Logo

第六届宽禁带半导体材料与器件国际论坛
6TH INTERNATIONAL WORKSHOP ON WIDE BANDGAP SEMICONDUCTOR MATERIALS AND DEVICES

会议手册
CONFERENCE MANUAL

2018 年 10 月 28-31 日 中国，平潭

October 28-31, 2018 Pingtan, China

目录 CONTENTS

会议名称：第六届宽禁带半导体材料与器件国际论坛

Conference：6th International Workshop on Wide Bandgap Semiconductor Materials and Devices

时间：2018 年 10 月 28-31 日

Time：October 28-31, 2018

地点：中国，平潭

Venue：Pingtan, China

指导单位：中国科学院半导体研究所

Guide Units：Institute of Semiconductors, CAS

主办单位:中国科学院半导体研究所-平潭综合实验区管理委员会半导体技术联合研究中心

Sponsor：Institute of Semiconductors, CAS- Administrative Committee of Pingtan Comprehensive Pilot Zone Joint R&D Center of Semiconductors, Ping Tan-IOS

协办单位：宗仁科技（平潭）有限公司

Co-organizers：CR Technology (Pingtan) Co., Ltd.

会议日程 Conference Agenda

第六届国际宽禁带半导体材料器件论坛 6th International Workshop on Wide Bandgap Semiconductor Materials and Devices	
时间：2018 年 10 月 28 日至 10 月 31 日 地点：平潭综合实验区麒麟荣誉酒店海西厅 Time: Oct 28-31,2018 Venue: Qilin Rongyu International Hotel(HAIXI HALL), Pingtan	
10 月 28 日/Oct 28	
13:30-18:00	第六届国际宽禁带半导体材料器件论坛注册签到 6th International Workshop on Wide Bandgap Semiconductor Materials and Devices registration sign-in
10 月 29 日/Oct 29	
09:00-10:00	中国科学院半导体研究所-平潭综合实验区管理委员会半导体技术联合研究中心揭牌仪式
10:00-10:30	**茶歇/Coffee Break**
10:30-10:40	第六届国际宽禁带半导体材料器件论坛欢迎辞 Welcome address of 6th International 6th International Workshop on Wide Bandgap Semiconductor Materials and Devices
主持人 Moderator	**伊晓燕/Xiaoyan YI** 中国科学院半导体研究所研究员/ Professor of Institute of Semiconductors, CAS
10:40-11:05	**荧光 SiC 与近紫外 LED 相结合的新型白光光源** **A new type of white LED light source by bonding fluorescent SiC and a near-UV LED** 欧海燕　丹麦科技大学光子学系教授 Haiyan OU　Professor of Department of Photonics Engineering, Technical University of Denmark
11:05-11:30	**GaN 基 VCSEL 与 microled 的进展与展望** **Progress and Prospects of GaN-based VCSEL and microled** 沈志强　台湾交通大学光电工程研究所研究员 Zhiqiang SHEN　Professor of National Chiao Tung University,Taiwan
11:30-13:00	**午餐/Lunch**
主持人 Moderator	**欧海燕/Haiyan OU** 丹麦科技大学光子学系教授/Professor of Department of Photonics Engineering, Technical University of Denmark

13:30-13:55	**超纯 Si** **Ultrapure Silicon** Leif JENSEN　高级工商管理硕士，全球晶元有限公司高级硅科学家 Leif JENSEN　MMT, eMBA ,Senior Silicon Scientist Topsil GlobalWafers A/S
13:55-14:20	**二维材料上氮化物的生长** **Floating-Epitaxy Growth of Nitrides on Two-Dimensional layers** 刘志强　中国科学院半导体研究所研究员 Zhiqiang LIU　Professor of Institute of Semiconductors, CAS
14:20-14:45	**光学器件中 SiC 吸收机制的研究** **Investigation of the absorption mechanisms of SiC for lighting applications** A.T. TAREKEGNE　丹麦科技大学光子学系博士 A.T. TAREKEGNE　Ph.D. of Department of Photonics Engineering, Technical University of Denmark
14:45-15:10	宗仁科技（平潭）有限公司 CR Technology (PIngtan) Co., Ltd.
15:10-15:30	**茶歇/Coffee Break**
主持人 Moderator	**刘志强/Zhiqiang LIU** 中国科学院半导体研究所研究员/ Professor of Institute of Semiconductors, CAS
15:30-15:55	**RGB MicroLEDs 的进展和关键技术** **Progress in RGB MicroLEDs and Key Technology** 徐宸科　三安光电 CTO Dr.Chen-K Hsu　CTO of San’an Optoelectronics Corporation
15:55-16:20	**基于宽禁带电介质材料超表面的紫外超透镜和分光器** **Ultraviolet Metalens and Routers Based on Wide-bandgap dielectric Metasurface** 汪炼成　中南大学机电工程学院教授 Liancheng WANG　Professor of College of Mechanical and Electrical Engineering, Central South University
16:20-16:45	**长波段 InGaN 基 LED 研究进展** **Progress of InGaN Based LED in Long Wavelength Range** 张建立　南昌大学副教授 Jianli ZHANG　Associate professor of Nanchang University
16:45-17:10	**石墨烯透明电极在 GaN 光电器件中的应用** **CVD graphene as transparent electrode in GaN optoelectronic devices** 孙捷　查尔姆斯理工大学微技术和纳米科学系量子器件物理实验室 Jie SUN　Quantum Device Physics Laboratory, Department of Microtechnology and Nanoscience, Chalmers University of Technology
17:30-19:30	**晚宴/Banquet**

10 月 30 日/Oct 30	
主持人 Moderator	**Mikael Syväjärvi** 林雪平大学理学院教授/Professor of Department of Physics, Chemistry and Biology Linköping University
09:00-09:25	**通过横向外延在图形化种子层上生长 SiC 以降低其缺陷密度** **Reducing defect density of SiC on patterned seeds by lateral growth** 胡小波　山东大学晶体材料国家重点实验室教授 Xiaobo HU　Professor of state key laboratory of crystal materials, Shandong university
09:25-09:50	**用于下一代能源器件的宽禁带氧化物半导体** **Wide Bandgap Oxide Semiconductors for Next Generation Energy Devices** 朱斌　中国地质大学(武汉) 加上英国 Bin ZHU　Faculty of Materials Science and Chemistry（Wuhan）, China University of Geosciences，Faculty of Physics and Electronic Science, Hubei University
09:50-10:15	**UVB/ UVC - LEDs 对水中大肠杆菌灭活/活化的影响** **Effects of UVB/UVC-LEDs on inactivation/reactivation of E. coli in water disinfection** 张保平　厦门大学教授 Baoping ZHANG　Professor of Xiamen Univerisity
10:15-10:35	**茶歇/Coffee Break**
主持人 Moderator	**汪炼成/Liancheng WANG** 中南大学机电工程学院教授/Professor of College of Mechanical and Electrical Engineering, Central South University
10:35-11:00	**碳化硅材料在新领域中的应用** **New application areas of silicon carbide** Mikael Syväjärvi　林雪平大学理学院 Mikael Syväjärvi　Department of Physics, Chemistry and Biology Linköping University
11:00-11:25	**碳化硅在固体氧化物和无电解质层燃料电池中的应用** **Silicon Carbide Application in Solid Oxide & Electrolyte-layer Free Fuel Cells** Muhammad AFZAL　瑞典皇家理工学院 Muhammad AFZAL　Department of Energy Technology, Fuel Cell & Solar Cell Group, KTH Royal Institute of Technology
11:25-11:50	
12:00-13:00	**午餐/Lunch**
14:00-15:30	中国-丹麦国际合作项目交流会

	China - Denmark international cooperation project exchange meeting
15:30-16:30	平潭展厅参观 Visiting the Pingtan experimental area
16:30-17:00	闭幕 Closing ceremony
10 月 31 日/Oct 31	
全天	第六届国际宽禁带半导体材料器件论坛及闭幕活动，参观中国国内半导体企业 The 6th international wide band gap semiconductor material device workshop and closing ceremony to visit China's domestic semiconductor enterprises

会议大会特邀报告人及报告简介

Invited Speakers and Reports

Haiyan Ou（Professor of Department of Photonics Engineering, Technical University of Denmark）

Haiyan Ou received the MSc from Huazhong University of Science and Technology in 1997 and PhD degree in semiconductor devices and microelectronics from the Institute of Semiconductors, Chinese Academy of Sciences in 2000. From 2000, she joined Technical University of Denmark, where she was promoted as associate professor in 2005. She has been a JSPS (Japanese Society for Promotion of Science) fellow at Meijo Univeristy (Japan), and a visiting professor at the Institute of Semiconductors, Chinese Academy of Sciences (China). Her scientific background is in the areas of materials and devices for optical communication, photovoltaics, and light emitting. She has published more than 212 peer-reviewed journal and conference papers, and is the founder of Light Extraction ApS.

