



Institute of
Materials Research
and Engineering



NUS
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of Singapore



**Institute of Materials Research and Engineering –
National University of Singapore – National Taiwan University**

Optoelectronics Student Exchange Workshop

27 June 2007 • 8.30am – 6.00pm • IMRE SR1

OBJECTIVE

To encourage more academic interaction and technological collaboration between Singapore and Taiwan, especially in the area of optoelectronics, IMRE, NUS and National Taiwan University are going to jointly hold an optoelectronics workshop. Graduate students from IMRE, NUS and National Taiwan University and research staffs from IMRE will be presenting their works in optoelectronics. This workshop will also serve to publicize the capability and strong infrastructure for research in IMRE, NUS and National Taiwan University.

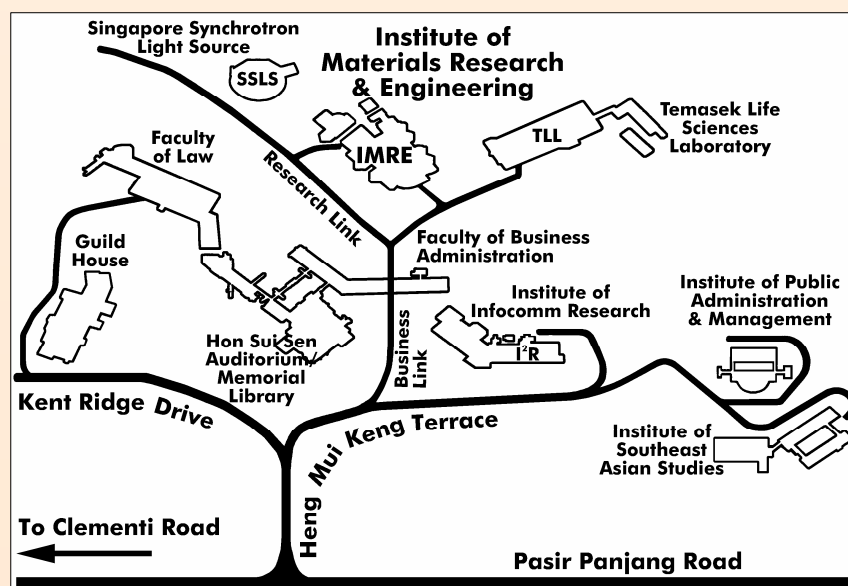
REGISTRATION

Register online by 25th June 2007 at:
www.imre.a-star.edu.sg/events-register/OptoStu

For registration enquiries, please email to:
joff-lye@imre.a-star.edu.sg

This is a non-chargeable workshop.

LOCATION



**Institute of Materials Research and Engineering –
National University of Singapore – National Taiwan University**
Optoelectronics Student Exchange Workshop
27 June 2007 • 8.30am – 6.00pm • IMRE SR1

PROGRAMME

**Venue: Seminar Room 1, Institute of Materials Research and Engineering,
Singapore**

- 8:30 – 9:30 Registration & Tea
- 9:30 – 9:45 Introduction to National University of Singapore (NUS) and Institute
of Materials Research and Engineering (IMRE)
Professor S. J. Chua, NUS, Deputy Director (Industry) of IMRE
- 9:45 – 10:00 Introduction to National Taiwan University (NTU)
Professor S. L. Huang, Vice Chairman of GIEOE, NTU

Technical Session I (Session chair: Tay Chuan Beng)

- 10:00 – 10:20 Nanoscale Lateral Epitaxial Overgrowth of Gallium Nitride
Zang Keyan (IMRE)
- 10:20 – 10:40 Prestrained Growth of InGaN/GaN Quantum-Well Structures with
MOCVD for Efficient Yellow, Red, and Phosphor-Free
white-light light-emitting diodes
Chi-Feng Huang (National Taiwan U.)
- 10:40 – 11:00 GaN-based Semiconductor Saturable Absorber Mirror (SESAM)
Operating in Blue Wavelength Region
Lin Fen (NUS / IMRE)
- 11:00 – 11:20 Fabrication and Characterization of Nano-porous GaN Template for
Strain Relaxed Gan Growth
Haryono Hartono (Singapore-MIT Alliance / IMRE)
- 11:20 – 11:40 Light Emission Enhancement with Surface Plasmon Coupling with
the Quantum Well in an Ingan/Gan Quantum-Well Light-Emitting
Diode
Dong-Ming Yeh (National Taiwan U.)
- 11:40 – 12:00 Field Emission Enhancement from Density-Patterned Gallium
Nitride Nanowires
Ng Keh Ting, Doris (NUS)
- 12:00 – 13:30 Lunch

