</sup> and Matthias Peter<sup>1</sup>; <sup>1</sup>OSRAM Opto Semiconductors GmbH, Regensburg, Germany; <sup>2</sup>Institut für Optoelektronik, Universität Ulm, Ulm, Germany; <sup>3</sup>Fraunhofer-Institut für Angewandte Festkörperphysik, Freiburg, Germany.

**9:00 AM B13.03**

**Offset in Emission Energy between Optical Polarization Switching and Valence Band Anti-Crossing in Semipolar InGaN Quantum Wells** Lukas Schade<sup>1,2</sup> and Ulrich T. Schwarz<sup>1,2</sup>; <sup>1</sup>Optoelectronics, IMTEK, University Freiburg, Freiburg, Germany; <sup>2</sup>Optoelectronic Modules, Fraunhofer Institute for Applied Physics, Freiburg, Germany.

**9:15 AM B13.04**

**Radiative and Non-Radiative Decay Rates in Green-Emitting InGaN/GaN Quantum Well Structures** Felix Nippert<sup>1</sup>, Anna Nirschl<sup>2</sup>, Ines Pietzonka<sup>2</sup>, Hans-Juergen Lugauer<sup>2</sup>, Thomas Kure<sup>1</sup>, Christian Nienstiel<sup>1</sup>, Gordon Callen<sup>1</sup>, Max Buegler<sup>1</sup>, Martin Strassburg<sup>2</sup> and Axel Hoffmann<sup>1</sup>; <sup>1</sup>Institut für Festkörperphysik, Technische Universität Berlin, Berlin, Germany; <sup>2</sup>OSRAM Opto Semiconductors GmbH, Regensburg, Germany.

**9:30 AM B13.05**

**Optical Properties of Extended and Localized States in m-Plane InGaN Quantum Wells** Saulius Marcinkevicius<sup>1</sup>, Kathryn Kelchner<sup>2</sup>, Shuji Nakamura<sup>2</sup>, Steven DenBaars<sup>2</sup> and James Speck<sup>2</sup>; <sup>1</sup>Materials and Nano Physics, KTH Royal Institute of Technology, Kista, Sweden; <sup>2</sup>Materials Department, University of California at Santa Barbara, Santa Barbara, California.

**9:45 AM B13.06**

**Properties of High Excitation Density Recombination Dynamics in InGaN/GaN Quantum Well Structures in Relation to Efficiency Droop** Matthew Davies<sup>1</sup>, Tom Badcock<sup>1</sup>, Phil Dawson<sup>1</sup>, Rachel Oliver<sup>2</sup>, Menno Kappers<sup>2</sup> and Colin Humphreys<sup>2</sup>; <sup>1</sup>Physics & Astronomy, University of Manchester, Manchester, United Kingdom; <sup>2</sup>Materials Science and Metallurgy, University of Cambridge, Cambridge, United Kingdom.

**10:00 AM B13.07**

**Light Emission Polarization Properties of (1-101) InGaN/GaN Stripe MQWs with Cavity Structure on Patterned Si Substrate** Maki Kushimoto<sup>1</sup>, Tomoyuki Tanikawa<sup>1</sup>, Yoshio Honda<sup>1</sup>, Masahito Yamaguchi<sup>1,2</sup> and Hiroshi Amano<sup>1,2</sup>; <sup>1</sup>Graduate School of Engineering, Nagoya University, Aichi-ken, Japan; <sup>2</sup>Akasaki Research Center, Nagoya University, Aichi-ken, Japan.

10:15 AM BREAK

**8:30 AM B14.01**

**Single Photon Emission from Site-Controlled InGaN Quantum Dots up to 90 K** Lei Zhang<sup>1</sup>, Chu-Hsiang Teng<sup>2</sup>, Tyler Hill<sup>1</sup>, Brandon Demory<sup>2</sup>, Pei-Cheng Ku<sup>2</sup> and Hui Deng<sup>1</sup>; <sup>1</sup>Department of Physics, University of Michigan, Ann Arbor, Michigan; <sup>2</sup>Department of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, Michigan.