Li Lin（PhD of Department of Photonics Engineering from Technical University of Denmark）

Li Lin received the Bachelor of Science in Department of Optical Communication Science and Technology from Shandong Jianzhu University in 2012 and MSc in Department of Photonics Engineering from Technical University of Denmark in 2015 and MSc in Department of Physics and Technology from Yunnan University in 2015 and currently has her PhD Study in Department of Photonics Engineering from Technical University of Denmark since 2015. Her scientific focus is in the areas of light-emitting diode device fabrication, aluminum-doped zinc oxide as current spreading layers on gallium nitride-based nearultraviolet light-emitting diodes and adhesive bonding of HSQ in SiC-related LED applications.

A new type of white LED light source by bonding fluorescent SiC and a near-UV LED

Haiyan Ou, Li Lin

Department of Photonics Engineering, Technical University of Denmark, Ørsteds Plads 345A, Kongens Lyngby DK-2800, Denmark

Abstract

Fluorescent silicon carbide (f-SiC) has advantages over phosphors in terms of abundancy, long lifespan, good thermal conductivity and high color rendering index [1, 2]. In this paper, we demonstrate a prototype of fluorescent SiC hybridly integrated with a near UV LED. The fabrication and characterization of the prototype are introduced and the future perspectives are foreseen.

The bonding process of an NUV LED and a B-N co-doped f-SiC epi-layer is shown in Fig.1. HSQ layers are spun on both the 4H-SiC substrate of the NUV LED and the polished backside of the free-standing f-SiC epi-layer. Afterwards, the NUV LED and the f-SiC epi-layer are placed with the surfaces covered by the HSQ layers in contact. During bonding at 400 °C, HSQ is converted into solid SiOx and by doing so the two samples are bonded together.

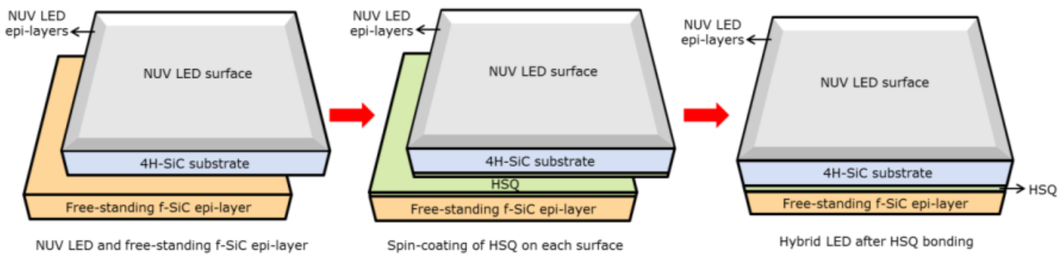


Fig.1 Schematic illustration of the bonding process of a NUV LED to a free-standing B-N co-doped f-SiC epi-layer assisted with HSQ layers spun on both SiC surfaces.

Through injection of an electric current to the hybrid LED, the generated NUV emission excites the B-N co-doped f-SiC epilayer finally presenting a warm white emission, as shown in Fig. 2(a). Fig. 2(b) shows that the NUV LED before bonding presents a peak wavelength around 390 nm and after bonding, the emission of the f-SiC epi-layer can be clearly observed from the hybrid LED showing a peak emission wavelength around 550 nm. According to the results, it can be concluded that, HSQ bonding could be an effective approach in the SiC-related LED applications.

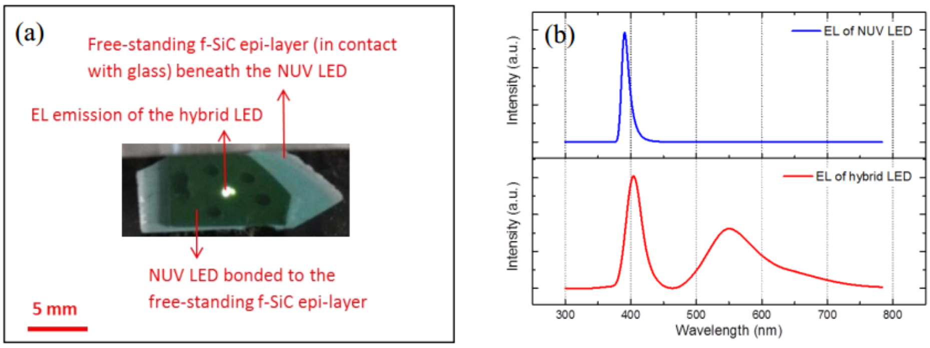


Fig. 2 (a) Photograph of the hybrid lighting LED from backside with electric current injection at 30 mA; (b) The EL spectra of the NUV LED before bonding and the hybrid LED measured from the backside at 30 mA.

Acknowledgments

This work was supported by Innovation Fund Denmark (project No. 4106-00018B).

[1] Ou, H., et al., and Syväjärvi, M., "Advances in wide bandgap SiC for optoelectronics," Eur. Phys. J. B **87**(3), 58 (2014).

[2] Kamiyama, S., et al., and Syväjärvi, M., **"**White light-emitting diode based on fluorescent SiC," Thin Solid Films **522**, 23-25 (2012).

Hao-chung Kuo（Distinguished Professor of National Chiao-Tung University）

Prof. Hao-chung Kuo, IEEE, OSA, SPIE, IET fellow

(BS, National Taiwan University 1990, MS, Rutgers University 1995, Ph.D. UIUC 1998)

Prof. Kuo has been university faculty in National Chaio-Tung University for over 18 years in Taiwan. He has also established the first GaN LED/laser graduate curriculum and taught graduate students. In addition he supervised graduate students on LED/Laser research and most of the graduates had become key LED and Laser professionals in Taiwan and abroad (30 Ph.D., 80 Master students). Since Aug 2007, he has been a Professor in the Department of Photonics and Institute of Electro-Optical Engineering (IEO), National Chiao Tung University, Hsin-Tsu, Taiwan, where he was Chairman and Director, Department of Photonics and IEO (Aug 2009-Feb 2011). Prof. Kuo's service to the photonics community and IEEE is multifaceted. He was elected as the Secretary of IEEE/Photonics Taipei Chapter (2008-2010), the Vice Chair (2010-2012) and the Chair of IEEE/Photonics Taipei Chapter (since 2012). He was in the Technical Program Committee for several major technical conferences for the IEEE, the Optical Society of America (OSA), the SPIE, and the American Physical Society (APS), which include IEEE/OSA Conference on Lasers and Electro-Optics (2009 – Present), SPIE Photonics West (2009 – Present), and others. He serves as a Panel Member for Taiwan National Science Council (Photonic Program- especially in semiconductor lasers and LEDs). He was the Guest Editor of the IEEE JOURNAL OF SELECTED TOPICS IN QUANTUM ELECTRONICS (2009) and has been an **Associate Editor of the OSA/IEEE Journal of lightwave technology since 2008.** He was the recipient of The Optical Engineering Society of Taiwan (SPIE Taipei Chapter) – Young Researcher Award in 2007. National Science Council of Taiwan- Dr. Ta-You Wu Award (Young Investigator Award, top 1% Young Researcher) in 2007. Faculty Research Award of National Chiao-Tung University in 2010, 2011. Micro-optics Conference (MOC) Contribution Award-10th MOC Program committee Chairman (2011). OSA Fellow (2012) IET Fellow (2012) SPIE Fellow (2013)

Progress and Prospects of GaN-based VCSEL and microled

S.C. Shen (Director of SClab, NCTU) H.C. Kuo
Department of Photonics & College of Photonics, National Chiao Tung University, Hsinchu, Taiwan

Abstract

GaN is a great material for making optoelectronic devices in the blue, blue-violet and green. Vertical-cavity surface-emitting lasers (VCSELs) have many advantages such as small footprint, circular symmetry of output beam, two-dimensional scalability and/or addressability, surface-mount packaging, good price-performance ratio, and simple optics/alignment for output coupling. In this paper , we would like to (1) Novel GaN based VCSEL/microled for Novel Display. (2) Nanoring structure for full color microdisplay (3) world first Green VCSEL using QD active region to overcome the green gap;

Corresponding author Hao-chung Kuo hckuo.nctu@gmail.com

Leif Jensen（MMT, eMBA ,Senior Silicon Scientist Topsil GlobalWafers A/S）

Resent work:

Silicon research and development of high minority carrier lifetime silicon solar material and high purity silicon for other types of silicon semiconductors like PIN didoes, CCD camera and RF low loss substrates for radio communication.

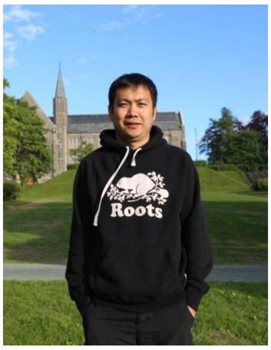
Danish research project SEMPEL (http://www.sempel.aau.dk/about/info/). The overall objective of this project is to create a solid understanding of GaN-on-Si as a new material in power electronics, and to study the new challenges these components introduce in the design of power electronic systems.