Technical Session II (Session chair: Chi-Feng Huang)

- 13:30 – 13:50 Analysis of Optical Waveguides and Photonic Crystal Structures
Sen-Ming Hsu (National Taiwan U.)
- 13:50 – 14:10 Femtosecond Laser-Assisted Surface Nanostructuring
Lin Ying (NUS)

- 14:10 – 14:30 Optical Waveguide Devices on LiNbO₃ Substrate
Wen-Hung Huang (National Taiwan U.)
- 14:30 – 14:50 LCD with High and Stable Color Gamut by Using Pre-compensated
Trichromatic LED Backlight Source
Tien-Lung Chiu (National Taiwan U.)
- 14:50 – 15:10 Surface Plasmonics Resonance Effect and Laser Nanofabrication
Ma Fang (NUS)
- 15:10 – 15:30 Integration of Micro-Optics with Display Devices and Systems
Kuan-Yu Chen (National Taiwan U.)
- 15:30 – 15:50 Tea Break

Technical Session III (Session chair: Lin Fen)

- 15:50 – 16:10 MBE Growth and Characterization of Dilute Nitride Related
Materials and Structures
Liu Hongfei (IMRE)
- 16:10 – 16:30 Enhanced Carrier Transportation on Passivated Gallium Nitride
Single Nanowire Field-Effect Transistor
Jeng-Wei Yu (National Taiwan U.)
- 16:30 – 16:50 Study of Thermal-Anneal-Induced Rearrangement of N-Bonding
Configurations in GaInNAs/GaAs Quantum Wells
Vivek Dixit (NUS)
- 16:50 – 17:10 Double-Wall Carbon Nanotube Field-Effect Transistor with Ru
Contacts
Huang Leihua (NUS)
- 17:10 – 17:30 ZnO/Organic Nanocomposite Electroluminescence Devices and
ZnO Nanostructures
Jing-Shun Huang (National Taiwan U.)
- 17:30 – 17:50 Prediction of ZnO Nanorod Morphology Grown by Hydrothermal
Method
Tay Chuan Beng (NUS / IMRE)
- 17:50 – 18:00 Closing Remarks

Prof C. C. (Chih-Chung) Yang (National Taiwan University)



Professor C. C. Yang received his BS degree in 1976 from the Department of Electrical Engineering, National Taiwan University, Taipei, MS (1981) and Ph.D. (1984) degrees also in electrical engineering from University of Illinois, Urbana-Champaign. Before he joined the Graduate Institute of Electro-Optical Engineering, National Taiwan University, as a full professor in 1993, he has been being a faculty member in the Department of Electrical Engineering, The Pennsylvania State University. During the period from August 2001 to July 2007, he served as the Chairman/Director of the Graduate Institute of Electro-Optical Engineering, National Taiwan University. His research areas include the MOCVD growth of nitride compounds, MBE growth of nitride and oxide semiconductor nanostructures, white-light light-emitting diodes for solid-state lighting and display, surface plasmonics, photonic crystals, ultrafast optics, and biophotonics (optical coherence tomography). He has published more than 500 journal and conference papers. Professor Yang is a fellow of the Optical Society of America.

Prof S. J. Chua (NUS. Deputy Director (Industry), IMRE)



Prof Chua Soo Jin is Professor of Optoelectronics at the Department of Electrical and Computer Engineering, National University of Singapore (NUS). He is also Director of the Opto and Electronics Systems Cluster at the Institute of Materials Research & Engineering (IMRE), conducting research on GaN MOCVD and OLED. His research area is in optoelectronics and has published over 230 papers in international journals and authored/co-authored 40 patents with 22 of them granted. He has received awards for Outstanding Contribution to Research, Excellent Teacher and also as an Outstanding University Researcher in 1996, 1998 and 1999 respectively. He is the inventor of the Quantum dot White LED and the first to demonstrate the quantum dot photodetector. His interaction with industry has been fairly extensive, providing consultancies to companies in Singapore and in the region. Concurrently, he serves as the Deputy Director of the Singapore-MIT Alliance, a position he has held since the Alliance was formed in 1999.

Prof Chua is Sr. member of IEEE. He served as Chairman of IEEE, Singapore Chapter from 1984 to 1986 and as Chairman of Education Committee, Region 10 from 1987 to 1988 and Vice-chairman of SPIE from 95-97. In 1978, he worked for the Standard Telecommunications Labs, Harlow, UK. In 1981, he spent a year at the Fraunhofer Institute of Semiconductor Technology, Munich under a German Exchange Scholarship (DAAD). He was a Visiting Fellow of Japan Society for the Promotion of Science in 1988 and of the British Council in 1990.