**8:45 AM B14.02**

**Non-Polar (11-20) InGaN Quantum Dots with Short Exciton Lifetimes Grown by Metal-Organic Vapour Phase Epitaxy** Robert M. Emery<sup>1</sup>, Tontong Zhu<sup>1</sup>, Fabrice Oehler<sup>1</sup>, Benjamin Reid<sup>2</sup>, Robert A. Taylor<sup>2</sup>, Menno J. Kappers<sup>1</sup> and Rachel A. Oliver<sup>1</sup>; <sup>1</sup>Materials Science and Metallurgy, University of Cambridge, Cambridge, United Kingdom; <sup>2</sup>Physics, University of Oxford, Oxford, United Kingdom.

**9:00 AM B14.03**

**Non-Classical Light Generation from InGaN Single Quantum Dots Embedded in Vertical Nanostructures with a Pyramidal Tip** Je-Hyung Kim, Young-Ho Ko, Su-Hyun Gong, Suk-Min Ko and Yong-Hoon Cho; KAIST, Daejeon-si, Korea, Republic of.

**9:15 AM B14.04**

**High Temperature Stability in Non-polar (11-20) InGaN Quantum Dots: Exciton and Biexciton Dynamics** Benjamin P. Reid<sup>1</sup>, Tongtong Zhu<sup>2</sup>, Christopher C. Chan<sup>1</sup>, Claudius Kocher<sup>1</sup>, Fabrice Oehler<sup>2</sup>, Robert Emery<sup>2</sup>, Menno J. Kappers<sup>2</sup>, Rachel A. Oliver<sup>2</sup> and Robert A. Taylor<sup>1</sup>; <sup>1</sup>Physics, University of Oxford, Oxford, United Kingdom; <sup>2</sup>Materials Science and Metallurgy, University of Cambridge, Cambridge, United Kingdom.

**9:30 AM B14.05**

**Site-Selective Single Photon Emission from InGaN/GaN Tapered Structure Coupled to Surface Plasmonic Modes** Su-Hyun Gong<sup>1</sup>, Je-Hyung Kim<sup>1</sup>, Young-Ho Ko<sup>1</sup>, Christophe Rodriguez<sup>1</sup>, Jonghwa Shin<sup>2</sup> and Yong-Hoon Cho<sup>1</sup>; <sup>1</sup>Department of Physics, KAIST, Daejeon, Korea, Republic of; <sup>2</sup>Department of Materials Science and Engineering, KAIST, Daejeon, Korea, Republic of.

**9:45 AM B14.06**

**Engineering InGaN Quantum Dots for Ultra-Large (>2500) Purcell's Factor and Enhanced Radiative Efficiency** Brandon Demory<sup>1</sup>, Tyler Hill<sup>2</sup>, Chu-Hsiang Teng<sup>1</sup>, Lei Zhang<sup>2</sup>, Hui Deng<sup>2</sup> and Pei-Cheng Ku<sup>1</sup>; <sup>1</sup>Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, Michigan; <sup>2</sup>Department of Physics, University of Michigan, Ann Arbor, Michigan.

**10:00 AM B14.07**

**Highly-efficient Optical Saturable Absorbers at 1.55  $\mu\text{m}$  Based on GaN/AlN QW and QD Waveguides** Laura Monteagudo-Lerma<sup>1</sup>, S. Valdeza-Felip<sup>2</sup>, A. Nunez-Cascajero<sup>1</sup>, F. Naranjo<sup>1</sup>, P. Corredera<sup>3</sup>, L. Rapenne<sup>4</sup>, G. Strasser<sup>5</sup>, E. Monroy<sup>2</sup> and M. Gonzalez-Herracz<sup>1</sup>; <sup>1</sup>University of Alcalá, Alcalá de Henares, Madrid, Spain; <sup>2</sup>CEA-Grenoble, INAC/SP2M/NPSC, Grenoble, France; <sup>3</sup>Instituto de Óptica, CSIC, Madrid, Madrid, Spain; <sup>4</sup>INP-Grenoble/Minatoc, Grenoble, France; <sup>5</sup>Zentrum für Mikro- und Nanostrukt., Vienna, Austria.