Topsil develops silicon products for semiconductor applications. New areas for semiconductors are III-V film growth on silicon surfaces. Also, silicon solar cell material is improved by involvement of EU Horizon 2020 project SiTaSol by developing a tandem solar cell.

Abstract

Topsil Semiconductor Materials A/S has signed an agreement with GlobalWafers Co., Ltd., Taiwan, to sell its silicon business. Topsil is a world leading supplier of ultrapure silicon to the global semiconductor industry. Engaging in long term relations with customers, Topsil focuses on premium quality, an efficient production process and a safe delivery of products.

Silicon is used in electronic components to aid conversion and control of electrical power, high efficiency solar cell and GaN film substrate. Topsil provides ultrapure silicon mainly for the most demanding purposes, based on extensive knowledge and significant investments in new technology, facilities and equipment.



Zhiqiang Liu（Professor of Institute of Semiconductors, CAS）

Zhiqiang Liu, Ph.D., Professor, semiconductor lighting R & D center, Institute of Semiconductors, Chinese Academy of Sciences, focuses on the area of wide bandgap materials growth, material characterization, the first principle calculation and devices fabrication. He has made pioneering contributions in the development of Solid-State Lighting in China and participated in the many national projects of nitrides field about high power LED structure design and key technology research. He received about $4 million research funding. In the recent 5 years, his research has resulted in more than 80 papers and 30 patents.

Floating-Epitaxy Growth of Nitrides on Two-Dimensional layers

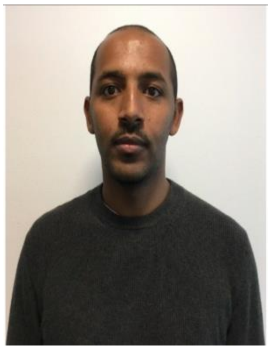
Zhiqiang Liu,[1] Meng Liang,[1,] Yunyu Wang,[1] Fang Ren[1], Yue Yin[1] and Xiaoyan Yi[1]
[1] Research and Development Center for Solid State Lighting, Institute of Semiconductors, Chinese Academy of Sciences, Beijing 100083, China

Abstract

To solve the problem of large lattice and thermal expansion coefficient mismatch between GaN and the hetero-epitaxial substrates, in this work the possibilities of two-dimensional buffers, for instance graphene，WS2 and MoS2 were investigated theoretically and experimentally. We present two-dimensional materials graphene as an atomically thin buffer for nitrides growth. High crystal quality of the nitrides are evidenced through transmission electron microscopy and x-ray diffraction. Furthermore, the possible epitaxial relationships between graphene and the first atomic plane of nitrides Via density functional theory.

Furthermore，we introduce a novel method towards controllable growth of horizontal GaN NWs using HVPE with a Au/Ni thin film as the catalyst. By simply flipping the substrate, horizontal GaN NWs with various growth directions and cross sections have been obtained on sapphire substrate with various facet orientations. Our work opens a new route and sheds light on the horizontal GaN NWs and will advance the development of horizontal NWs based nanoelectronics and nanophotonics device and system.

Key words: GaN, nanowire, graphene, MOCVD



Abebe Tilahun Tarekegne（Ph.D. of Department of Photonics Engineering, Technical University of Denmark）
Academic history:
PhD at Department of photonics engineering, DTU, Denmark
MSc at Karlsruhe Institute of Technology, Germany
BSc at Mekelle University, Ethiopia

Investigation of the absorption mechanisms of SiC for lighting applications

A.T. Tarekegne and H. Ou
Department of Photonics Engineering, Technical University of Denmark, 2800 Kgs. Lyngby, Denmark

E-Silicon carbide (SiC) was a pioneer optoelectronic material from which the first luminescence was observed [1]. Yet, its optoelectronic properties remain to get little attention. It is a wide bandgap material where its bandgap depends on the specific stacking arrangement of carbon and silicon bilayers. As a wide gap semiconductor material, its bandgap is suitable for white light generation by introducing artificial energy states within the bandgap. Its exceptional material properties, such as excellent thermal conductivity, high radiation resistance, high breakdown voltage, are suitable for high power white light generation [2]. Fluorescent silicon carbide (fSiC) has proven to be a promising candidate with demonstrated capability to produce excellent color quality [35]. Donor-acceptor pair (DAP) recombination of N and B co-doped silicon carbide emits a broadband yellow light. Blue light emission can be achieved from either porous structures or from DAP recombination involving N donor and Al acceptor. In the development of white light devices from SiC by conversion of NUV excitation, full understanding of the absorption parameters are crucial to engineer white light devices. Here we measured the absorption coefficients of 4H and 6H SiC polytypes over broad spectral ranges (see Fig. 1 a, b). The measurements show strong subband absorption in n-doped SiC samples, including near the band edge. These are caused by light absorption by the free electrons in the conduction band and the bound electrons at donor states [6]. While the sub-bandgap absorption with peak near 626 nm (for 6H SiC) affects the out coupling of the generated light, the near band edge absorption implies possible absorption of the excitation source by free carriers, consequently dissipating the excitation power. In a highly doped 6H SiC sample, excitation by 405 nm laser results in the dissipation of more than half of the excitation power. Similarly excitation of the highly doped 4H SiC by 375 nm causes more than half of the excitation power to be absorbed by free carriers. These experiments predict significant dissipation of excitation power in high injection conditions where high densities of free electrons are generated.

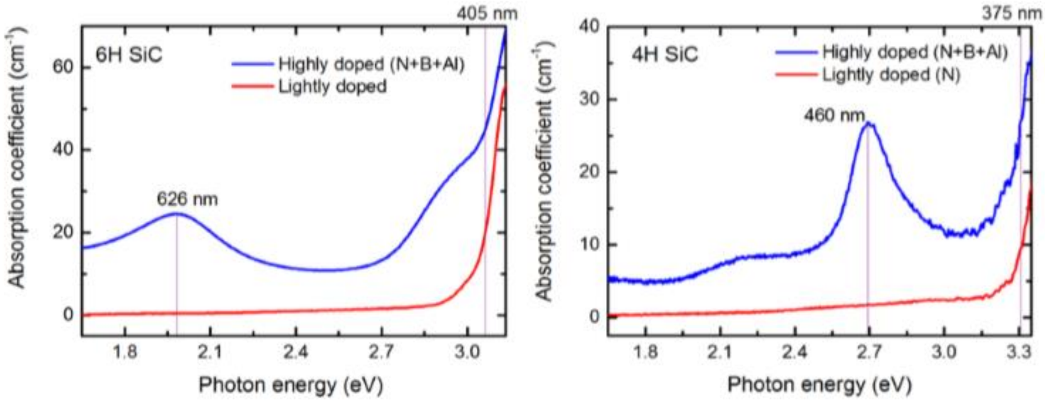


Fig. 1. Measured absorption coefficients of highly doped and lightly doped silicon carbide samples over broad spectral range: (a) 6H and (b) 4H SiC. The heavily doped samples are doped with nitrogen, boron and aluminium.

[1] H. J. Round, “A note on carborundum,” Electr. World, vol. 19, no. 309, 1907.
[2] T. Kimoto and J. A. Cooper, “Fundamentals of Silicon Carbide Technology”, (John Wiley & Sons, Inc., Singapore, 2014).
[3] S. Kamiyama, et al., J. Appl. Phys., 99, 093108(2006).
[4] W. Lu, et al., Sci. Rep., 7, 9798(2017).
[5] H. Ou, et al., Eur. Phys. J. B, 87, 58(2014).
[6] S. Limpijumnong et al., PRB 59, 12890(1999).

Dr.Chen-K Hsu (CTO of San'an Optoelectronics Corporation)

Dr.Chen-K Hsu is CTO of San'an Optoelectronics Corporation, a biggest and high-performance LED epi-wafer and chip manufacturer. He obtained a Ph. D degree in Electro physics from Taiwan Chiao Tung University in 2000. He has engaged in many years of semiconductor lighting LED epitaxy, chip and package technical and R&D management. He is also expert in LED products performance, yield and quality improvement technology. Dr. Hsu has published 19 papers and conference papers of well-known journals. He also has 89authorized patents. Dr.Hsu presided over a lot of projects to improve competitiveness of products. He is focus on new growing LED market in UVB/UVC LED, biometric recognition (Iris,VCESLs), LD and Micro-LED.