Prof S. L. Huang (Vice Chairman of GIEOE, National Taiwan University)



Professor Huang received the B.S. degree from the Department of Electrical Engineering, National Taiwan University in 1986, and the M. S. and Ph. D. degrees from the Department of Electrical Engineering, University of Maryland, College Park in 1990 and 1993, respectively. He joined the Institute of Electro-Optical Engineering, National Sun Yat-Sen University in 1993, and became a Professor in 1999. He served as Director of the Institute of Electro-Optical Engineering, National Sun Yat-Sen University from April 2003 to Jan. 2006. Since Feb. 2006, he joined the Graduate Institute of Electro-Optical Engineering and Department of Electrical Engineering, National Taiwan University. His research areas include crystal fiber growth of laser and nonlinear optical materials, and diode-laser pumped solid-state lasers. Professor Huang is a senior member of the IEEE Lasers and Electro-Optics Society (LEOS), and a member of the Optical Society of America and the Photonics Society of Chinese-Americans. He served as the Chairman of IEEE LEOS Taipei Chapter, 2005-2006, and is presently a Topical Editor of Optics Letters.

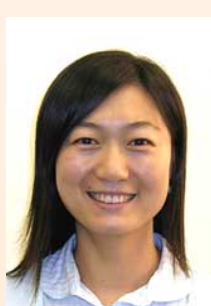
ABSTRACT

Nanoscale Lateral Epitaxial Overgrowth of Gallium Nitride

Zang Keyan (IMRE)

Threading dislocation in GaN is still a key issue for high efficiency and long life time nitride based Light Emitting Diodes (LEDs) and Laser Diodes (LDs). Threading dislocations are known to be nonradiative recombination centers, and thus lower the internal quantum efficiency of nitride based LEDs. A number of approaches to high quality GaN-based materials to improve the internal quantum efficiency, i.e, epitaxial lateral overgrowth, cantilever epitaxy, nonpolar GaN, and GaN nanorod structures.

Nanoscale laterally epitaxial overgrown (NLEO) GaN layers were investigated for the improvement of microstructural and optical properties of GaN. Nanoporous SiO₂ films on the surfaces of GaN/sapphire and GaN/Si (111) were fabricated by inductively coupled plasma etching using anodic alumina templates as etch masks. GaN was grown over the nanoporous SiO₂ layer using metalorganic chemical vapor deposition to realize a continuous and smooth film. NLEO GaN was found to result in a significant reduction of threading dislocation density as characterized by transmission electron microscopy and atomic force microscopy. The threading dislocation density was $\sim 10^7 \text{cm}^{-2}$ on the surface of NLEO GaN/sapphire. The narrower band-edge excitonic transition in photoluminescence spectrum shows a better optical quality in the NLEO GaN film. NLEO GaN reduces number of threading dislocations and will be a potential template for high efficiency LEDs and LDs.



Zang Keyan obtained her Bachelor and Master degree in the school of Materials Science and Engineering from Tianjin University, Tianjin, China in the year of 1998 and 2001, respectively. She obtained her PhD degree in Advanced Materials for Micro-and Nano- system from Singapore-MIT Alliance c/o National University of Singapore in 2005. She is now working as research engineer in Institute of Materials Research and Engineering. Her research interest is focused on Metal Organic Chemical Vapor Deposition (MOCVD) growth of III-V semiconductor compounds and their related

low-dimensional structures and devices; Semiconductor nanotechnology- fabrication, growth and devices; Structural, optical and electrical characterizations of thin films, heterostructures and nanostructures.

Prestrained Growth of InGaN/GaN Quantum-well Structures with MOCVD for Efficient Yellow, Red, and Phosphor-free White-light Light-emitting Diodes

Chi-Feng Huang (National Taiwan U.)

We grew a white-light InGaN/GaN quantum-well (QW) light-emitting diode epitaxial structure with its electroluminescence spectrum close to the ideal condition in Commission International de l'Eclairage chromaticity based on the prestrained metalorganic chemical vapor deposition technique. The prestrained growth leads to the efficient yellow emission from three InGaN/GaN QWs of increased indium incorporation. The color mixing for white light is implemented by

adding a blue-emitting QW at the top of the yellow-emitting QWs. The blue shifts of the blue and yellow spectral peaks of the generated electroluminescence spectra are only 1.67 and 8 nm, respectively, when the injection current increases from 10 to 70 mA. Such small blue shifts imply that the piezoelectric fields in our QWs are significantly weaker than those previously reported.



