Research Fellows and Research Projects (2003/2004)

AMM&NS programme

Dr Chen Zhen
Expertise: III-nitride materials and devices characterization and fabrication

GaN-Based White LED Research and Fabrication

Project Advisor (Singapore)	:	Prof Chua Soo Jin
Project Advisor (MIT)	:	Prof Eugene A. Fitzgerald
Duration	:	October 2002 to October 2004

Project Abstract :
The current applications of the white LED include the instrument panels of motor vehicles and LCD backlighting. Its main goal is to increase the level of luminosity allowing replacement for incandescent lamp because LEDs are smaller, higher efficiency, and live about 50 times longer compared to ordinary light bulbs. The different methods are put forward to incorporate the various emission-band layers into one chip in order to produce the white LED which will be cheaper, more convenient and more stable. Various physical principles, such as the peak redshift by piezoelectric field, the impurity emission and the emission from InGaN with various compositions, will be used to obtain the whole visible spectrum.

Study of the ZnO-GaN Nanostructures

Project Advisor (Singapore)	:	Prof Chua Soo Jin
Project Advisor (MIT)	:	Prof Eugene A. Fitzgerald
Duration	:	October 2003 to October 2004

Project Abstract :
GaN-based materials and devices are widely applied in blue/green, UV optical and electronic devices. The GaN group, headed by Prof Chua Soo Jin has fabricated the UV/ visible LEDs and is equipped with facilities for the III-nitride materials growth, characterization and device processing. This piece of work is done in collaboration with IMRE and chemistry department. Assoc Prof Loh Kian Ping's group in the chemistry department has fabricated ZnO and BN nanostructure on different substrates with various growth methods. This project will combine the strength of both groups to grow AlGaInN / ZnO and AlInGaN / BN hetero-nano structures with the aim of achieving highly efficient visible LEDs. AlGaInN/ZnO and AlGaInN/BN structures can be used to fabricate novel high efficiency light emitting devices because of the much larger active area which can be obtained when using nano-hetero-structure as active layer compared with the ordinary planar devices. Furthermore, The AlInGaN/BN and AlInGaN/ZnO will have many novel properties due to the low dimensional structures. These properties will be investigated in this project.

Dr Fu Yongqing
Expertise: Shape memory alloy actuators, MEMS, nanocomposite thin film and coatings

Shape Memory Alloy Thin Films for MEMS Applications

Project Advisor (Singapore)	:	Assoc Prof Du Hejun
Duration	:	March 2003 to March 2005

Project Abstract :
Shape memory TiNi thin film has been recognized as a promising and high performance material in the field of micro-electro-mechanical system (MEMS) applications. The work output per volume of thin film SMA exceeds that of other micro-actuation mechanisms. In this project, TiNi based (TiNiCu, TiNiPt, TiNiPd, etc.) films are prepared using magnetron sputtering. Microstructure, mechanical properties and shape memory effects of the prepared thin films are characterized with the consideration of different process parameters. Based on the high-performance TiNi based thin films, different MEMS based structures (microcantilever, microgripper, microvalves and pumps, micromirror, etc.) will be designed and fabricated using MEMS processes.

Dr Michael Brian Sullivan
Expertise: Molecular modeling of apatites

Density Functional Theory Studies of Halide Apatites

Project Advisor (Singapore)	:	Dr Wu Ping
Duration	:	July 2003 to July 2004

Project Abstract :
Apatites are found in everything from natural sources like bone, shells and rocks to materials found in fluorescent light bulbs and treatment of industrial and nuclear wastes. We have used computational methods to study the energetics and crystal structure of fluorapatite as well as starting to study chloro and bromo apatite when placed under pressure. For fluorapatite, when we apply pressures up to 100 GPa, we see a contraction of the cell lattice especially along the a axis while the c axis does not change as dramatically. As expected, the phosphate groups become more tetrahedral with applied pressure. We will continue this work as fluorapatite is replaced with chloro and bromo apatite as well as other possible substitutions both with and without pressure.

Dr Zhang Guoge
Expertise: Materials characterization; joining technology

Advanced Bonding Technology for Microelectronics

Project Advisor (Singapore)	:	Assoc Prof Wong Chee Cheong
Duration		March 2003 to February 2005

Project Abstract :
Although various bonding methods have been developed for flip chip assembly, most of them cannot be applied to ultra-high density interconnections for the next generation. Direct metal bonding is a promising candidate for solving all the above problems. Presently, most direct metal bonding is done by thermosonic methods, where ultrasonic energy is applied to lower the bonding temperature and pressure. Although thermosonic bonding is an attractive choice, there are distinct disadvantages. For example, it is difficult to control the ultrasonic energy transmission. Small deviations from planarity between the bonding tool and the stage can result in non-uniform ultrasonic energy distribution. Another potential problem is silicon cratering, which results from excessive ultrasonic vibration. This project is to develop a direct metal bonding method at low temperatures and low pressures for hybrid integration, build up a model on the interfacial kinetics of bond formation, and carry reliability studies on direct metal direct bonding for fine-pitch flip chip and waferscale 3-d interconnections.

Dr Zhang Yong
Expertise: Formation and properties of bulk metallic glasses, and bulk metallic glass matrix composites

Mechanical Behavior of Bulk Metallic Glasses and Bulk Metallic Glass Matrix Composites

Project Advisor (Singapore)	:	Assoc Prof Li Yi
Project Advisor (MIT)	:	Prof W. Craig Carter
Duration	:	April 2003 to November 2004

Project Abstract :
Bulk metallic glasses are a new kind of materials which were discovered in 1990's, the discovery opened a new research area for both fundamental science and engineering applications. The unique microstructures of bulk metallic glasses, e.g. absent of long range order, grain boundary, and dislocation, and with homogeneous metallography structure, lead the bulk metallic glasses to have unique properties compared with its counterpart - the crystalline materials. In this project, mechanical properties of the bulk metallic glasses and the bulk metallic glass matrix composites, such as compressions, tensions, and impacts properties, are systematically studied. The mechanical properties are analyzed by oof (object-oriented finite element analysis).

Dr Zhu Tiejun
Expertise: Pulsed laser deposition of ferroelectric thin films and thin micro-batteries

Pulsed Laser Deposition of Oxide Thin Films on Si Substrates

Project Advisor (Singapore)	:	Assoc Prof Lu Li
Project Advisor (MIT)	:	Prof Carl V. Thompson
Duration	:	January 2002 to January 2004

Project Abstract :
Perovsike oxide thin films have attracted much attention for their applications in microelectronic and optoelectronic devices. Pulsed laser deposition (PLD) is an extremely versatile technique to obtain epitaxial thin films and multilayers of multi-component oxides. This research focuses on fabrication of piezoelectric lead zirconate titanate (PZT) thin films with various underlayers on Si substrates by PLD technique. The objective of the present project is to grow thin films with preferred orientation under different processing conditions. The effects of deposition parameters, downscaling and materials integration strategies on orientation, micro-structure, ferroelectric properties and domain structure of PZT films are systematically addressed.