Liancheng Wang（Professor of College of Mechanical and Electrical Engineering, Central South University）

Liancheng Wang is now working as Full Professor at the State key Laboratory of High Performance Complex Manufacturing, Central South University in China. He received his PhD in the institute of semiconductors，Chinese Academy of Science in 2013, and has been Postdoctor Fellow in Nanyang Technological University, Singapore (NTU), Singapore University of Technology and Design, Singapore (SUTD), and University of Sheffield, UK. His main research is wide-bandgap and ultrawide-bandgap semiconductor material and optoelectronics device. He has authored over 60 journal publications. He is now the reviewer of Nanoscale and Nano Energy, and directs Professorship Start Up Funding, Project of State Key Laboratory of High Performance Complex Manufacturing, and Innovation-Driven Project of Central South University.

Ultraviolet Metalens and Routers Based on Wide-bandgap dielectric Metasurface

Liancheng Wang*

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Phone: 86-18008497660

Abstract

Ultraviolet (UV) optical devices and equipment have various applications in sterilization, military covert communication, medical treatment, nanofabrication, Gem identification and so on. The traditional constituent UV components are known to be expensive, bulky, inefficient due to high absorption loss of UV light, and easily aging under UV radiation. Here we demonstrate the designs of ultraviolet optical components and devices based on all-dielectric metasurface with wide-bandgap material of Aluminum nitride (AlN): UV meta-reflectors UV metalens, and UV routers. The metasurface is made up of nanodisks for reflection design and nanorods for transmittance design. The designed UV reflectors composed of AlN nanodisks

array on silica substrate have reflectance peaks able to be continuously tuned throughout the UVA, UVB and UVC regions by varying the structural parameters, such as periodicity, height and diameter of the constitute AlN nanodisk, where ED and MD resonances can be tuned to be overlapped by adjusting the radius of the AlN nanodisk. The designed metalenses with fixed numerical aperture (NA) of 0.2 are composed of high-aspect-ratio Aluminum nitride (AlN) nanorod array, with focusing efficiency to be 75.44%, 73.32% and 47.09% at representative UVC (244nm), UVB (308nm) and UVA (375nm) wavelengths, where focusing configurations including in-plane on-axis, off-axis, and out-of-plane have been demonstrated. According to the design of out-of-plane focusing metalens, UV routers for mono-wavelength and multiple wavelengths have been designed further, with the routing efficiency to be 12.4% (244nm), 18.6% (308nm of first quadrant), 18.0% (308nm of third quadrant) and 7.17% (375nm) for the presented Bayer four quadrant optics. Our designed AlN metasurface UV optical components compatible with semiconductor fabrication would promote the miniaturization and high-density integration of UV nanophotonics.

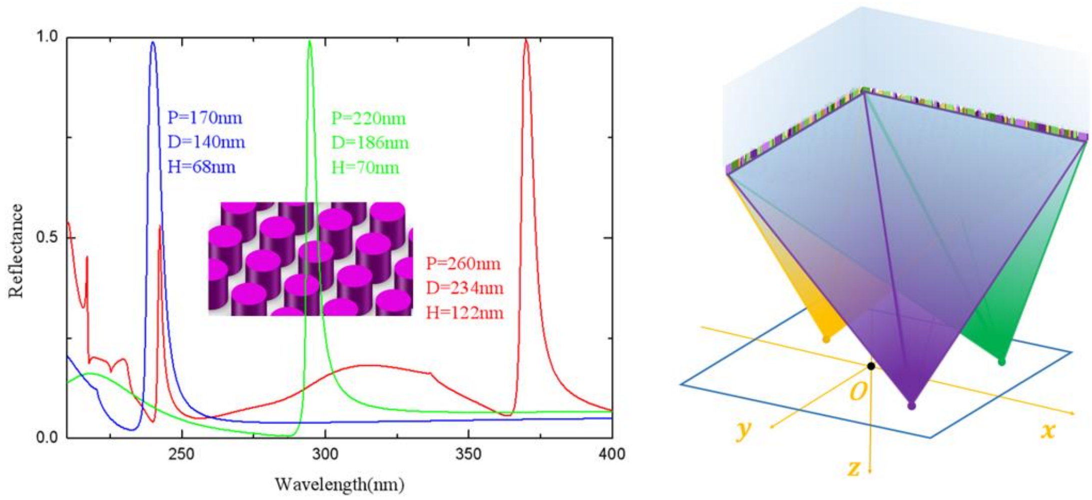

Figure caption: UV reflector with tuned reflection peaks (left) and UV router for guiding diffrent incidences to specific spatial positions (right)

[1] L.H. Guo, L.C. Wang*, "Design of aluminum nitride metalens in the ultraviolet spectrum," J. Nanophoton. 12(4), 043513(2018).

[2] L.H. Guo, L.C. Wang*, "Design of aluminum nitride metalens for broadband ultraviolet incidence routing," Nanophotonics, 2018.

Zhang Jianli（associate professor of Nanchang University, focus on epitaxy of high indium content InGaN）

Zhang Jianli, studied at the Materials Department of the National University of Singapore and anchang University. After graduation, he entered the National Silicon-based LED Engineering Technology Research Center of Nanchang University and worked as a Nanchang University. He is also an associate researcher at the National Silicon-based LED Engineering Technology Research Center. He is also the Deputy Director of Equipment Manufacturing Department of Nanchang Huanglu Lighting Co., Ltd.

Progress of InGaN Based LED in Long Wavelength Range

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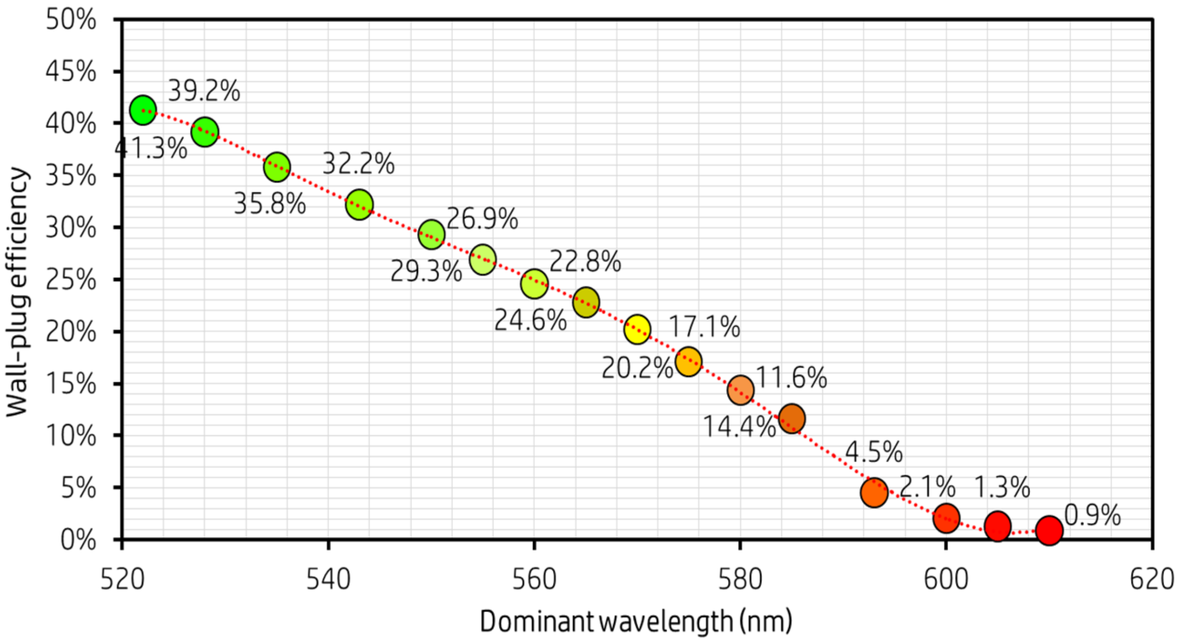
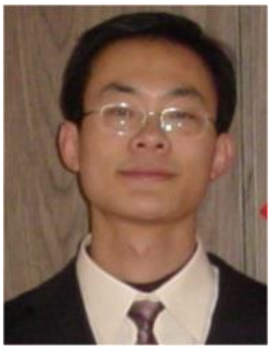
Abstract

The "green gap" of LED has been lasting for a long time, neither InGaN nor AlGaInP system performed well in the green-yellow emission range. After integral optimizations on InGaN LED, a significant progress has been made. 523nm-Green LED with wall-plug efficiency (WPE) up to 41.3% was made. As wavelength increase to 565nm, WPE decreased to 22.8%, but which still made great advancement on yellow LED.





