FORUM FOR JOINT ATN-ISTA RESEARCH NETWORK IN NANOTECHNOLOGY

Venue :	Liu Yuan Hotel, Southeast University
Date :	30 June 2008 – 1 July 2008
Organizers :	Australian Technology Network (ATN) International Strategic Technology Alliance (ISTA)
Host Institution:	Southeast University, Nanjing, China

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PROGRAMME

30 June 2008 (Monday)

Liu Yuan Hotel, Southeast University, Nanjing, China

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09:10	**Session One** **Speakers:** Prof. Ning Gu, Dean, School of Biological Science and Medical Engineering, Southeast University, China ***The Effect of Magnetic Nanoparticles on Smooth Muscle Cells and Cardiomyocytes*** Prof. Mike Cortie, Director, Institute for Nanoscale Technology, University of Technology Sydney, Australia ***Plasmonic Heating in Anisotropic Arrays of Precious Metal Nanoparticles*** Prof. Wan-lin Guo, Director, Institute of Nanoscience, Nanjing University of Aeronautics and Astronautics, China ***Physical Mechanics of Intelligent Nanomaterials and Devices*** Assoc. Prof. Huai Yong Zhu, Associate Professor, School of Physical and Chemical Sciences, Queensland University of Technology, Australia ***Functional Materials from Titanate Nanofibres***
10:50	Refreshment break
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Assoc. Prof. Michael John Ford, Associate Professor, Institute for Nanoscale Technology, University of Technology Sydney, Australia
Large-scale Atomistic Simulation of Nanostructures and Materials

Dr Tian-bin Ren, Associate Professor, Institute of Nano and Bio-polymeric Material, School of Material Science and Engineering, Tongji University, China
Introduction of Nanomaterial Research in Tongji University

Dr Benjamin Thierry, Research Fellow, Ian Wark Research Institute, University of South Australia, Australia
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Speakers:

Prof. Gao-jun Teng, Professor and Director, Department of Radiology, Clinical Medical College, Zhongda Hospital, Southeast University, China
Cellular MR Imaging with Superparamagnetic Iron Oxide Particles (SPIO)

Dr Cheng Yan, Senior Lecturer, School of Engineering Systems, Queensland University of Technology, Australia
Characterization of Nanomaterials and Nanostructures

Dr Rahul Gupta, Research Fellow, Rheology and Materials Processing Centre (RMPC), School of Civil, Environmental and Chemical Engineering, RMIT University, Australia
Rheology of Polymeric Nanocomposites: An Overview

Dr Thomas Becker, Research Fellow, Nanochemistry Research Institute, Curtin University of Technology, Australia
SPM at Curtin University of Technology: The Facility & Some Projects

Dr Vipul Bansal, Tenure Track Fellow, School of Applied Science, RMIT University, Australia
Nanoporous and Capsular Nanostructures for Catalysis and Drug-Delivery Applications

17:45 **Closing Remarks**

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1 July 2008 (Tuesday) **Liu Yuan Hotel, Southeast University, Nanjing, China**

09:00 **Discussion for Next Steps Towards Research Collaborations among ATN and ISTA Member Institutions**

Participants:

Representatives of participating universities, ATN Secretariat and ISTA Secretariat

10:00 End of Forum

Laboratory Visit

A visit to the State Key Laboratory of Bioelectronics and the Jiangsu Key Laboratory for Biomaterials & Devices in Southeast University will be held at 10:00-11:30 after the Forum.

LIST OF PARTICIPANTS

ORGANIZATION	TITLE	NAME
Australian Technology Network	Director	Ms Vicki Thomson
Curtin University of Technology	Senior Lecturer, Nanochemistry Research Institute	Dr Bill Richmond
Curtin University of Technology	Research Fellow, Nanochemistry Research Institute	Dr Thomas Becker
Hong Kong Polytechnic University	Project Manager, Innovative Technology Research Syndicate	Mr Micky Lo
International Strategic Technology Alliance	Secretary-General	Mr Alwin Wong
Nanjing University	Executive Dean, Institute of Advanced Technology	Prof. Yi Shi
Nanjing University	Professor, School of Chemistry and Chemical Engineering	Prof. Zheng Hu
Nanjing University of Aeronautics and Astronautics	Director, Institute of Nanoscience	Prof. Wan-lin Guo
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Queensland University of Technology	Associate Professor, School of Physical and Chemical Sciences	Assoc. Prof. Huai Yong Zhu
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RMIT University	Pro Vice Chancellor, Research and Innovation	Prof. Neil Furlong
RMIT University	Senior Lecturer, School of Electrical and Computer Engineering	Dr Kourosh Kalantar-zadeh
RMIT University	Research Fellow, School of Civil, Environmental and Chemical Engineering	Dr Rahul Gupta
RMIT University	Tenure Track Fellow, School of Applied Science	Dr Vipul Bansal
Southeast University	Vice President	Prof. Jiong Shen
Southeast University	Dean, School of Biological Science and Medical Engineering	Prof. Ning Gu
Southeast University	Professor and Director, Department of Radiology, Clinical Medical College, Zhongda Hospital	Prof. Gao-jun Teng
Southeast University	Director, Science and Technology Office	Dr Jian-qing Li
Southeast University	Deputy Director, Science and Technology Office	Dr Pei-lin Huang
Southeast University	Associate Professor	Dr Yu Zhang
Southeast University	Lecturer	Dr Fei Xiong
Southeast University	Lecturer	Dr Jian-fei Sun
Southeast University	Lecturer	Dr Xin Chen
Tongji University	Associate Professor, Institute of Nano and Bio-polymeric Material, School of Material Science and Engineering	Dr Tian-bin Ren
University of Shanghai for Science and Technology	Director, Institute of Processing Machinery	Prof. Shu-lin Wang
University of South Australia	Research Fellow, Ian Wark Research Institute	Dr Benjamin Thierry
University of Technology Sydney	Director, Institute for Nanoscale Technology	Prof. Mike Cortie
University of Technology Sydney	Associate Professor, Institute for Nanoscale Technology	Assoc. Prof. Michael John Ford