Chi-Feng Huang was born on March 11, 1979 at Taoyuan, Taiwan. He received his BS degree in electrical engineering from National Taiwan Ocean University in 2001 and his MS degree in electro-optical engineering from National Taiwan University in 2003. Currently, he is working on his Ph.D. dissertation in the Graduate Institute of Electro-Optical Engineering, National Taiwan University. His research areas include MOCVD growth of InGaN nanostructures for fabricating phosphor-free white-light light-emitting diodes.

Mr. Huang has published more than 10 SCI journal papers and more than 15 international conference papers.

GaN-Based Semiconductor Saturable Absorber Mirror (SESAM) Operating in Blue Wavelength Region

Lin Fen (NUS/IMRE)

A broadband GaN-based semiconductor saturable absorber mirror (SESAM) operating in blue wavelength region was studied. A dielectric $\text{SiO}_2/\text{Si}_3\text{N}_4$ distributed Bragg reflector (DBR) was deposited by plasma enhanced chemical vapor deposition (PECVD) after the metal organic chemical vapor deposition (MOCVD) growth of the saturable absorber. Such a dielectric DBR provided a much broader stopband and higher top reflectivity than the monolithically grown GaN-based DBR. However, this structure suffered from severe interference-induced reflectivity fluctuation. To suppress the interference effect, laser lift-off of the sapphire substrate, inductively coupled plasma etching of the GaN buffer and epilayer, and PECVD deposition of anti-reflective coating were conducted. Through the above optimization process, the interference-induced reflectivity fluctuation was effectively reduced. The experimental results agreed well with the simulation predictions, which verified the successful realization of an optimized SESAM structure. This SESAM can be applied in the passive modelocking of blue lasers to produce ultra-short optical pulses for data storage, printing and spectroscopy applications.



Ms Lin Fen obtained her Bachelor degree in optical engineering from Zhejiang University in July 2004. She joined Center for Optoelectronics (COE), NUS in August 2004 as a PhD candidate. Her research interests include semiconductor saturable absorber mirrors (SESAMs), metal organic chemical vapor deposition (MOCVD) growth and characterization of GaN-based III-V materials.

Fabrication and Characterization of Nano-porous GaN Template for Strain Relaxed GaN Growth

Haryono Hartono (Singapore-MIT Alliance / IMRE)

A simple and cost-effective Si-doped porous GaN is fabricated by UV-enhanced electrochemical etching, produces a high density of uniform pores across the surface. TEM reveals that the etching results in layered nano-pores structures along the (0001) direction. A red shift of 0.7 cm^{-1} in the E_2 (high) phonon peak of GaN from micro-Raman corresponds to a relaxation of compressive stress in the porous GaN surface with respect to the underlying epitaxial GaN. Subsequent growth of GaN layer on the porous template results in air gap formation, which is believed to serve as sinks for dislocations for reducing residual strain in the film. Reduction of FWHM of the XRD rocking curve by as much as 0.033° and doubling of the intensity of the PL spectrum clearly show improvement on the crystalline and optical quality of the overgrown GaN layer as compared to the as-grown. A red shift of $\sim 0.4 \text{ cm}^{-1}$ towards the stress-free GaN also indicates a relaxation of compressive stress in the overgrown GaN layer. Such a template is useful for high quality GaN growth.



Mr Haryono Hartono is a PhD student from the Department of Advanced Materials for Micro and Nano Systems under the Singapore-MIT Alliance program. He graduated from Nanyang Technological University, Singapore in 2003 from the Department of Electrical and Electronic Engineering with major in Photonics. His main research interest is III-V-Nitrides growth on different templates for long wavelength emission.

Light Emission Enhancement with Surface Plasmon Coupling with the Quantum Well in an InGaN/GaN Quantum-well Light-emitting Diode

Dong-Ming Yeh (National Taiwan U.)

Several phenomena of surface plasmon (SP) coupling with an InGaN/GaN quantum well (QW) for light emission enhancement are first discussed in this presentation, including the phonon-assisted coupling between the carriers in the QW and the SP, the metal nano-crystal-assisted coupling between the SP and photon, the screening effect of the quantum-confined Stark effect on the SP-QW coupling, and the SP leakage through an Ohmic contact during the process of SP-QW coupling. Based on the above results, the use of the SP-QW coupling for emission enhancement in a light-emitting diode is evaluated. Finally, the characteristics of such a light-emitting diode are discussed to show the effects of the SP-QW coupling.