Jie Sun (associate professor in Chalmers U. Technology)

Jie Sun is a senior member of IEEE and an associate professor in Chalmers U. Technology (the only coordinator university of the EU Graphene Flagship) and an adjunct professor in Beijing U. Technology. His current group includes 5 PhD students, 1 research assistant, and 7 master students. He got his PhD degree from Solid State Physics Division, Lund University, Sweden. His major is semiconductor and carbon materials and devices. In particular, he focuses on III-V and Si semiconductors, high-k dielectrics, ballistic and quantum transport, and carbon electronics. Currently, he is responsible for CVD of graphene and its applications in Chalmers and Beijing U. Technology. He has published over 100 papers that are covered by Web of Knowledge. His h-index is 21 with ~1300 citation times. His current research directions include: 1. Catalytic and noncatalytic CVD of graphene on metals, dielectrics and semiconductors; 2. Eco-friendly electrochemical bubbling transfer of graphene (theory and technique); 3. CVD of h-BN, MoS_2 and hybrid electronic devices; 4. Graphene-GaN and graphene-organics optoelectronics; 5. Graphene in THz science; 6. Graphene's bio-applications (e.g. biochips).

CVD graphene as transparent electrode in GaN optoelectronic devices

Jie Sun[1,2]
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[2]Key Laboratory of Optoelectronics Technology, College of Microelectronics, Beijing University of Technology, Beijing 100124, China

Abstract

Graphene is traditionally prepared by exfoliation of graphite, and to fabricate large area single layer graphene is challenging. Chemical vapor deposition (CVD) of graphene on transition metals is recently developed for this purpose. Since 2009, we in Chalmers have grown single layer graphene on metal foils (Cu, Pt, Ta, etc.), or evaporated metallic thin films on silicon substrate.[1-9] The graphene is grown in a cold-wall commercial Aixtron system with CH_4 or C_2H_2 precursors. The graphene can be transferred onto other substrates such as SiO_2/Si by wet chemically etching away the copper catalyst or, more environmentally friendly, by electrochemical bubbling delamination.[10] The carrier mobility for electrons and holes is about 3000 cm^2/(Vs), measured through both the field effect and the Hall effect. Some devices show mobilities ~5000 cm^2/(Vs).

We also grow graphene directly on insulators without metal catalysts in CVD.[1-9] The as-deposited graphene is nanocrystalline, large area and uniform. Despite the lower mobility (40 $cm^2/(Vs)$) compared to catalyzed graphene, its transparency (97%) and conductivity (1-a few kΩ/□ without intentional doping) is similar to standard graphene, making such transfer-free graphene very promising in applications of transparent electronics and molecular electronics. The graphene can be grown on arbitrary dielectrics that withstand high temperature. We have proposed a novel noncatalytic CVD (as opposed to catalytic graphene CVD on metals) mechanism to explain our experimental findings.[3] Both the catalyzed and noncatalyzed graphene can be suspended, which is promising for nanoelectromechanical systems (NEMS).[7,8]

The CVD graphene finds its applications in GaN based optoelectronics. GaN compounds are widely used in light emitting diodes (LEDs) covering the spectrum from yellow to ultraviolet. We first study ordered and dense GaN light emitting nanorods with graphene grown by CVD as suspended transparent electrodes.[11] As the substitute of indium tin oxide (ITO), the graphene avoids complex processing to fill up the gaps between nanorods and subsequent surface flattening and offers high conductivity to improve the carrier injection. The as fabricated devices have 32% improvement in light output power compared to conventional planar GaN-graphene diodes, mainly due to the much more enlarged light emitting areas.[11]

Nevertheless, although the graphene is well conducting and transparent, due to its Fermi level mismatch with the GaN, their electrical contact is not ohmic, leading to an unacceptably high work voltage of the device for real applications. To understand this issue further, CVD graphene is used in (planar) GaN LEDs as transparent electrodes, where 7–10 nm ITO contact layer is inserted between the graphene and p-GaN to enhance hole injection.[12] Devices with forward voltage and transparency comparable to those using traditional 240 nm ITO are achieved with better ultraviolet performances.[12] This result indicates that the large turn-on voltage can be indeed attributed to the poor graphene-GaN contact, which can be solved by the thin ITO interlayer.

However, the ITO interlayer is not a sustainable solution due to the scarcity of indium resources. Therefore, we suggest depositing graphene directly on GaN by CVD. The graphene-GaN interface is produced in high temperature and high vacuum CVD chamber, resulting in improved electrical properties. Furthermore, in situ doping of graphene can be carried out which will tune the Fermi level further to match that of p-GaN. Also, it is a reproducible and scalable technique, getting rid of all the uncertainty and irreproducibility associated with the complex transfer process of CVD graphene. Some preliminary results will be presented regarding the direct growth method,[13] indicating its promising future in real industrial applications of GaN optoelectronics.

Xiaobo Hu (Professor of State Key Laboratory of Crystal Materials, Shandong University)

Xiaobo Hu is Professor of State Key Laboratory of Crystal Materials, Shandong University. He received his Ph.D degree from Department of Physics, Nanjing University in 1997. His early research work was involved in the observation of growth defects in functional crystal materials. Using X-ray diffraction and topography, he investigated extensively on the growth defects in NYAB, YbYAB, YCOB, KTP crystals et al. His work is helpful to grow perfect crystal materials for crystal grower. Since 2001, his research interest has transferred to the growth and characterization of wide band gap semiconductor single crystals such as SiC and AlN. He has major contribution to grow SiC single crystal with the diameter of 2~6 inches and process SiC substrate with high surface quality in his laboratory. Up to now, he has published more than 150 research papers.

Reducing defect density of SiC on patterned seeds by lateral growth

Xiaobo Hu, Xianglong Yang, Yan Peng, Xiufang Chen and Xiangang Xu*
State Key Laboratory of Crystal Materials, Shandong University
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Abstract

Silicon carbide (SiC) is one of the most attractive and promising wide-bandgap semiconductor materials. Due to its excellent thermal and electrical properties, SiC has tremendous potential for applications in high-temperature, high-frequency, and high-power electronics.1–3 The most successful method for growing large SiC crystals with high quality is the physical vapor transport (PVT) method.4 In recent years, the structural quality of SiC single crystals has been substantially improved as the bulk growth technology matured, which led to the commercial availability of 6 in, high-quality, micropipefree SiC substrates.5 However, there are still a large number of crystallographic defects, such as dislocations and stacking faults. For example, the density of dislocation is still present in the 103–104 cm−2 range.5,6 It has been noted that the dislocations could be replicated in the epilayer,7 causing the degradation of device performance and long-term stability problems, especially in high-voltage high-power switching devices.8 The elimination or reduction of dislocations in PVT-grown SiC boules is, therefore, one of the most fundamental issues to further advance

SiC as a robust material for mainstream power device applications. Accordingly, the reduction of dislocations is now a major focus of material research.

It is proposed two methods to reduce defect density of SiC in this study. First one is growth of SiC on patterned seeds with the vertical side walls composed of {11–20} and{1–100}faces. Anisotropy in lateral growth rates was observed, i.e the growth rate towards <11-20> was faster than that along <1-100.> (Fig.1). It was found that free lateral growth on mesas was accompanied by a sharp decrease in the density of threading dislocation (Fig.2).

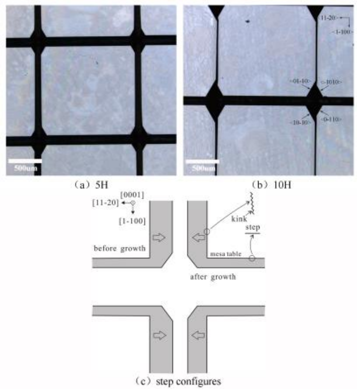

Fig. 1 LSCM photographs showing anisotropy in lateral growth rates: (a) after 5h growth at 1866℃, (b) after 10h growth at 1866℃, (c) schematic representation of step configurations on 6H-SiC(0001) faces

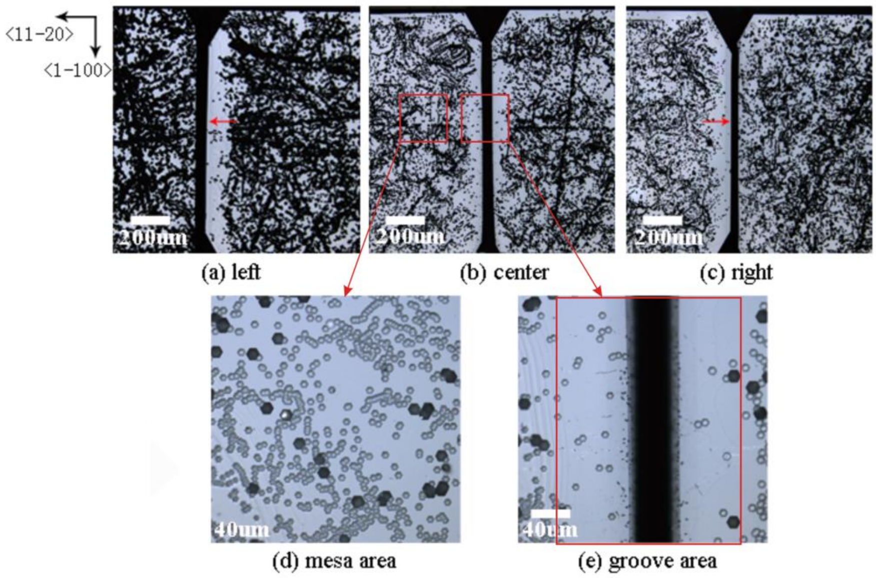

Fig. 2 LSCM microphotographs of etch pit distribution at different positions on the overgrown SiC crystal surface. (a) micrograph located to the left of center; (b) micrograph at center of the grown layer; (c) micrograph located to the right of the center; (d) and (e) local photograph of mesa and groove corresponding to the areas indicated by two red squares in (b) in higher magnification, the free lateral growth region above the groove indicted by red square in (e)