The Effect of Magnetic Nanoparticles on Smooth Muscle Cells and Cardiomyocytes

Prof. Ning Gu

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Abstract

In this presentation, we will introduce the biological effect of magnetic nanoparticles on Sprague-Dawley (SD) rat aortic SMC and cardiomyocytes. When incubated with SMC, magnetic nanoparticles do not cause inflammation or apoptosis of cells, but inhibit the proliferation of cells. For cardiomyocytes, magnetic nanoparticles have shown good biocompatibility under the conditions of experiments. Interestingly, the magnetic nanoparticles can protect the cardiomyocytes against the injury of hypoxia-reoxygenation, which should be potentially applicable for some medical purposes.

Speaker biography

Prof. Gu obtained his bachelor degree in radio engineering from Nanjing Institute of Technology, master and doctoral degree in bioelectronics and biomedical engineering respectively from Southeast University. Since 1997, he has been appointed as a Professor in Southeast University. He had been visiting scholars to Tokyo University, Yamanashi University, National Institute of Materials and Chemical Research (NIMS) and Institute for Molecular Science (IMS). Currently, he is the Dean of the School of Biological Science and Medical Engineering, and the Director of the Research Centre for Nanoscale Science and Technology in Southeast University. Prof. Gu has published over 180 journal papers on organic materials, thin films, AFM characterization of biomaterials, nanoparticles and nanofabrication for biomedical applications, etc. His current research interests include functional nanomaterials, molecular assembly, nanofabrication, nanodevices, and their applications in biomedicine.

<u>A Brief Introduction of the Biological and Medical Nanotechnology Group</u>

Established in 2000 and belongs to the School of Biological Science and Medical Engineering in Southeast University, the Biological and Medical Nanotechnology Group is a crucial constituent of the State Key Laboratory of Bioelectronics. Based on the researches in nanomaterials, especially magnetic nanomaterials, and their applications in the biomedical field, it has become one of the most outstanding biomedical nanotechnology research groups in China.

The group focuses in the researches on nanomaterial, molecular assembly, biosensors, nanodrug delivery, tumour diagnosis, therapy and nanobiological effects. Supported by numerous national programs and foundations of China, such as the “863 Program”, the “973 Program” and the “National Natural Science Foundation of China”, it has many distinguished achievements in the fields of magnetic nanomaterials, magnetic fluid hyperthermia and the interaction between nanomaterials and cells.

Plasmonic Heating in Anisotropic Arrays of Precious Metal Nanoparticles

Prof. Mike Cortie

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Abstract

Nanoscale particles and structures of metals such as gold and silver can undergo a plasmon resonance with light. As a result, some of the incident light is scattered and some is absorbed. The absorbed portion is converted to heat, a phenomenon sometimes known as ‘plasmonic heating’. The temperature rise in the vicinity of the nanoparticles can be exploited for a variety of applications. For example, it seems possible to design and produce spectrally-selective optical coatings based on this technology. The optical properties and hence plasmonic heating in coatings of precious metal nanoparticles is also affected by their geometric arrangement. A coating comprised of a random arrangement of nanoparticles, for example, has different properties to one comprised of aligned or ordered nanoparticles. We are studying these differences using both experimental and modelling techniques because they offer new insights and opportunities.

Speaker biography

Prof. Cortie has a BSc, a MSc and a PhD degree, all in materials engineering. After some years at the Atomic Energy Board in South Africa, he worked at a gear-cutting works, and then, for 15 years, at Mintek, a South African research organisation devoted to the minerals and metals industry. While at Mintek he acquired extensive consultancy experience with international metallurgical and manufacturing industries. He relocated to Australia in 2002 and is currently the Director of the Institute for Nanoscale Technology, at the University of Technology Sydney. Prof. Cortie’s research interests include nanostructured materials with metastable structures, precious metal alloys and compounds, gold nanoparticles and catalysts, shape memory alloys and smart materials, and nanoscale devices and manufacturing. His current research activities include plasmonic devices, and diverse applications of mesoporous and nanoparticulate gold as optically selective coatings and for systems and sensors involving proteins.

Physical Mechanics of Intelligent Nanomaterials and Devices

Prof. Wan-lin Guo

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Abstract

Functional or intelligent materials which can transfer energy from one form into other forms have provided us various means to invent novel devices and machines. We found from recent researches on the nanoscale structures that when the scale is close to the characteristic physical scale of the matter, the local fields of the atomic structures become strongly coupled with the external applied forces or fields. It is this coupling effect which causes a matter, even a very common matter such as carbon, to behave intelligently, and to confer energy from one form into other forms with surprisingly high energy density.