Dong-Ming Yeh was born on November 17, 1979, at Hsinchu, Taiwan. He received his BS degree in electrical engineering from National Taiwan Ocean University in 2001 and his MS degree in electro-optical engineering from National Taiwan University in 2003. Currently, he is working on his Ph.D. dissertation in the Graduate Institute of Electro-Optical Engineering, National Taiwan University. His research areas include the fabrication of highly efficient light-emitting diodes, particularly those based on the

emission enhancement through the coupling between surface plasmon and InGaN/GaN quantum wells. Mr. Yeh has published more than 10 SCI journal papers and more than 15 international conference papers.

Field Emission Enhancement from Density-Patterned Gallium Nitride Nanowires

Ng Keh Ting, Doris (NUS)

Density-patterned gallium nitride nanowires have been grown on n-Si (100) substrates by pulsed laser ablation. The nanowires are patterned using a physical mask, resulting in regions of different density nanowires growth. These gallium nitride nanowires are single-crystalline with hexagonal wurzite structures. The field emission characteristics of these density-patterned gallium nitride nanowires show a turn-on field of 8.4 V/mm to achieve current density of 0.01 mA/cm² and an enhanced field emission current density as high as 0.96 mA/cm² at an applied field of 10.8 V/mm. The field emission results indicate that density difference in the nanowires growth greatly enhances their field emission properties by reducing the screening between nanowires, in addition to good crystalline quality as well as the low electron affinity of gallium nitride.



Doris obtained her Bachelor of Engineering Degree with honours from the Electrical and Computer Engineering Department at the National University of Singapore (NUS) in 2003. Since then, she has been pursuing a PhD degree at the Center for Optoelectronics and Laser Microprocessing Laboratory in NUS. Her current research interests focus on pulsed laser ablation synthesis, material and device study of gallium nitride nanowires.

Analysis of Optical Waveguides and Photonic Crystal Structures

Sen-Ming Hsu (National Taiwan U.)

In our group, we have developed several powerful numerical models for the analysis of photonic and electromagnetic problems. With conscientious examination for the precision of these numerical models, we can obtain high-accuracy numerical results for various devices, even with sophisticated structures. Consequently, we can provide convincing guides and verifications for theoretical arguments, experimental results, and device designs. The finite element method, characterized by the high-precision and the flexibility of modeling complex geometries, is one numerical scheme employed in our group. The related formulation based on this method for the analysis of optical waveguides and photonic crystal structures will be introduced. To show the practicability of this numerical model, several structures will be analyzed and discussed in this presentation.



Sen-ming Hsu was born in Changhua, Taiwan, Republic of China, on December 11, 1979. He received the B.S. degree with double majors in industrial engineering and engineering management and electrical engineering from National Tsing Hua University, R.O.C., in 2002, and the M.S. degree in communication engineering from National Taiwan University, R.O.C., in 2004. He is now working toward the Ph.D. degree in Graduate Institute of Electro-Optical Engineering, National Taiwan University. His current research interests include the advanced numerical modeling for electromagnetic problems, the analysis of optical waveguides, and the theory and application of photonic crystal structures.

Femtosecond Laser-Assisted Surface Nanostructuring

Lin Ying (NUS)

Two types of optical lithography techniques, namely microlens array (MLA) patterning and near-field scanning optical lithography (NSOL), using a femtosecond laser, are developed and presented to show their capabilities in fabrication of nanofeatures. MLA patterning on phase-change thin film by pulse laser irradiation is presented. Multi-foci appearing at the focal plane of an MLA act as “pens” to write features over a large area in a short time. The small size of each lens in the MLA reduces the laser energy at the focal point significantly, which helps to minimize the feature size on the phase-change thin film. Based on this MLA patterning, phase-change nanolithography is developed by wet chemical etching to fabricate 3D nanostructures. To further decrease feature sizes, NSOL in photoresist with a femtosecond laser coupled into the NSOM is developed. Variation of feature shapes at different distances from the NSOM probe agrees with the field distribution simulated according to the Bethe-Bouwkamp model very well. To demonstrate the use of femtosecond laser NSOL in optical data storage, nanofeatures fabricated in nano-cells of phase-change random access memory (PCRAM) with improved performance are fabricated.

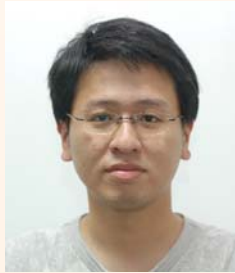


Ms Ying Lin received her BE (2000) degree from Shandong University in China. She is currently pursuing her PhD degree in Department of Electrical & Computer Engineering, National University of Singapore now. Her research interests are in the areas of laser assisted nanostructure fabrication and application in optical data storage. She has co-authored 12 journal and conference papers.