Second method is to alter the supersaturation over the seed surface by modulating the thermal profile. Two kinds of differential thermal conductivity regions are formed on the backside of the seed. The regions of lower thermal conductivity were formed by removing portions of the seed crystal so as to provide grooves in the seed crystal and filling the grooves in the seed crystal with graphite material, which has a thermal conductivity of 80 W mK^{-1}(Fig.3). As a result, the selective-area preferential growth of SiC corresponding to the predefined pattern in the initial stage of crystal growth was realized. It was found that the piling up of dislocation etch pits repeats the arrangement and boundaries of the predefined pattern, and the free lateral growth was accompanied by a sharp decrease in the density of threading dislocation.

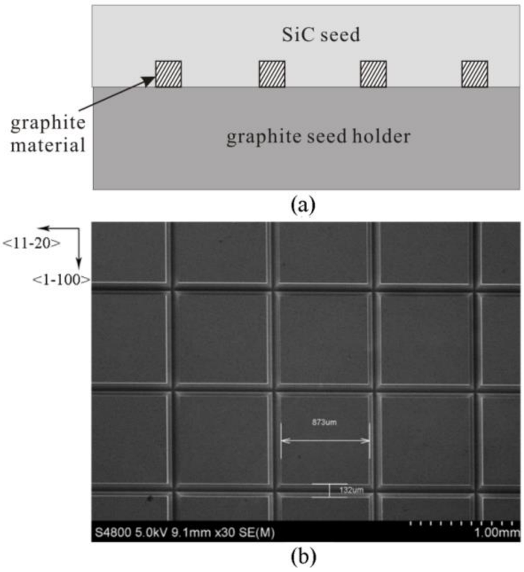

Fig. 3 Backside patterned seed. (a) schematic illustration of backside patterned seed mounted on a seed holder; (b) SEM image of backside patterned seed surface.

In summary, these two methods may be a promising technique for obtaining high-quality SiC crystals with low threading dislocation density.

Bin Zhu (Faculty of Materials Science and Chemistry, China University of Geosciences (Wuhan))

Bin Zhu received M.Sc., in 1987 from University of Sci. & Tech. of China and PhD in 1995 from Chalmers University of Technology, Physics and Engineering Physics, Sweden and during 10/ 95-12/97 worked as Postdoc. in Uppsala University (in Ångström Lab). Since 1998, Dr. Zhu moved to KTH and in 1999 became associate professor in Dept of Chemical Engineering and Technology, and then in Dept of Energy Technology KTH until 2018. He is visiting professor in Aalto University and Nanyang Technological University as well as has acted as guest professor and professor in several Chinese universities to co-supervise research projects and PhD students. From 2018, Bin has been appointed as a visiting professor appointed by Loughborough University, UK.

Zhu has H-index 43 (@ google scholar) citation over 6500. He is one of the Most Cited Researchers in China (Energy sector) for 2014, 2015, 2016 and 2017 published by Elsevier. Dr. Zhu chaired and supervises research teams more than 30 members, around ten associate professors, lectures, postdocts and more than10 PhD students. Dr. Zhu is leading the research on innovative fuel cell and Semiconductor-Ionics as well as semiconductor-ionic energy devices. His research field has recently granted an Innovation Award of WSSET (World Society of Sustainable Energy Technologies).

Wide Bandgap Oxide Semiconductors for Next Generation Energy Devices

Bin Zhu[1,2]

[1]Faculty of Materials Science and Chemistry, China University of Geosciences (Wuhan), Wuhan 430074, China

[2]Faculty of Physics and Electronic Science, Hubei University, Wuhan, Hubei 430062, P.R. China

[3]Department of Aeronautical & Automotive Engineering, Loughborough University, Loughborough LE113TU, United Kingdom.

Studies on Ionic nobility in oxide semiconductors lead to new generation electron and semiconductor devices, e.g, displays, valve switches, new memory devices, superconducting devices, supermagnetic devices, electrochemical transistors, low-power electronics and novel sensing/energy devices etc; but to ionic properties and transports missing that has the same important significance than electrons, because the electronic effect on ions' transport can be widely applied for new generation energy technologies.

Over hundred years, people have designed and looked for ionic conductors and ionic conductivity focusing on so called ionic materials or conductors, but challenge unsolved, typically, solid oxide fuel cell (SOFC), yttrium stabilized zirconia (YSZ), which needs high operational temperature in excess of 700 °C to operate properly, dominated the SOFC technology over hundred years, not yet commercially. The traditional ionic electrolyte, e.g. YSZ can be replaced by oxide semiconductors, typically wide bandgap oxides and their heterostructure with ionic properties to demonstrate higher device performance at temperatures well below 550°C and much simpler technology, e.g. single component/layer fuel cell to replace traditional anode, electrolyte and catholic three components fuel cell technology. Turning semiconductors to develop semiconductor ionic materials and conductivities, we can reach ever higher ion conductivity which have demonstrated more advanced fuel cell technology with wide applications in next generation energy devices.

State of the art semiconductor-ionic materials can be summarized as three categories: i) single phase semiconductors (I), e.g. perovskite and layered structured oxides, $SmNiO_3$, $SrTiO_3$, ZnO etc.; ii) wide bandgap oxides, e.g. oxygen deficit oxides (II), e.g. CeO_2 and TiO_2; iii) Semiconductor and ionic heterostructure materials (III). They can experience a transformation under fuel cell operation as shown in Figure 1.

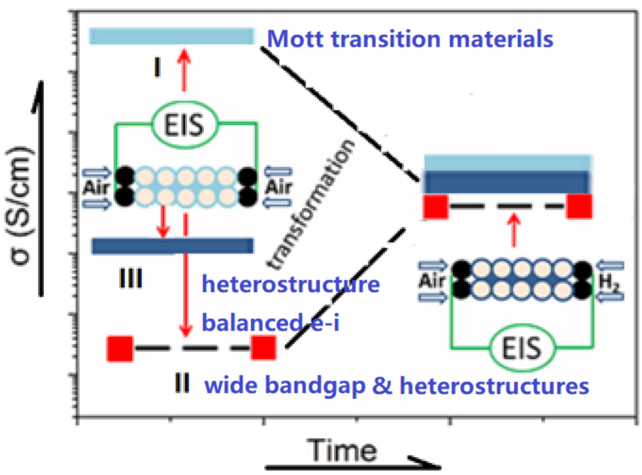

Figure 1. Three categories, I-III, of the semiconductor (ionic) materials undergo a conducting transformation during the fuel cell operation from air/air turned to H_2/air conditions.

Baoping Zhang（Professor of Xiamen Univerisity）

Prof. **Baoping Zhang** received the B.S. degree in physics from Lanzhou University, Lanzhou, China, in 1983, the M.E. degree in electronic engineering from Hebei Semiconductor Research Institute, Shijiazhuang, China, and the Dr. Eng. degree in applied physics from the University of Tokyo, Tokyo, Japan, in 1994. He is currently a Distinguished Professor with the College of Electronic Science and Technology, Xiamen University, China, where he is engaged in wide gap semiconductor materials and devices, especially GaN-based LEDs and vertical-cavity surface-emitting lasers.

Effects of UVB/UVC-LEDs on inactivation/reactivation of E. coli in water disinfection

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Baoping Zhang [a, *]
[a] Department of Electronic Engineering, Laboratory of Micro/Nano-Optoelectronics, Xiamen University, Xiamen, Fujian, 361005, China
[b] Department of Electronic Science, Fujian Engineering Research Center for Solid-State Lighting, Xiamen University, Xiamen, 361005, China
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Abstract

Ultraviolet light emitting diodes (UV-LEDs) are being considered to replace traditional UV pressure lamps for water disinfection. However, there are still some issues need to be clarified. In this work, UV-LEDs with peak emissions at 267, 275, 310 nm and their combinations were applied to water disinfection and the inactivation efficiency, reactivation (due to photoreactivation and dark repair) after UV irradiation and electrical energy consumption were evaluated using *Escherichia coli*. The 267 nm UV-LED was found to have the highest inactivation efficiency than other UV-LEDs. Reactivation occurred after irradiations was found to be dominated by photoreactivation, demonstrating that photo-effect rather than dark reactivation is the dominant mechanism of reactivation. The irradiation by the 275 nm UV-LED showed a better persistence against reactivation which could be attributed to protein damage at 275 nm. No synergistic effect for combined wavelengths was observed in this study. Due to its higher wall plug efficiency, the electrical energy consumption was lower for the 275 nm UV-LED than the other UV-LEDs. By totally considering the inactivation efficiency, the reactivation after UV irradiation and the electrical energy consumption, the 275 nm UV-LED is concluded to be a better and a promising option in water disinfection.

