

# Compound Semiconductor Optoelectronics Research at the Australian National University

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The group at the Australian National University (ANU) engages in multi-disciplinary research in the field of semiconductor optoelectronics and nanotechnology. The group is led by Professor C. Jagadish and consists of 2 research fellows, 2 post-doctoral fellows, 10 PhD students and a technician. In addition to this, usually there are several researchers and students who spend 3-12 months in the group working on a variety of projects. Although not limited to it, the group's main focus is on compound semiconductors. Listed below is a synopsis of the projects currently undertaken:

## Growth of Nanostructures

The synthesis and study of materials having at least two dimensions with nanometer scale size (i.e. so called 1D materials) such as nanotubes and nanowires has attracted intense interest due to their potential applications in electronics and photonics. Semiconductor nanowires have drawn considerable interest due to the potential of using conventional processes such as doping, junction formation, growth of heterostructures and superlattices during growth of nanowires. We are growing these nanowires by the so-called vapour-liquid-solid process in the Metalorganic Chemical Vapour Deposition (MOCVD) reactor. In addition we are also using ordered alumina porous membranes to create nano scale ordered gold patterns as nucleation sites for the growth of nanowires that could be used for fabrication of 3-D photonic crystals. On a separate but parallel study, we are investigating the growth of inverted opal III-V structures by MOCVD where the starting template of regularly stacked silica spheres are being infiltrated by III-V materials.

## Growth of Novel Materials

Novel (In,Ga)SbN compound semiconductors are of great interest for a wide range of device applications in the mid- to long-wavelength infrared spectral region. Due to the huge negative bandgap bowing effect from N, the emission/absorption wavelength of InGaSb and InSb can

respectively be extended to mid- and long-wavelength infrared spectral range by adding a few percent of N. The wavelength can be fine-tuned by controlling the N content. This project aims to develop such a novel (In,Ga)SbN material system for a new generation of mid- to long-wavelength infrared optoelectronic devices using MOCVD that could lead to the development of advanced applications in thermal imaging, environmental monitoring, biological and chemical sensing, disease diagnosis and treatments.

## Quantum Dot Optoelectronics Devices

Self-assembled semiconductor quantum dots (QDs) grown in the Stranski-Krastanow growth mode have found application in a multitude of optoelectronic devices such as lasers, modulators and photodetectors. Improved characteristics are predicted for these devices due to the unique electrical and optical properties provided by the quantum dots as a result of their 3-dimensional carrier confinement and delta function like density of states.

Research in the areas of QD lasers involves the growth of In(Ga)As(N) QDs laser structures on GaAs or InP substrates and investigating the properties of the devices such as gain saturation, the built-in electric field and the strain effects arising from the QDs.

The concept of using the intersubband absorption of infrared radiation has led to the development of quantum well infrared photodetectors (QWIPs) in the past decades. Quantum dot infrared photodetectors (QDIPs) are expected to show improved performance over their quantum well counterpart in detecting infrared signal due to the localized states in quantum dots and they respond to normal incidence photoexcitation. We fabricate and characterize QDIP devices grown by MOCVD and also investigate the various schemes that can be used to improve device performance and tunability (such as dots-in-a-well structure and intermixing).

## Integrated Optoelectronic Devices

# Semiconductor Optoelectronics Proceedings

**Sue-chu Shen,J H Chu,Z P Wang,J Q  
Yu,Gy Zhang**



## **Semiconductor Optoelectronics Proceedings:**

**Semiconductor Optoelectronics** Marian A. Herman, 1980      **Spectroscopy And Optoelectronics In Semiconductors And Related Materials - Proceedings Of The Sino-soviet Seminar** Sue-chu Shen, J H Chu, Z P Wang, J Q Yu, Gy Zhang, 1990-11-23 This proceedings volume covers new results from recent studies on impurity states bound states in semiconductors phonons excitons and electron confinement in superlattices and quantum wells magneto-optics optical properties of solids in far infrared and millimeter wave regions optical nonlinearity for III V II VI compounds Si Ge amorphous and organic semiconductors as well as optical crystals Special emphasis is placed on the 2DEG system

**Semiconductor Materials for Optoelectronics and LTMBE Materials** J.P. Hirtz, C. Whitehouse, H.P. Meier, H.J. von Bardeleben, M.O. Manasreh, 2016-07-29 These three day symposia were designed to provide a link between specialists from university or industry who work in different fields of semiconductor optoelectronics Symposium A dealt with topics including epitaxial growth of III V II VI IV VI Si based structures selective area localized and non planar epitaxy shadow mask epitaxy bulk and new optoelectronic materials polymers for optoelectronics Symposium B dealt with III V epitaxial layers grown by low temperature molecular beam epitaxy a subject which has undergone rapid development in the last three years

Proceedings of the Symposium on Light Emitting Devices for Optoelectronic Applications and the Twenty-Eighth State-of-the-Art Program on Compound Semiconductors Electrochemical Society. Luminescence and Display Materials Division, Electrochemical Society. Meeting, 1998      *Semiconductor Optoelectronics*, 1995      **Proceedings of the**