As any motion of an atom in a nanosystem is strongly coupled with electron redistributions, in order to find the exceptional intelligent properties of nanostructures due to the strong coupling of the local fields of the matters with the applied external fields, one have to unify the traditional mechanics principles with the quantum mechanics theory. This brings us challenges as well as opportunities for new findings. Here we demonstrate this new trend with some of our recent advances in the physical mechanics study of nanomaterials and devices.

Speaker biography

In 1981-1991, Prof. Guo studied aerospace engineering and solid mechanics in Northwestern Polytechnical University and obtained his bachelor, master and PhD degrees. Since 1991, he had been a Postdoctoral Researcher, Associate Professor and Professor in Xi'an Jiaotong University and had been the Deputy Director of the State Key Laboratory of Mechanical Strength and Vibration for six years. In 1995-1998, he worked at the Centre-of-Expertise of Australian Defence Science and Technology Organization at Monash University. He obtained the Outstanding Young Scientist Award (Premier Fund) of China in 1996. He was then honoured the Cheung Kong Scholars in 1999 and had been a Chair Professor in Nanjing University of Aeronautics and Astronautics since 2000. In 2002-2004, he had been the Visiting Professor in the Max Planck Institute for Metals Research in Stuttgart, Germany, and the Hong Kong University of Science and Technology.

He has published over 120 refereed papers in mechanics-related journals and over 50 papers in conferences. His current research interests include:

- nanoscale physical mechanics
- intelligent nanomaterials and devices
- high efficiency energy transfer nanotechnology
- structure-function correlation of functional proteins and ion channels
- biomechanics, bioinformation and molecular biomimics

- large scale scientific calculations and multiscale simulations

His current research activities include:

- physical mechanics of carbon nanomaterials
- mechanical and electromagnetic properties of boron nitrogen nanotube and nanoribbons
- dimensional and size effects of ZnO structures
- synthesis and physical mechanics of optoelectronic and thermoelectric nanomaterials
- high-frequency nanodevices and energy transfer nanotechnology
- nano tribology and manipulation
- biomechanics and bioinformation
- dynamic functions of potassium ion channels and NaK channel
- multiscale failure mechanics of materials and structures

Functional Materials from Titanate Nanofibres

Assoc. Prof. Huai Yong Zhu

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Abstract

Titanate nanofibres can be produced by reacting concentrated NaOH solution with a titanium compound or titania (even a rutile mineral) under hydrothermal conditions (200°C or below). These nanofibres have layered structures and exchangeable sodium ions. They have a large surface to volume ratio, and are able to react with dilute acids or transform to TiO_2 polymorphs at moderate temperatures. These properties are utilized to fabricate a series of functional materials. The nanofibres can selectively absorb the bivalence radioactive ions from water through ion exchange process, and such sorption finally induces collapse of the interlayer space, which results in entrapment of the radioactive cations in the fibres permanently. Such intelligent absorbents are ideal for removal of radioactive ions from water. We can fabricate high-flux ceramic nanofilters by constructing the separation layer with the nanofibres, on the top of porous ceramic supports. This approach greatly improves the performance of the membranes, which can effectively filter out species larger than 60nm at flow rates that are 15-100 times greater than that for conventional membranes with similar separation selectivity, and can be used in various separation processes, including water and air purification, enriching radioactive materials, separations in petrochemical, pharmaceutical and food industries. The efficient photocatalysts can also be obtained by controlled phase transition of the fibres. They include nanofibres of mixed anatase and TiO_2(B) phases, TiO_2(B) nanofibres covered with anatase nanocrystals and single-phase anatase nanofibres. Such studies result in catalysts that possess high photocatalytic activity and can be readily dispersed into and separated from liquid phase, or exhibit considerable activity under visible light.

Speaker biography

Assoc. Prof. Zhu obtained his BSc degree in physical chemistry from Inner Mongolia University, China, MSc degree in chemistry from Nankai University, China, and PhD degree in chemistry from University of Antwerp, Belgium. He had been a researcher in Hiroshima University, University of Queensland and the University of Sydney.

Assoc. Prof. Zhu joined Queensland University of Technology in 2005, and is currently an Associate Professor of material chemistry. His research is mainly in the areas of inorganic nanomaterials. Current interests and significant contributions to the research field include: visible light photocatalysts of gold nanoparticles on oxide supports, synthesis of one dimensional inorganic nanostructures, advanced fibril adsorbents, ceramic membranes of nanofibres and new photocatalysts.

Assoc. Prof. Zhu was invited to be an International Expert of the Innovation Team of Chinese Academy of Sciences, and was invited to give lectures at a number of international conferences and universities in various countries. He was granted a Queen Elizabeth II Fellowship in 2000-2004 and has been awarded 7 Australian Research Council (ARC) Discovery or Large Projects consecutively, an ARC Linkage International and an ARC Linkage Project since 1998. He has published 93 journal papers as well as 17 papers in peer-reviewed conference proceedings. These publications have been cited over 1,700 times so far, and 7 papers are listed as "Highly Cited Papers" by ISI Web of Knowledge in the fields of chemistry, materials science and engineering. He is an inventor of seven invention patents.

Hetero-nanocrystals and their Applications in Non-volatile Memories

Prof. Yi Shi

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Abstract

Nanocrystal-based floating gate memories have been studied extensively, which is considered as the promising candidate of non-volatile memories based on polycrystalline silicon film. For a homo-nanocrystal based memory, however, the trade-off between long retention time and high programming/erasing speed still remains The heterostructures are considered as the most hopeful way to overcome the above-mentioned dilemma, where the combination of different band-gaps makes the injected charge well stored in the side of lower energy band. Simulation and experimental results demonstrate that Ge/Si hetero-nanocrystal improves the retention characteristics dramatically without influencing the writing/erasing speed.