Optical Waveguide Devices on LiNbO₃ Substrate

Wen-Hung Huang (National Taiwan U.)

Research achievements of our group on lithium niobate (LiNbO₃) optical waveguide devices are briefly introduced. First, a variable polarization (mode) splitter using Zn and Ni co-diffused LiNbO₃ waveguides is presented. The power ratio between TE and TM modes at two output arms can be electrically controlled to a desired ratio. Second, a novel joint proton source for wet etching in LiNbO₃ is introduced. With the proposed source, proton diffusion in the lateral directions can be suppressed and thus, the sidewalls are much more vertical than that with the conventional one. Finally, a gallium in-diffused optical waveguide in LiNbO₃ substrate is firstly demonstrated. And the measured waveguide characteristics are discussed.



Wen-Hung Huang was born on October 18, 1977 at Taipei, Taiwan. He received his BS degree in electrical engineering from National Taiwan University in 2001. Currently, he is working toward his Ph.D degree at National Taiwan University. He joined the Integrated Optical Laboratory, National Taiwan University since 2001. His research interests include lithium niobate optical waveguide devices and integrated-optic devices.

LCD with High and Stable Color Gamut by Using Pre-compensated Trichromatic LED Backlight Source

Tien-Lung Chiu (National Taiwan U.)

We demonstrate a stable and high color gamut liquid crystal display (LCD) system (>100 % NTSC) over a wide operational temperature range from 25 to 70 °C by using a pre-compensated light emitted diodes (LEDs) backlight units without extra costs for expensive heat-sinks. LED's optical characteristics will be varied with junction temperature such as spectral redshift and intensity decreasing, etc. They are contributed to the dramatically declining color rendering area due to the backlight module temperature rising during operation. Well choosing individual pre-blueshift dominant wavelength for RGB LEDs spectrum to match color filter in LCD can compensate color gamut decreasing caused by the spectral redshift and intensity decay when rising module temperature.



Tien-Lung Chiu was born on August 25, 1974 at Kaohsiung, Taiwan. He got his MS degree from Graduate Institute of Electro-Optical Engineering, National Taiwan University (GIEOE-NTU) (1998) and took a short term Ph.D program in University of California, Irvine (2001). Currently, he is going on his Ph.D. career in GIEOE-NTU from 2004 and his research focus on the field of Display Technology such as next generation backlight source within liquid crystal display and novel organic light emitted device (OLED) for high ambient contrast application. Mr. Chiu has published more than 3 SCI journal papers, 5 international conference papers and 3 American patents.

Surface Plasmonics Resonance Effect and Laser Nanofabrication

Ma Fang (NUS)

Surface plasmons are electromagnetic waves that propagate along the surface of a conductor. By altering the metal's surface structures, the properties of surface plasmons can be tailored, which enables manipulation of light at the nano-scale. Plasmonics becomes more and more attractive due to its great potential in next chip-scale technology. In this talk, we will discuss the dependence of plasmonic effect on the shape and size of metallic nanostructures. Large area nano-structures fabricated by laser interference lithography (LIL) will be demonstrated and the tuning properties of the plasmonic resonance wavelength will be shown. We will also discuss the plasmonic effect in backside nano-patterning on silicon substrate by infrared CO₂ laser and laser removal of Au nano-particles, which implies a promising future of laser cleaning.



Ms Ma Fang is currently a PhD student in Electrical and Computer Engineering department at NUS. She obtained her Bachelor degree in opto-electronics engineering from Xi'an Jiaotong University in July 2006 and joined laser microprocessing lab in August 2006. Her research interests include nanostructures fabrication, near field optics, plasmonics and sub-wavelength optics. She has co-authored one conference paper.

Integration of Micro-Optics with Display Devices and Systems

Kuan-Yu Chen (National Taiwan U.)

With the growing demands for high definition displays, most display systems are equipped with large arrays of micro-devices for improving the system performance. We will briefly introduce the attitudes for a good display, such as high brightness, high contrast ratio, good uniformity, and nice color saturation, etc. From those considerations, we will introduce some of our research topics on integrating the micro-optical elements into display devices or systems. The particular example that we will focus on is to integrate a microstructure array onto OLED devices. The light extraction efficiency has been studied and correlated with coverage ratio and height ratio of the microstructure. However, image blurring was observed to decrease the contrast ratio and thus lower image quality. We have designed innovative microstructure array arrangements to reduce the blurring effect and keep almost the same extraction efficiency as that obtained by applying a conventional microstructure array.