**IEEE/LEOS 3rd International Conference on Numerical Simulation of Semiconductor Optoelectronic Devices**, 2003      Mid-infrared Semiconductor Optoelectronics Anthony Krier, 2007-05-22 Optoelectronic devices operating in the

mid infrared wavelength range offer applications in a variety of areas from environmental gas monitoring around oil rigs to the detection of narcotics They could also be used for free space optical communications thermal imaging applications and the development of homeland security measures Mid infrared Semiconductor Optoelectronics is an overview of the current status and technological development in this rapidly emerging area the basic physics some of the problems facing the design engineer and a comparison of possible solutions are laid out the different lasers used as sources for mid infrared technology are considered recent work in detectors is reviewed the last part of the book is concerned with applications With a world wide authorship of experts working in many mid infrared related fields this book will be an invaluable reference for researchers and graduate students drawn from physics electronic and electrical engineering and materials science

**Directory of Published Proceedings**, 1996      **Proceedings of the Symposium on III-V Opto-Electronics Epitaxy and Device Related Processes** V. G. Keramidis, Subhash Mahajan, 1983      *Scientific and Technical Aerospace Reports*, 1994      **Lasers** Charles Blain, 2002 Developments in lasers continue to enable progress in many areas such as eye surgery the recording industry and dozens of others This book presents citations from the book literature for the last 25 years and

groups them for ease of access which is also provided by subject author and titles indexes      **Advances in Dielectric Materials and Electronic Devices** K. M. Nair, Ruyan Guo, Amar S. Bhalla, D. Suvorov, S.-I. Hirano, 2012-04-11 This proceedings contains papers presented at the Advanced Dielectric Materials Design Preparation Processing and Applications and Advanced Dielectrics for Wireless Communications symposia Topics include design of material materials synthesis and processing processing microstructure property relationship multilayer device materials thin and thick films device applications low temperature co fired ceramics LTCC for multilayer devices microwave dielectric materials and much more

**Proceedings of the Fourth Symposium on Low Temperature Electronics and High Temperature Superconductivity** Cor L. Claeys, 1997      Microelectronics Education - Proceedings Of The European Workshop George Kamarinos, Nadine Guillemot, Bernard Courtois, 1996-08-22 The 1st EWME is an International Tribune where The Education in Microelectronics in 15 universities from 10 different countries are presented The International Cooperation using the available multimedia is discussed Pedagogical problems concerning the teaching of classical microelectronics technology devices and CAD as well as those concerning the sensors microsystems and advanced materials are examined Besides more general pedagogical views relative to the extended use of models CAD and simulations are exposed      **Proceedings of the ... European Conference on Chemical Vapor Deposition**, 1995      Materials for Optoelectronic Devices, OEICs and Photonics H. Schlötterer, M. Quillec, P.D. Greene, M. Bertolotti, 1991-10-08 The aim of the contributions in this volume is to give a current overview on the basic properties and applications of semiconductor and nonlinear optical materials for optoelectronics and integrated optics They provide a cross linkage between different materials III V II VI Si Ge glasses etc various sample dimensions from bulk crystals to quantum dots and a range of techniques for growth LPE to MOMBE and for processing from surface passivation to ion beams Major growth techniques and materials are discussed including the sophisticated technologies required to exploit the exciting properties of low dimensional semiconductors These proceedings will prove an invaluable guide to the current state of optoelectronic and nonlinear optical materials development as well as indicating trends and also future markets for optoelectronic devices      *Proceedings of the Twenty-Seventh State-of-the-Art Program on Compound Semiconductors (SOTAPOCS XXVII)* S. N. G. Chu, 1997      Optoelectronic Integrated Circuit Design and Device Modeling Jianjun Gao, 2011-09-19 In Optoelectronic Integrated Circuit Design and Device Modeling Professor Jianjun Gao introduces the fundamentals and modeling techniques of optoelectronic devices used in high speed optical transmission systems Gao covers electronic circuit elements such as FET HBT MOSFET as well as design techniques for advanced optical transmitter and receiver front end circuits The book includes an overview of optical communication systems and computer aided optoelectronic IC design before going over the basic concept of laser diodes This is followed by modeling and parameter extraction techniques of lasers and photodiodes Gao covers high speed electronic semiconductor devices optical transmitter design and optical receiver design in the final three chapters Addresses a gap within the rapidly growing

area of transmitter and receiver modeling in OEICs Explains diode physics before device modeling helping readers understand their equivalent circuit models Provides comprehensive explanations for E O and O E conversions done with laser and photodiodes Covers an extensive range of devices for high speed applications Accessible for students new to microwaves Presentation slides available for instructor use This book is primarily aimed at practicing engineers researchers and post graduates in the areas of RF microwaves IC design photonics and lasers and solid state devices The book is also a strong supplement for senior undergraduates taking courses in RF and microwaves Lecture materials for instructors available at [www.wiley.com/go/gao](http://www.wiley.com/go/gao)      **Handbook of Optoelectronic Device Modeling and Simulation** Joachim Piprek, 2017-10-12

Optoelectronic devices are now ubiquitous in our daily lives from light emitting diodes LEDs in many household appliances to solar cells for energy This handbook shows how we can probe the underlying and highly complex physical processes using modern mathematical models and numerical simulation for optoelectronic device design analysis and performance optimization It reflects the wide availability of powerful computers and advanced commercial software which have opened the door for non specialists to perform sophisticated modeling and simulation tasks The chapters comprise the know how of more than a hundred experts from all over the world The handbook is an ideal starting point for beginners but also gives experienced researchers the opportunity to renew and broaden their knowledge in this expanding field      **Infrared**

**Detectors** Antonio Rogalski, 2010-11-15 Completely revised and reorganized while retaining the approachable style of the first edition Infrared Detectors Second Edition addresses the latest developments in the science and technology of infrared IR detection Antoni Rogalski an internationally recognized pioneer in the field covers the comprehensive range of subjects necessary to un

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