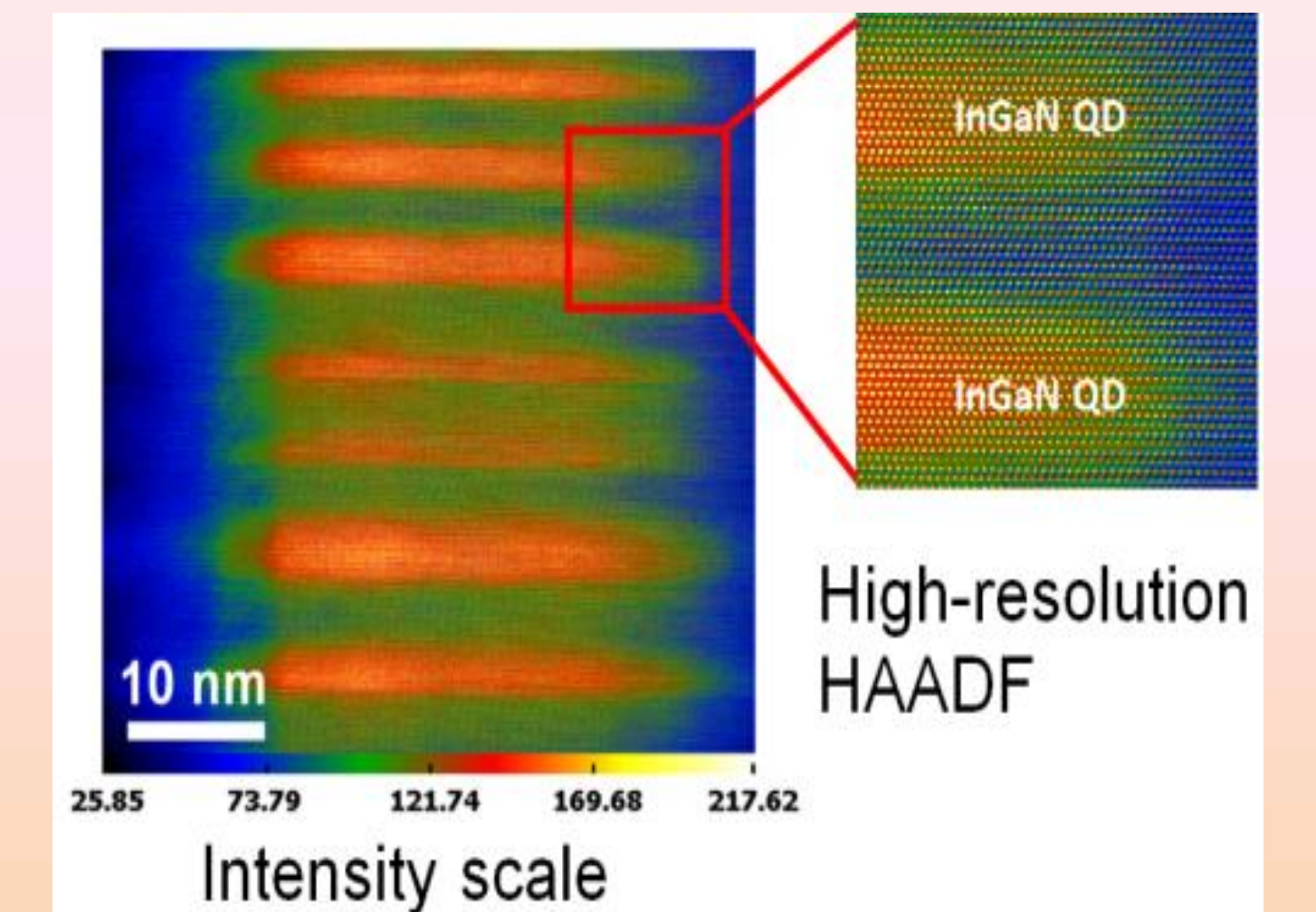
10:15 AM BREAK

# Current-Voltage Characteristics of Single InGaN/GaN Nanowire LEDs

Binh Huy Le, Shamsul Arafin, Nhung Hong Tran, Hieu Pham Trung Nguyen, Songrui Zhao and Zetian Mi\*  
Department of Electrical and Computer Engineering, McGill University