Kuan-Yu Chen was born on 21st August, 1982 at TaiChung, Taiwan. He received his BS degree in electrical engineering from National Taiwan University in 2004 and his MS degree in electro-optical engineering from National Taiwan University in 2006. Currently, he is working on his Ph.D. dissertation in the Graduate Institute of Electro-Optical Engineering, National Taiwan University. His research areas include integration of microstructure on OLED devices for image quality enhancement.

MBE Growth and Characterization of Dilute Nitride Related Materials and Structure

Liu Hongfei (IMRE)

Dilute nitride semiconductors such as GaInNAs, GaNAs and their related quantum structures are attracting intensive research interests due to their unique physical properties and telecommunication applications. By introducing a small amount of N ($\leq 3\%$ in mole fraction) into GaInAs or GaAs matrix replacing the As atom sites, both the band gap and the crystal lattice can be effectively reduced. The emission wavelength of GaInAs/GaAs quantum well can thus be extended to 1.3-1.55 μm , which is feasible to be monolithically intergraded with GaAs/AlAs distributed Bragg mirror (DBR) on GaAs substrate. However, in order to effectively incorporate N, growth of dilute nitrides has to be conducted at relatively low temperatures as compared to that of GaInAs/GaAs system, which leads to a lot of defects such as Ga vacancies and N complexes incorporated simultaneously. Post-growth thermal annealing is usually needed to remove the as-grown defects and improve the optical properties; however it causes an undesired blue-shift in photoluminescence emission. In this presentation we will report on the growth and characterization of dilute nitride materials and their related quantum structures.



Dr Liu Hongfei, born in 1973, was awarded his Ph. D. degree at the Institute of Physics, Chinese Academy of Sciences in 2001. After that he worked as a postdoctoral researcher in US, Finland, Germany and Singapore. In 2006 he joined the Institute of Materials Research and Engineering. His research area is focused on fabrication and characterization of compound semiconductors. So far he got more than 50 publications in peer-review journals and international conference proceedings.

Enhanced Carrier Transportation on Passivated Gallium Nitride Single Nanowire Field-Effect Transistor

Jeng-Wei Yu (National Taiwan U.)

We reported on the enhanced carrier transportation in gallium nitride single nanowire field-effect transistor with top gate structure. The GaN nanowires were synthesized by a selective-site growth mechanism using vapor-liquid-solid method on a silicon-dioxide capped p-type silicon substrate. The GaN nanowires were characterized with a length of 20 μm and about 80nm diameter as observed by scanning electron microscope. Data from the electrical characterization revealed a twenty-fold increase of the saturation current on the SiO_2 passivated GaN single nanowire FETs compared the ones without SiO_2 layer. We ascribed this observation to the suppression of the surface states density of GaN nanowires by the oxide layer. We conclude that due to a large surface to volume ratio in the nanowire structure, it is essential to provide surface passivation process to achieve a better control of the current modulation capability in a nanoscale electronic device.



Jeng-Wei Yu was born on March 22, 1981 at Chiayi, Taiwan. He received his BS degree in Electrical Engineering from National Chung Cheng University in 2003 and his MS degree in Electro-Optical engineering from National Taiwan University in 2005. Currently, he is working on his Ph.D. dissertation in the Graduate Institute of Electro-Optical Engineering, National Taiwan University. His research areas include vapor-liquid-solid growth of III-V nanowires and nanorods for fabricating light-emitting diodes and field-effect transistors.

Study of Thermal-Anneal-Induced Rearrangement of N-Bonding Configurations in GaInNAs/GaAs Quantum Wells

Vivek Dixit (NUS)

Blueshifts of photoluminescence (PL) peak wavelength from GaInNAs/GaAs quantum well (QW) at various annealing temperatures have been studied theoretically and experimentally. The reorganization of the nitrogen-bonding configurations in short-range-order (SRO) $N\text{-In}_m\text{Ga}_{4-m}$ clusters and the In/Ga interdiffusion across the QW interfaces have been simultaneously taken into consideration when analyzing the blueshifts. Our results indicate that as-grown GaInNAs/GaAs QW sample has $N\text{-Ga}_3\text{In}_1$ phase, which changes to a mixture of $N\text{-Ga}_3\text{In}_1$ and $N\text{-Ga}_2\text{In}_2$ after annealing. The activation energy characterized for SRO is 2.38 eV, which is smaller compared to activation energy of the diffusion process (3.196 eV). This indicates that the SRO is the dominant mechanism that induces the PL blueshift at low annealing temperature and for short time annealing.