Speaker biography

Prof. Shi obtained his bachelor degree in applied physics from the National University of Defense Technology in 1983, and the master and PhD degrees from Nanjing University in 1986 and 1989 respectively. He was appointed as an Associate Professor and a Professor in Nanjing University in 1993 and 1995 respectively. Prof. Shi was awarded the National Natural Science Foundation of China (NSFC) fund for Outstanding Young Scientists of China in 2003. He is currently a Professor in the Department of Physics and the Executive Dean of Institute of Advanced Technology in Nanjing University.

Since 1991, Prof. Shi had been visiting scholars to Institute for Materials Research in Tohoku University, Debye Institute for Nanomaterials Science in Utrecht University, University of Tokyo, University of California, Berkeley, Massachusetts Institute of Technology and University of Cambridge. Over the past ten years, he has over 130 publications and has filed 17 patents. His main research areas include silicon-based nanostructure fabrication, nano-electronics, nano-optoelectronics, fabrication, characterization, and applications of semiconductor nanowires.

Nano/micro Technology Research Activities at MMTC, RMIT University

Dr Kourosh Kalantar-zadeh

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Abstract

The current research activities on nano/micro technology at the Microelectronics and Materials Technology Centre (MMTC) will be presented. This includes the work on chemical and electrochemical sensors, optical and electronic devices as well as microfluidics.

RMIT University's MMTC was established in 1982 as a Commonwealth Government funded “Centre of Excellence” specialising in microelectronics and materials research. Today, the MMTC is recognized as a leading Australian research facility for the design, fabrication, packaging and characterization of micro/nano-scale devices. Located in RMIT’s School of Electrical and Computer Engineering, the MMTC has an extensive range of fabrication and characterization equipment and recognized expertise in device fabrication and packaging technologies. The Centre includes two clean-rooms, a vacuum laboratory, a device characterization laboratory and a device packaging laboratory. In addition, there is an associated integrated optics laboratory and a sensor technology laboratory

Speaker biography

Dr Kalantar-zadeh is currently involved in the development of micro/nano chemical and biochemical sensors, micro/nano sized materials and devices, as well as microfluidic systems. He has published more than 140 scientific papers in refereed journals and in the proceedings of national and international conferences. He holds 4 patents. His recent book entitled “Nanotechnology Enabled Sensors” became one of the best-selling technical books in the field of nanotechnology in 2007 just within 4 weeks.

Dr Kalantar-zadeh has been highly motivated to initiate new areas of fundamental and applied research. He was instrumental in the development of Layered Surface Acoustic Wave Biosensors, which has been patented and underwent commercial development through the spin-off company Biosenz. He has received more than A$1,000,000 in grant funding as the principal investigator or project leader for the year 2007 alone. Dr Kalantar-zadeh has been a co-chair of the SPIE conference on Microelectronics, MEMS and Nanotechnology held in 2007 and 2008. He has received several prestigious awards, including Endeavour Australia Cheung Kong Award 2005, IEEE Ultrasonics 2004, CASS travel grants 2008, 2004 and 2003, the IEEE Ferroelectrics 2002 and the MOEC business plan award, Melbourne University. He is the associate editor of the “Journal of Sensors” and also serves as a reviewer for numerous scientific journals.

Nanoscale Crystallisation Research at Curtin University of Technology

Dr Bill Richmond

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Abstract

Precise control of size and shape are important goals in the synthesis of functional nanoparticles, as these factors play a key role in determining properties. Morphology control in the formation of iron oxide and oxyhydroxide nanoparticles can be approached in a number of ways, and this presentation outlines some of the approaches that have been explored in recent work at the Nanochemistry Research Institute. In some cases, control of nanostructure and particle aggregation characteristics can be achieved by simple control of supersaturation conditions, while in others, crystal morphology is modified by the face-selective action of organic additives. For example, the effect of polyphosponates on hematite nanoparticle morphology has been studied under both acidic and basic conditions and the experimental results have been interpreted in conjunction with molecular modelling studies of the crystal surface/additive interaction. Studies of crystal growth mechanisms in the formation of iron oxide and oxyhydroxide nanoparticles will also be presented, with examples of some novel, tube-like morphologies and evidence for growth of larger assemblies by oriented aggregation of nanoparticulate sub-units.

Speaker biography

Dr Richmond is a senior lecturer at Curtin University of Technology and is the program leader of the “Solid State Chemistry” program within the Nanochemistry Research Institute (NRI). His research interests lie in the area of precipitation-based nanoparticle synthesis with a particular interest in morphology control and crystallisation mechanisms. Much of his research activity is concerned with the characterisation of nanoscale materials using electron and scanning-probe microscopies as well as X-ray analytical methods. He has a research group of three PhD students and two honours students and works closely with NRI colleagues with expertise in computational modelling and synthetic chemistry. In addition to his research activities, Dr Richmond teaches various topics within the chemistry degree at Curtin, and since 2005, he has been the course coordinator for Curtin’s BSc(Nanotechnology) degree.