## Introduction

Recently, III-nitride nanowire LEDs have been intensively studied. They promise significantly improved performance, due to the drastically reduced dislocation densities and polarization fields. To date, however, their practical applications have been limited by the low electrical efficiency and quantum efficiency. We have recently developed phosphor-free InGaN/GaN dot-in-a-wire white LEDs on Si substrate that can exhibit relatively high internal quantum efficiency and reduced efficiency droop. In this work, we have further examined the current-voltage (I-V) characteristics of single nanowire LEDs. It is observed that the photocurrent can be significantly enhanced when the active region is excited using a 405 nm laser. Detailed analysis suggest that the electrical performance of nanowire LEDs is severely limited by the surface band bending and the resulting carrier depletion in the active region. This study also shows that the carrier injection efficiency of nanowire LEDs is compromised by the carrier spillover and the resulting surface recombination.



InGaN/GaN dot-in-a-wire heterostructure

## Nanowire LED Growth and Fabrication

❖ InN nanowires

❖ InGaN/GaN dot-in-a-wires

❖ Single InGaN/GaN dot-in-a-wire LEDs are fabricated using e-beam lithography process and Ni/Au metalization.

❖ Absence of surface electron accumulation

❖ Tunable Emission

❖ III-nitride nanowire (NW) heterostructures are grown directly on Si substrate by plasma-assisted molecular beam epitaxy under nitrogen rich conditions.

❖ Single InGaN/GaN dot-in-a-wire LEDs are fabricated using e-beam lithography process and Ni/Au metalization.

## Conclusion

❖ The current-voltage characteristics and ultimately the electrical efficiency of nanowire LEDs is severely limited by the band bending and surface depletion of the device active region.  
❖ Carrier spillover from the device active region and the resulting surface recombination may lead to very low carrier injection efficiency of nanowire LEDs.  
❖ This study provides a unique approach for examining the carrier leakage process in nanowire devices and for probing the effect of surface electronic properties on the performance of nanowire LEDs.

**References:**  
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 [2] Nguyen P T H, Cui K, Zhang S, Djavid M, Korinek A, Botton G A and Mi Z 2012 *Nano Lett.* 12(3):1317-23.  
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 [4] Zhao S, Mi Z, Kibria M, Li Q and Wang G T 2012 *Phys. Rev. B* 85(24):245313.  
 [5] Ahn B-J, Kim T-S, Dong Y, Hong M-T, Song J-H, et al. 2012 *Appl. Phys. Lett.* 100(3):031905.  
 [6] Calarco R, Marso M, Richter T, Aykanat A I, Meijers R, Hart A, et al. 2005 *Nano Lett.* 5(5):981.  
 [7] Chen H Y, Chen R S, Chang F C, Chen L C, Chen K H, Yang Y J. 2009 *Appl. Phys. Lett.* 95(14):143123.  
 [8] Sanford N, Blanchard P, Bertness K, Mansfield L, Schlager J, Sanders A, et al. 2010 *J. Appl. Phys.* 107(3):034318.

## Optical and Electrical Properties

❖ Large area InGaN/GaN dot-in-a-wire LEDs can exhibit relatively high internal quantum efficiency and reduced efficiency droop. However, the electrical efficiency is limited by the high turn-on voltage and large resistance.

❖ Temperature-dependent normalized PL spectra of single NW device with peak emission wavelengths of ~ 510 nm.

❖ Intrinsic I-V characteristics of single nanowire LEDs, with turn-on voltage ~ 3.5 V and series resistance ~ 1.2 GΩ.  
 ❖ Inset: Photocurrent under dark and illumination conditions.

❖ (a) Semilog plot of the enhancement factor  $\Gamma = I_{ph}/I_{dark}$  measured at 300 K under 8 V bias under various excitation power levels.  
 ❖ (b) Photoresponsivity as a function of bias voltage. The device exhibits a photoresponsivity up to 50 A.W<sup>-1</sup> for a power of ~ 6 nW.