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Silicon Carbide Application in Solid Oxide & Electrolyte-layer Free Fuel Cells

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Abstract

In the fuel cell history, several challenges were faced by this technology. Most of the challenges were related to operational and capital costs of the fuel cell system while several hidden challenges were related to the device's operational mechanism. One of these is the activation energy. Recently, several new materials are investigated to exploit the technology for practical applications. Devices including solid oxide fuel cell (SOFC) and electrolyte-layer free fuel cell (EFFC), need activation energy to perform their redox reactions and can be calculated from the performance plot of the cell. Most of the time, core part of the cell takes more time to be activated than the outer part. This may happen due to lower thermal conductivity of the single component material used to fabricate EFFC. In this study, it is expected that if materials capable of higher thermal conductivity are mixed homogeneously into mixture of semiconductor-ionic part of the EFFC, it may enhance the device performance due to its faster activation internally and externally. 3C Silicon Carbide (3C-SiC) is a well-known material for higher thermal conductivity. If 3C-SiC (e.g. 10% by weight) is homogeneously mixed within single component or electrolyte material, it may reduce the time of activation of the devices because of faster heat conduction internally from one end to the other. So, SiC may enhance the performance of the devices (SOFC and EFFC). Considering from another perspective, electrical conductivity of commercial 3C-SiC is measured by DC 4 Probe technique which is unchanged referred to 44 S/cm in low temperatures (300-600 ^{o}C) which shows that using 3C-SiC material in SOFC and EFFC, may help in cell stability. It is really a target working temperature and this property of 3C-SiC may help to enhance device stability and performance for low temperature SOFC and EFFC. Hence the new results from upcoming experiments will be published accordingly on international journals.

Muhammad Imran ASGHAR（New Energy Technologies Group, Department of Applied Physics, Aalto University）

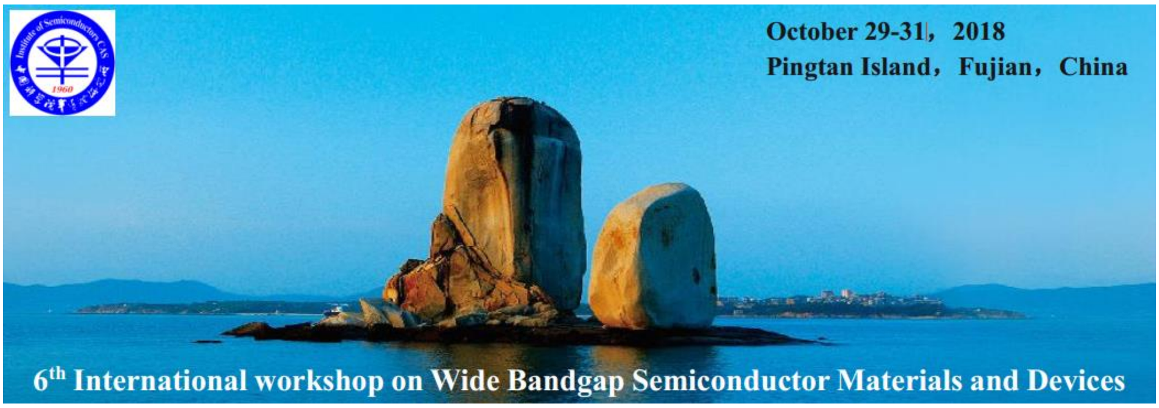
"Title of Docent" (translated as Adjunct Professor) at Aalto University School of Science in the field of Materials in Energy Technology was granted by the Head of the Department of Applied Physics, two external experts and the School of Science tenure track committee on 19th July 2017.He has been mainly working on the renewable energy including silicon solar cell, dye solar cell, perovskite solar cell, ceramic nanocomposite fuel cell, single-component fuel and lithium ion batteries. He coordinated a 4-year EU-Indigo project which involves 6 partner organizations including Aalto University (Finland), University of Oslo (Norway), University of Aveiro (Portugal), VESTEL (Turkey), CSIR (India) and IIT-Delhi (India).

Abstract

In this work, firstly a general overview of the progress of the photovoltaic technology is presented. The global cumulative photovoltaic installations by the end of year 2016, reached 315 GW [1]. Annual new solar PV system installations increased from 29.5 GW in 2012 to 79.4 GW in 2016. The building applied and integrated photovoltaic installations are growing gradually from 343.1 MW in year 2012 to expected 1.15 GW by year 2019 [2]. The cumulative building applied and integrated installations are expected to reach around 8 GW by year 2020. According to European directive 2010/31/EU [3], each new building should be made nearly zero energy from 2020 onwards. Therefore, it is expected that PV installations are expected to increase for building application in European countries. Conventional photovoltaic panels based on crystalline silicon thin film technologies available in the market are presented and their limitations are discussed. Then, new generation photovoltaic panels based on emerging technologies such as dye solar cells, perovskite solar cells and their tandem combinations are presented. Furthermore, our novel innovation related to sandwich structured flexible and light weight crystalline silicon solar cell is presented. Finally, issues related to the building applied and integrated applications are covered and suitable photovoltaic panels are suggested for roofing, facades, glazing, architectural and cladding applications.

会议介绍

Conference Introduction



2018 年 10 月 28 日至 31 日，第六届国际宽禁带半导体材料器件论坛将在福建省平潭岛举办。为期四天的论坛旨在促进宽带隙半导体材料和器件的国际交流与合作，概述该领域未来的发展方向。它覆盖了宽带隙半导体材料和器件，为研讨会，相关材料和工艺的讨论，器件和应用的创新开发提供基础，为研究人员，专家和教育工作者提供合作平台，分享他们的想法并讨论前沿领域的。

范围和主题

本次论坛的内容主要涵盖但不限于以下专题领域：

•宽禁带半导体材料和器件的发展现状

•材料增长

•器件制造及其工艺

•LED，太阳能电池及其相关材料的特性

•LED 和太阳能电池的工业应用

此外，科技部官员还将简要介绍政府间国际合作项目。

本次会议语言为中文和英文。

The 6th International workshop on Wide Bandgap Semiconductor Materials and Devices will be held on October 28-31, 2018 at PingTan island, Fujian province. Four-day workshop is aimed at promoting international communication and cooperation on wide bandgap semiconductor materials and devices, outlining the future directions in the field. It comprehensively covers wide bandgap semiconductor materials and devices, providing a basis for the discussions in the workshops, related materials and processes, innovative development of devices and applications, provides cooperation platform for researchers, experts and educators to share their thoughts and to discuss the frontier of the field.

Scope and topics

The workshop aims to cover the LEDs and solar technologies in the following major topical fields (but not limited to):

- review the current status of wide bandgap semiconductor materials and devices
- Material growth
- Device fabrication and its process
- Characterization of LEDs, solar cells, and their related materials
- Industrial application of LEDs and solar cells

Besides, an officer from the ministry of science and technology to give a brief introduction to the intergovernmental international cooperation project.

Conference: Chinese/English bilingual

中国科学院半导体研究所-平潭综合实验区管理委员会半导体技术联合研究中心介绍

Introduction of Institute of Semiconductors, CAS- Administrative Committee of Pingtan Comprehensive Pilot Zone Joint R&D Center of Semiconductors, Ping Tan-IOS

中国科学院半导体研究所–平潭综合实验区管理委员会半导体技术联合研究中心，由中国科学院半导体研究所与平潭综合实验区管委会合作组建。该中心旨在开展前沿半导体技术和半导体照明高端应用与设计等领域研究，建立成果孵化基地、展示中心和半导体照明成果示范基地。定期举办半导体技术领域的高级人才研修培训班，举办海峡两岸与国内外学术会议和论坛，吸引台湾人员来岚就业，积极开展同台湾、日韩、欧美等高等院校、科研单位以及知名企业之间的合作，全力打造海峡两岸和国际合作基地。筹建福建省工程中心/重点实验室，筹建光源检测中心（资质）；成立中科院成果转换基地，推广高品质光源产品的市场应用并孵化当地企业，打造平潭智慧照明岛，建立国际合作基地。该项目也是中科院半导体所在福建省合作的首个分支机构，将有力推动该区科研人才建设。

Institute of Semiconductors, Administrative Committee of Pingtan Comprehensive Pilot Zone have launched the CAS and Institute of Semiconductors, CAS- Administrative Committee of Pingtan Comprehensive Pilot Zone Joint R&D Center of Semiconductors, Ping Tan-IOS. The center aims to carry out research on advanced semiconductor technology and high-end application and design of semiconductor lighting, and to establish achievements incubation base, Exhibition Center and semiconductor lighting demonstration base. Organize seminars for senior personnel about semiconductor technology, two sides of the Taiwan Straits and International academic conferences and forums will be held regularly, which will attract Taiwanese personnel to work. It will carry out cooperation with Taiwan, Japan, South Korea, European, American universities, research institutes and well-known enterprises, and strive to build cross-strait and international cooperation bases actively. Fujian Provincial Engineering Center/Key Laboratory, Light Source Testing Center, Chinese Academy of Sciences Achievement Conversion Base will be built. It aims to promote the market application of high quality light source products and incubate local enterprises, build Pingtan Smart Lighting Island, and establish an international cooperation base. The project is also the first branch of Institute of Semiconductor, CAS cooperation in Fujian Province, which will powerfully promote the construction of scientific research personnel in this area.