Growth, Structures and Properties of Carbon-based Nanotubes and One-dimensional Nanostructured Materials of Group-III Nitrides

Prof. Zheng Hu

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Abstract

The discovery of carbon nanotubes (CNTs) has opened a new and fascinating family of one-dimensional nanostructures with great scientific and technological importance. Here below are the recent progress of our team in researches related to carbon-based nanotubes and one-dimensional AlN nanostructured materials.

1. By using in-situ thermal analysis-mass spectroscopic technique, the CVD growth process of CNTs with benzene precursor has been clearly demonstrated and the six-membered-ring-based growth mechanism is deduced. By applying this mechanism to the synthesis of CNx nanotubes from pyridine precursor, the nitrogen content in CNx nanotubes has been regulated within 3-8%. The so-synthesized CNx nanotubes have quite uniform distribution of the nitrogen species which is beneficial for surface functionalization. The platinum nanoparticles were then conveniently immobilized on the CNx nanotubes due to the N-participation. The promising electrocatalytic property of the as-prepared Pt/CNx catalyst is suitable for methanol oxidation.

2. Despite the growing popularity of nanotubular structures, most of them possess evenly-bent geometry due to layered compounds as in the case for CNTs. Our research demonstrated that a template-free synthesis of faceted single-crystalline h-AlN nanotubes is possible. This extends the nanotubular structures from layered compounds to non-layered compounds. This also provides an ideal substrate for the construction of GaN-based nanoheterostructures in future nanoelectronics. In addition, AlN nanowires, nanocones and nanobelts, random or aligned, are also successfully prepared and well-characterized. The promising field emission properties observed from h-AlN nanowires and nanocones imply their potentials for various important applications.

Speaker biography

Prof. Hu obtained his BSc, MSc and PhD degrees from Nanjing University in 1981-1991. He had been an Associate Professor and Professor in the same university since 1993. During the ten years from 1996, he had been a visiting scientist to the Research Centre of Karlsruhe in Germany, the National University of Singapore and the University of Cambridge, UK. As the principal scientist, Prof. Hu has finished more than 15 research projects with honour. In 2005, he got the highly competitive National Natural Science Foundation of China (NSFC) fund for Outstanding Young Scientists of China. He has published more than 100 papers in peer-reviewed journals and is the principal inventor on 11 Chinese patents. He is currently the Director of the Key Laboratory of Mesoscopic Chemistry of the Ministry of Education, and the Deputy Director of Jiangsu Provincial Lab for Nanotechnology.

His research group engages in the studies on the preparation, structural characterization and functionalization of carbon-based nanotubes and nanostructured materials of Group-III nitrides and some other semiconductors. The group also involves in the exploration of energy materials, such as the new catalyst for fuel cells.

Synthesis of Binary Nanocomposite of $Ti_{50}Zr_{50}$ and its Characterization

Prof. Shu-lin Wang

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Abstract

Our research works showed that dispersed zinc particles of 3-5nm in size can be obtained in large scale with low cost by the Roller Vibration Milling (RVM) method at room temperature and in dry mode. Pure binary nanostructured Ti-Zr alloy of 7.6 nm grain size can also be produced by the RVM method at room temperature, which was ever considered ‘impossible’. The alloy still has hexagonal characteristic, but the axial ratio is much smaller than that of the ideal hexagonal close-packed structure and the standard value of Ti and Zr. Surface chemical change analysis by photoelectron spectrum demonstrated that the mechanical property, biocompatibility, corrosion resistance, and the wear resistance of the materials make it suitable in orthopedic applications. The RVM method can also modify active carbon as electrode materials of super-capacitors to increase their specific capacitance. The significance of this milling method is that it can increase the specific area, crystallinity, and improve the pore distribution of the materials at the same time.

Speaker biography

Prof. Wang is a distinguished specialist in science and technology nominated in 1986 by the Nation. He is the Director of the Institute of Processing Machinery and the leader of the doctoral program in the University of Shanghai for Science and Technology. In 1981-1983, he got the national scholarship and studied as a visiting scholar in TU Braunschweig. In 1992-1993, he was a visiting professor in TH Aachen, Germany. Research interests of his team are Zn nanoparticles, ZnO nanorods, photo-catalytic degradation, binary nanocomposite of Ti-Zr and its orthopedic applications.

Large-scale Atomistic Simulation of Nanostructures and Materials

Assoc. Prof. Michael John Ford

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Abstract

Computer simulation at the level of atoms and molecules have played a crucial role in the development and basic understanding of materials for some time now. A variety of techniques are available from empirical potential methods where interatomic potentials parameterised against experiment and higher-order theory are used in classical trajectory simulations, to full first principles methods where solution of the quantum mechanical problem is tackled head-on. Each has its advantages and disadvantages and regions size scales where they are commonly used.

With the advent of cheaper computing power these two ends of the spectrum are approaching with first principles calculations being attempted on ever bigger systems. However, the limit of state of the art density functional (DFT) calculations has remained at around 1,000 atoms. This can be particularly restrictive when dealing with nanostructures where there are no simple symmetries to reduce the problem size. For example, a gold nanoparticle of 1,000 atoms is still extremely small. DFT calculations are important because they allow calculation of electronic properties, for example the optical response of a metallic nanostructure.

In a collaboration with Curtin University (Julian Gale) we have developed a linear scaling method within the SIESTA DFT code that can be applied to 100,000s of atoms on relatively modest high performance computing facilities. We are applying this code to treat a diverse range of problems previously outside the scope of first principles calculations, for example surface adsorption effects of ZnO nanorods, metal-oxide frameworks and gold nanoparticles.