Mr Vivek Dixit obtained his Bachelor of Technology Degree from the Electrical engineering Department at the Indian Institute of Technology Delhi, New Delhi, India 2004. July-to-December 2004, he worked as Hardware engineer for nVIDIA graphics Bangalore. Since Jan 2005, he has been pursuing a PhD degree at the Center for Optoelectronics in NUS. His current research interests include Molecular beam epitaxy growth of dilute nitrides; XRD characterization, TEM analysis, Photoluminescence measurement and simulations.

Double-Wall Carbon Nanotube Field-Effect Transistor with Ru Contacts

Huang Leihua (NUS)

Field-effect transistors (FETs) have been fabricated using double-walled carbon nanotube (DWNT) bundles with Ru contacts. Annealing at 400 °C in an O_2 ambient has led the contact resistance of the DWNT FET to decrease by two decades. In contrast, annealing in vacuum at the same temperature has resulted only in a small reduction in the contact resistance. We believe O_2 annealing at 400 °C has oxidized Ru to RuO_2 , which has a higher work function than Ru. The higher work function of RuO_2 has yielded a reduced Schottky barrier between the contact and DWNT, and this may be one of the reasons for the improvement observed in the contact resistance. Hence, Ru could be a promising contact metal to DWNT (and possibly to

single-walled carbon nanotube as well). Among the DWNT devices fabricated, metallic, semiconducting, and hybrid semiconducting-metallic characteristics were observed. This is not surprising as the DWNT bundles comprise both metallic and semiconducting individual tubes. Furthermore, some of double-walled carbon nanotubes can have the hybrid characteristics owing to their two layer structure. FETs with purely semiconducting characteristics were achieved by electrical breakdown of the metallic DWNTs. It was observed that Schottky barrier exist between the semiconducting DWNTs and Ru electrodes. Both ambipolar and unipolar transport characteristics were also found among fabricated devices because of the diameter distribution of the DWNTs.



Huang Leihua obtained his Bachelor of Science Degree from the Material Science Department at the Fudan University in China in 2004. Since then, he has been pursuing a PhD degree at the Center for Optoelectronics in NUS. His current research interests focus on carbon nanotube based one dimensional device.

ZnO/Organic Nanocomposite Electroluminescence Devices and ZnO Nanostructures

Jing-Shun Huang (National Taiwan U.)

We report electroluminescence of hybrid ZnO/organic light emitting devices (LEDs) from ZnO nanoparticle-based devices prepared by the spin-coating process. The TPD enhances electrons and holes to recombine in the ZnO nanoparticles. The optimal device exhibits a narrow spectrum at 392 nm. The combination of ZnO nanoparticles with organic polymers allows the fabrication of flexible thin film LEDs. Besides, we also study the solution-based grown ZnO nanowire arrays at low temperature on Si substrates via use of ZnO thin film as a seed layer. The change of the morphology and crystallinity of ZnO nanowires was also investigated with variation of annealing temperature of the seed layer.



Jing-shun Huang was born on July 4, 1981 at Kaohsiung, Taiwan. He received his BS degree in electronic engineering from National Taiwan University of Science and Technology in 2003. Currently, he is working on his Ph.D. dissertation in the Graduate Institute of Electro-Optical Engineering, National Taiwan University. His research areas include hydrothermal growth of ZnO nanostructures.

Prediction of ZnO Nanorod Morphology Grown by Hydrothermal Method

Tay Chuan Beng (NUS / IMRE)

Preparation of ZnO nanostructures using solution-based synthesis have been reported through several different methods such as sol-gel, spray pyrolysis, electrodeposition and solution-based methods. This presentation will focus specifically on the low temperature solution-based method which uses zinc acetate and ammonium hydroxide precursors. We will also focus on ZnO nanorods grown on substrates that have been pre-coated with ZnO nanoparticles. The solubility of zinc in the solution is calculated from the ionic equilibrium of the chemical system. Finally, the relationships between solubility, density and morphology of ZnO nanorods, based on classical thermodynamics of nucleation, are shown for the pH region between 10 and 11.2.



Mr Tay Chuan Beng graduated from NUS with B.Eng (Electrical) and M.Eng degrees in the year 2000 and 2001 respectively. After working with Offshore Technology Development as an engineer for 3 years, he returned to NUS in the year 2005 to pursue his PhD degree in Electrical Engineering, COE. His current research interest is in ZnO nanostructure fabrication and photodetectors based on ZnO.