平潭中科半导体技术联合研究中心

平潭综合实验区是国家“一带一路”的核心枢纽，也是福建自由贸易试验区的重要组成部分。平潭综合实验区管理委员会与中国科学院半导体研究所以推进平潭综合实验区建设智慧、低碳、绿色、开放的城市和国际旅游岛为目标，联合建立“半导体技术联合研究中心。该中心以中国科学院半导体研究所的人才和技术作为科技支撑，充分集成各自资源，带动平潭综合实验区半导体技术升级和新兴高科技企业的成长壮大，提高平潭地区产业科技自主创新能力。

建设一平台、打造四中心、布局五产业

■ 建设开放式、联合型半导体前沿技术研发平台

利用中心人才及智力优势，开展前沿半导体技术和半导体照明高端应用与设计等领域的研究。五年内建立立足平潭、面向全国的开放式、联合型半导体技术研发平台，为国内外企业、科研机构提供技术开发和支持。

定位

开发前沿技术，打造四中心

- ■国际、海峡两岸合作中心
- ■成果宣传孵化中心
- ■技术研发中心
- ■人才培养中心

产业布局

整合优势资源，布局五大产业

- ■半导体光电器件
- ■智能光源
- ■绿色能源
- ■生态农业
- ■海洋渔业

会务安排

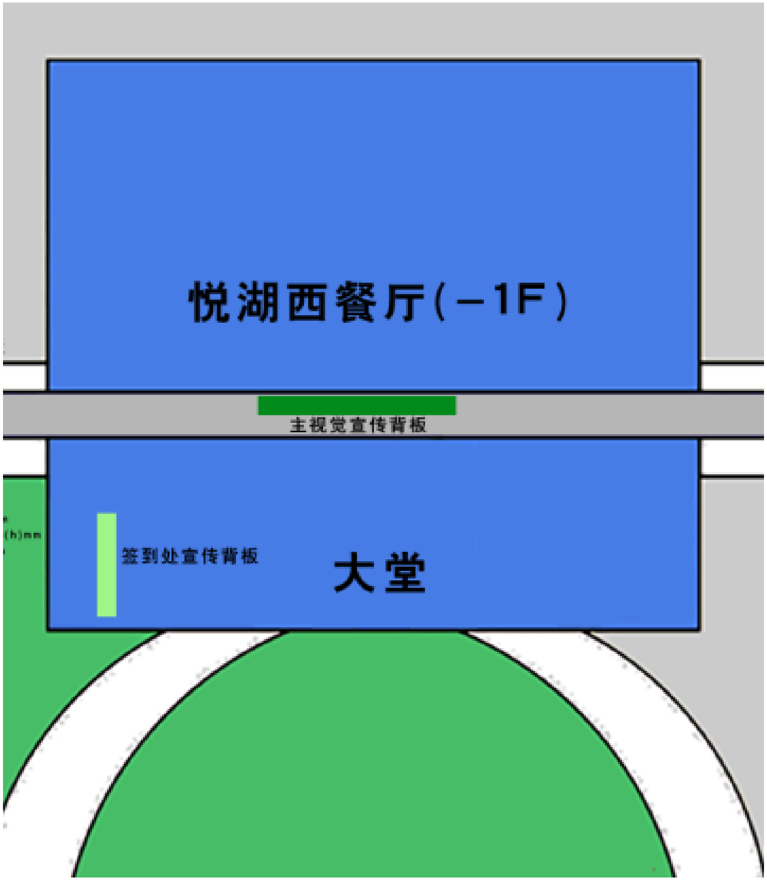
Conference Arrangements

麒麟荣誉酒店布置图

Plan of Qilin Rongyu International Hotel

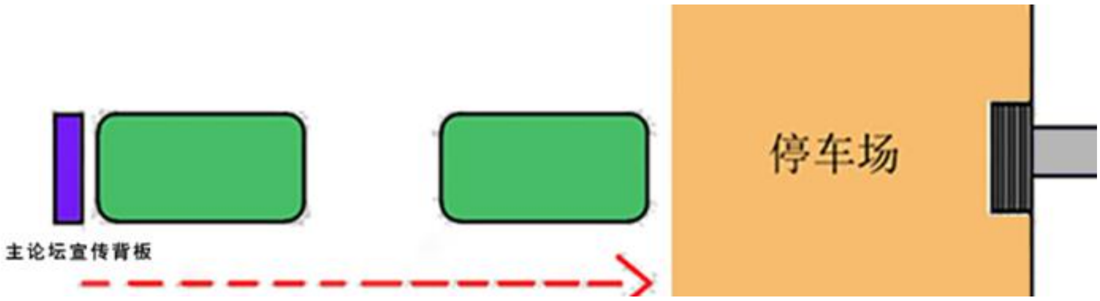
1. 大堂区域

   Area of foyer

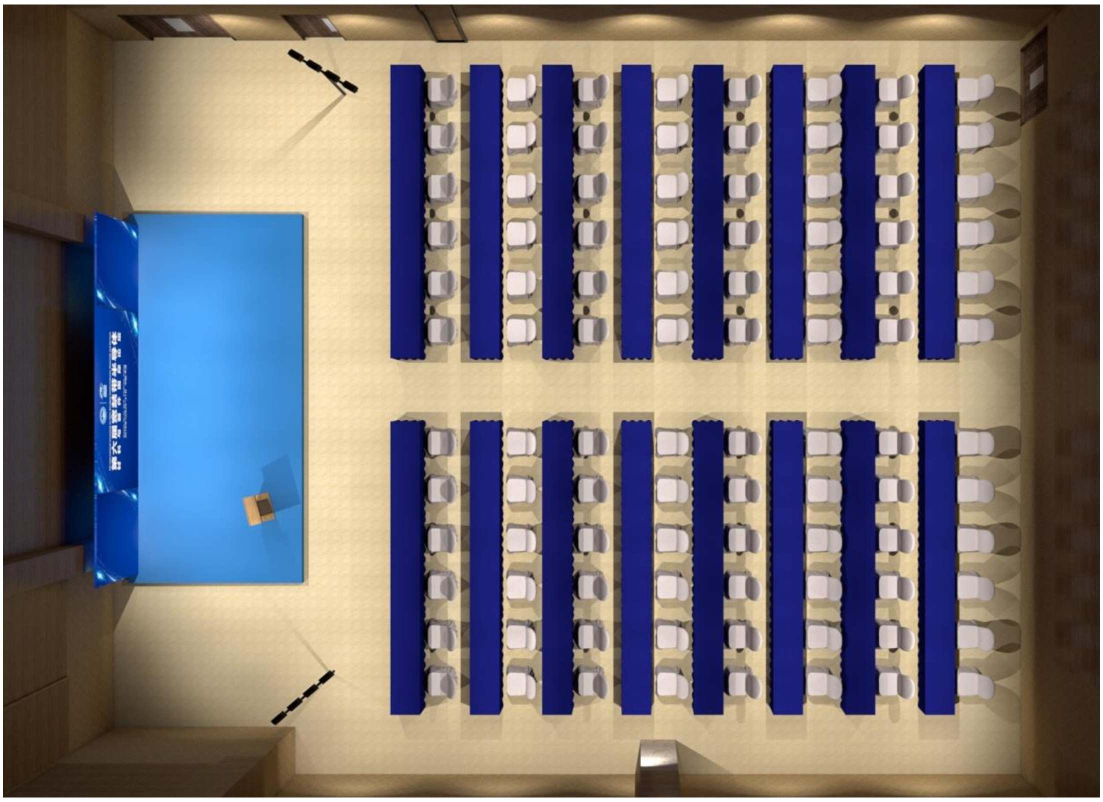


2. 酒店公路拐角

   Road corner of hotel



3. 海西厅布置
Arrangement of HAIXI HALL



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（末尾封皮）