Speaker biography

Assoc. Prof. Ford obtained his PhD from Southampton University in the UK and subsequently undertook postdoctoral research at the University of Western Australia and then University of Maryland. During that period, he focused on the development of instruments for measuring the correlated motion of electrons, atoms and molecules using electron beams as a probe. At Maryland, he designed and developed one of the first instruments capable of detecting all three electrons in an electron-impact double ionisation event, thereby being able to measure correlation in a direct manner. His interest in electron motion continued as a faculty member at the Flinders University of South Australia, where similar electron beam impact techniques were applied to solid state targets to give the first direct measurements of electron band structure for a range of metals and metal-oxides. Computational methods were also employed in this work to support the experiments. On moving to University of Technology Sydney, the computational side has taken the forefront and he is now mainly interested in atomistic simulations of nanostructures using density functional theory based methods. This work includes studies of adsorption energetics on Au surfaces, where a new class of self-assembled monolayer has been predicted, electron transport properties through molecular junctions, optical properties of metallic and alloy nanoparticles and classical simulations of the interaction of light with nanostructures.

Introduction of Nanomaterial Research in Tongji University

Dr Tian-bin Ren

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Abstract

The Institute of Nano and Bio-polymeric Materials was founded under the School of Material Science and Engineering in 2003. With over 30 researchers, the Institute engages in the research of organic and inorganic composites based on polymer, biodegradable medical polymeric material, supercritical technology and the synthesis of supermolecule material. Current major research areas include:

- polymer nanocomposite, including PP/MMT, PVC/MMT, PLA/MMT, PLA/nanoHA, organic/inorganic nanocomposite
- preparation and application of PLA and its copolymer nanoparticle for drug release and targeted drug delivery
- preparation of PLA, material for tissue engineering and drug release with supercritical CO_2 technology
- preparation of tissue engineering scaffold and its application for bone tissue engineering
- industrial-scale technology for the preparation of PLA, its copolymer and composites

Recent major research outputs achieved by the Institute include:

- aerogel particles and powders derived in ambient condition, application of carbon aerogels
- artificial active membrane template, living bio-membrane, bi-templates supporting
- proton conductivity polymers
- magnetic powder, magnetic film, soft magnetic, ribbon bulk metallic glasses
- nanobiomaterials, such as
  - magnetic PLLA nanoparticles for magnetic target
  - AmB-loaded PLA-PEG nanoparticles for brain target
  - PLA and its copolymer controlled release microsphere by supercritical CO_2
  - nanofibre tissue engineering scaffold by electrospinning
  - P(lactic acid)/hydroxapatite nanocomoposites scaffold for tissue engineering
- preparation and application of polymer nanocomposites, including PP/MMT, PVC/MMT, PLA/HA, PLA/MMT

Speaker biography

Dr Ren obtained his BSc, MSc degrees from Hubei University and his PhD degree from Shanghai Jiaotong University. In 2003, he worked on the project “Microwave plasma surface modification of silicone biomaterial” in GKSS Research Centre, Germany. Since 1999, Dr Ren has published over 20 papers, and over half of them were indexed by SCI. He began his teaching and research work in Tongji University in 2004.

His research interests include water-soluble epoxy resin anticorrosive paint, preparation and properties of polylactide composite wrapper, bone tissue engineering polymeric scaffolds and its application, drug targeting and controlled release nanoparticles.

Controlling Nanoparticles Bio-interfaces: A Key-Requirement to Nanobiotechnology?

Dr Benjamin Thierry

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Abstract

The fine control and application of nanoparticles in a complex biological environment remains a formidable challenge. Understanding and controlling biologically non-specific interactions of bio-entities such as cells and proteins with nano-sized materials is of paramount importance in the design of advanced functional biomaterials. Procedures to create biointerfaces able to resist non-specific interactions have been widely implemented on macroscopic surfaces, for instance using non-ionic macromolecules such as polyethylene glycol (PEG). However, despite their tremendous potential in the medical field, reports on efficient bio-interfacial coating procedures of functional nanoparticles are scarce. Surface engineering of nanoparticles is indeed more difficult to perform than macroscopic surfaces. This presentation will discuss novel bio-interfacial coating procedures developed for nanoparticles, including self-assembly of PEG-copolymers, covalent grafting achieved in low solubility conditions and a novel solvent-free conjugation procedure. Applications to functional nanoparticulate systems, namely drug-encapsulating mesoporous silica nanoparticles, superparamagnetic iron oxide nanoparticles (contrast agent for magnetic resonance imaging) and gold nanorods (contrast agent for optical imaging technique and intracellular hyperthermia agents), will be described. Finally, an example will be presented where the "bio-interface science toolbox" applied to functional nanoparticles is used, in combination with a novel immunotargeting approach, to develop molecularly targeted nano-probes for in vivo detection of apoptotic cells and earlier assessment of tumour response to therapy.

Speaker biography

Dr Thierry obtained his PhD degree in 2004 at the Department of Biomedical Engineering at McGill University, Canada. He is currently a Research Fellow at the Ian Wark Research Institute (IWRI) in the University of South Australia. Although still an early career researcher, Dr Thierry has gained significant research experience throughout his education in France, Canada, and Australia, and has undertaken high quality and high impact independent research, in the areas of nanomedicine. He has a well-established network of national and international collaborators and a growing local, national and international profile. His research activities are currently funded by competitive grants from the Australian Research Council, the National Health and Medical Research Council, the Canadian Institutes of Health Research, and the South Australian Cancer Council.

Dr Thierry is currently focusing on three particular research areas. First, he is interested in the "green synthesis" of novel functional nanoparticles, with a special emphasis on the developments of magnetic resonance imaging contrast agents and light-mediated multimodal anti-cancer therapies. The second area involves the control of bio-interfaces at the nanoscale towards the improved (immune) targeting of nanoparticles to pathological tissues. A successful collaboration with the Royal Adelaide Hospital has been established to design an advanced MRI-nanoprobe for the detection of intratumoral apoptosis, which could potentially spare ineffective chemotherapy to patients and advance the drug development process. The third component of his research program aims at designing solid state capture systems able to provide fast and reliable detection of target cells captured from biological samples, which aim to better predict cancer outcomes. A key aspect of his research strategy is the establishment of genuine inter-disciplinary research projects.

Cellular MR Imaging with Superparamagnetic Iron Oxide Particles (SPIO)

Prof. Gao-jun Teng

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Abstract

After transplantation of the stem cells, recognizing the donor cells is essential for a better understanding their migration and differentiation. Several studies have described the feasibility of intracellular labelling with superparamagnetic iron oxide particles (SPIO). This technique allows the nanomagnetic particles to be retained intracellularly over time and thus cell tracking in vivo under MRI. There are several advantages of MR imaging over other molecular imaging techniques, such as nuclear imaging:

1. it offers high spatial resolution and good tissue contrast, especially in soft tissue;
2. it does not require radioactive isotopes;
3. it is non-invasive; and
4. it can track cellular events in vivo in living animals, continuously and repeatedly in real time. Such a technique has been developed in our laboratory and employed for MRI tracking after transplantation of stem cells in several animal models.

Speaker biography

Prof. Teng, is a Professor of Radiology and Director of the Radiological Department in Clinical Medical College, Zhongda Hospital, Southeast University. He graduated from Nanjing Railway Medical College and Fudan University with a master degree in medicine and a PhD degree in 1989 and 2003 respectively, and finished his fellowship at Dartmouth-Hitchcock Medical Center during 1995-1998. He started his clinical radiological practice since 1982 and currently focuses on interventional radiology and molecular imaging.

Characterization of Nanomaterials and Nanostructures

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Abstract

Interest in the development of advanced materials with improved and novel properties is driven by microstructural refinement and modification through the formation of composites. In the past two decades there has been great activity in the area of nanostructured materials and nanocomposites due to their superior mechanical and physical properties. On the other hand, with ever-continuing miniaturization, there is a great demand on the understanding of materials behaviour at micrometer or nanometer scale for reliability evaluation in microsystems. Recently, mechanical behaviour of nanostructured materials and microsystems has been conducted and the on-going projects are focused on characterization of nanocrystalline Mg alloys, bulk metallic glasses, polymer nanocomposite, hydrogen storage alloys and thermal-mechanical behaviour of microelectronic and photonic packaging.

Speaker biography

Dr Yan had a BEng, a MEng and a PhD from the University of Sydney. He had been appointed by the China High Education Committee as a Guest Researcher in the State Key Laboratory of Materials Strength in 2000-2001. He had been an Australian Research Council (ARC) Australia Research Fellow in the University of Sydney since 2003. He is currently a Senior Lecturer in materials engineering in the Queensland University of Technology.

Dr Yan has been the co-chair of several international conferences, including the 2^{nd} International Workshop on Innovation and Commercialization of Micro & Nanotechnology (ICMAN 2008), Xian, China; and the Frontiers in Materials Science and Technology 2008, Brisbane, Australia. He has over 130 publications in refereed journal and conference proceedings with about 300 citations. His main research areas include:

- polymer nanocomposites
- synthesis of novel materials via mechanical milling
- deformation and fracture of nanocrystalline and amorphous alloys
- mechanical behaviour of thin films in micro- and nanodevices
- microelectronic and photonic packaging

Rheology of Polymeric Nanocomposites: An Overview

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Abstract

Polymer nanocomposites are a class of reinforced polymers with low quantities (< 5 wt%) of nanometric-sized fillers (clay particles). These clay particles, referred as layered silicates are dispersed within the polymer matrix. Although the high aspect ratio of silicate nanolayers is ideal for reinforcement, the nanolayers of clay are not easily dispersed in most polymers due to their preferred face-to-face stacking in agglomerated tactoids. The use of these new materials is expected to be widely used by the industrial community due to their outstanding mechanical, barrier and heat resistant properties. These materials are also environmentally friendly since natural clay is used in their development and production.

The processability of a polymer silicate nanocomposite to a final product is directly linked with its internal structure and its rheological behaviour. Melt rheological properties are dictated by a combination of mesoscopic structure and the strength of interaction between the polymer and the layered silicates. Shear rheological studies have provided insight into the inherent viscoelastic properties of these nancomposites and demonstrated how these properties are dependent on the strength of the polymer/layered silicate interaction as well as the viscoelastic properties of the matrix polymer in which these particles are dispersed. Dynamic shear rheological studies also indicated that in the linear viscoelastic region, rheology is very sensitive to intercalation and exfoliation of the layered silicate with matrix. Shear rheological studies of the nanocomposites highlight the shear thinning characteristics up to a certain maximum loading depending on the clay polymer interaction. In dynamic measurements, normal solid like behaviour is observed at low frequencies particularly at higher loadings. Usually, normal stress is not a significant issue, since fillers do not influence the normal stress, unless there is a strong interaction between the filler and the polymer. Percolation threshold is largely affected by the geometry and, in particular, the aspect ratio of the filler. Extensional rheology studies for nanocomposites are very limited. Uniaxial extensional viscosity is affected by the presence of the filler and the strain imposed.

Speaker biography

Dr Gupta of Rheology and Materials Processing Centre (RMPC) of RMIT University has been involved in research related to polymeric composite, polymer processing, viscoelastic behaviour of polymers, extensional and shear rheology of polymers, dynamic mechanical and physical properties of polymeric nanocomposites since 2001. He is actively seeking and studying polymer industry problems at present. He has produced many clay based polymeric nanocomposites using polar and non-polar polyolefin based polymer matrices and characterised their rheological, physical and morphological properties. He has demonstrated the relationship between the filler orientation and shear and extensional rheology. These polymers with high stretching properties are targeted for film and sheet industries requiring high barrier and mechanical properties.

Dr Gupta is also working on extensional rheology of polymer melts and nanocomposites in an international collaboration with McGill University, Canada for development of nanocomposites for commercial use. Recently, he has shown that extensional and shear rheology is related to the structural change and clay particle dispersion. At present, he is working with biodegradable polymeric nanocomposites for packaging application and collaborating with IIT, Delhi under DEST funding.

SPM at Curtin University of Technology: The Facility & Some Projects

Dr Thomas Becker

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Abstract

The Scanning Probe Microscopy (SPM) facility of the Nanochemistry Research Institute (NRI) at Curtin University of Technology, is equipped with 8 top-class scanning probe microscopes. The microscopes are equipped for Atomic Force Microscopy (AFM) and Scanning Tunnelling Microscopy (STM) applications and can be operated in air, gaseous environments or in solutions, which allows for example the in-situ investigation of biological samples or the study of crystal growth and dissolution. SPM's produce real three-dimensional topography images and are further used to obtain information about physical properties of the sample (i.e. adhesion, wettability, viscoelasticity, electric and magnetic properties, etc.). Apart from imaging it is also possible to probe interparticle forces with pico-Newton precision. Using SPM manipulation, nano-hardness measurements can be performed and SPM lithography allows researchers to generate user-defined structures on nanometer scale.

An overview of the SPM facility will be presented with examples of SPM applications in some research projects currently being conducted in the facility.

Speaker biography

Dr Becker studied physics at the University of Ulm, Germany. In his diploma thesis, he investigated nanodroplets on wettability patterned substrates with a highly specialised Atomic Force Microscope (AFM). He obtained his PhD from the University of Twente, The Netherlands in 2005. His thesis entitled "Collapse Dynamics of Confined Liquid Films" involved experimental work in the field of nanoscience, in particular nanofluidics utilising both Scanning Probe Microscopy (SPM) and Surface Forces Apparatus (SFA). Since then, Dr Becker is employed by the Nanochemsitry Research Institute (NRI) at Curtin University of Technology, where he manages the SPM facility. Currently, he is involved in projects for both industry and research, covering a wide range of different areas like corrosion research, bio-inspired hydrometallurgy, crystal growth and nanomanipulation.

Nanoporous and Capsular Nanostructures for Catalysis and Drug-Delivery Applications

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Abstract

Nanoporous materials are of great interest because of their interesting structural, optical and surface properties. Among various properties of porous materials, their high surface area, low density, and cost-effectiveness are particularly notable and make them attractive candidates for catalysis, sensing and biomedicine applications. Galvanic replacement reactions have been previously employed to synthesize nanoporous metal particles in solutions. However, for various applications, it is desirable to fabricate nanoporous structures on rigid surfaces, rather than in solution. We have recently shown that galvanic replacement reactions can indeed be performed on rigid substrates to create nanostructured bi-metallic surfaces, thus opening their potential for catalysis and sensing applications.

In addition to nanoporous metal structures, polymer nanocapsules are excellent candidates for drug-delivery and other biomedical applications, since they can facilitate higher payloads, prolong the circulation time of drugs, improve drug targeting and solubility, and provide controlled-release of the therapeutics to the targeted tumour tissues. Layer-by-layer (LbL) assembly process is the most commonly followed method to synthesize polymer nanocapsules. However, LbL process often requires multiple assembly steps and use of more than one polymer, which makes the process relatively intensive and time-consuming, particularly for the synthesis of thick walled polymer capsules. To overcome these limitations, we have recently demonstrated a single step procedure for fabrication of thick-walled, single-component polymer nanocapsules and have shown the potential of biodegradable polymer nanocapsules in cancer therapy applications.

Speaker biography

Dr Bansal is a Tenure Track Fellow of nanobiotechnology at School of Applied Science, RMIT University. He received his BSc in Agricultural Sciences in 2001, his MSc in Biotechnology in 2003 and his PhD in Nano-biomaterials from National Chemical Laboratory, India in 2007, with Dr Murali Sastry as his supervisor. He was working as a Postdoctoral Fellow with Prof. Frank Caruso at University of Melbourne and Ludwig Institute for Cancer Research, Australia in 2007, before taking up his current position. He has currently 36 publications including 3 US patents to his credit, with majority of publications in high impact journals with a high citation index. His research interests include advanced functional nanomaterials synthesis for applications in catalysis, (bio)sensing and biomedicine.