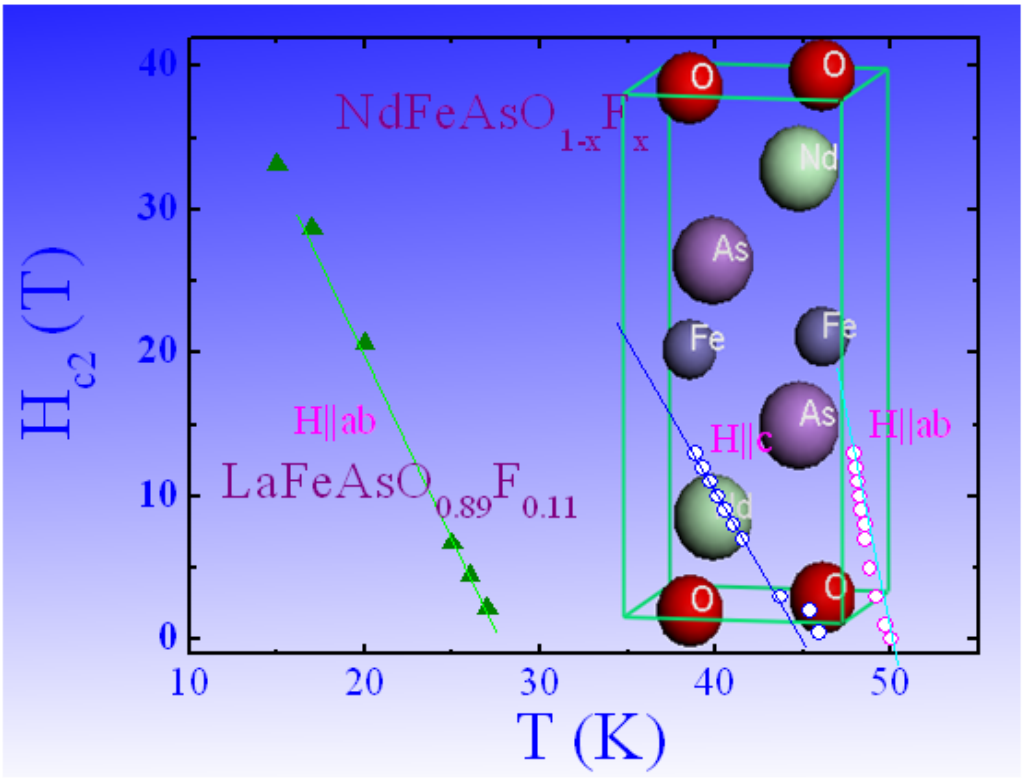
Institute for Superconducting & Electronic Materials



Annual Report 2008

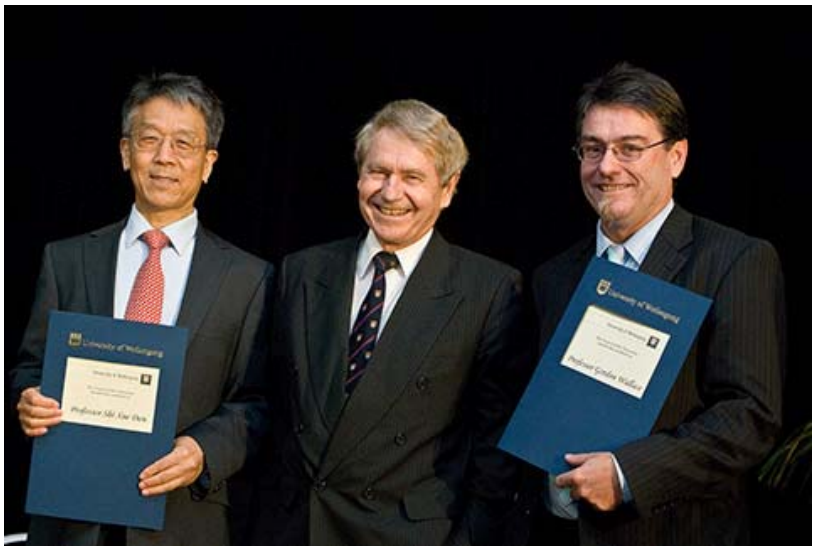
Contents

Cover picture:
Taken from publication X. L. Wang et al. "Very High Critical Field and Superior J_c-Field Performance in $NdFeAsO_{0.82}F_{0.18}$ with T_c of 51 K", *Advanced Materials* **21** (2), 236 (2009).

Vice Chancellor's Inaugural Research Excellence Award

The Vice-Chancellor's Awards recognize the outstanding contributions staff make to the University of Wollongong. This year, the award was presented to ISEM's Director Professor Shi Xue Dou along with Professor Gordon Wallace (Director, Intelligent Polymer Research Institute, Faculty of Science).

VC's Innaugural Research Excellence Award for Senior Researchers



Pictured (Left to Right): Professor Shi Xue Dou (Director, ISEM), Professor Gerard Sutton (Vice Chancellor, University of Wollongong), Professor Gordon Wallace (Director, IPRI).

Inaugural Major Grant Announcement & Expo

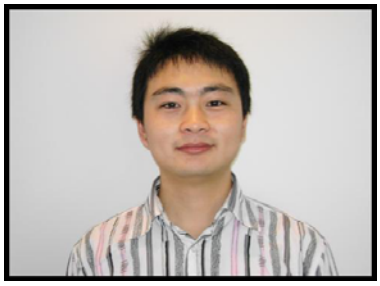
A/Prof. Alexey V. Pan has been invited to the inaugural Major Grant Announcement & Expo, which was held at the Parliament House in Canberra for invited guests on 15th October, 2008. Alexey was one of the few invited researchers to showcase his project during the expo.

Pictured (Left to Right): Prof. Margaret Sheil (Chief Executive Officer of the ARC), Senator Kim Carr (Minister for Innovation, Industry, Science and Research), A/Prof Alexey Pan (ISEM).

ISEM Postgraduate Student Awards

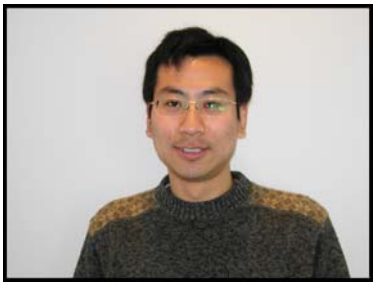
Each year ISEM selects a number of outstanding students and in recognition of their research efforts, these students are presented with a Certificate to mark their achievements, together with a cash prize.

2008 Postgraduate Student Excellence Award Recipients



Shulei Chou

Stuart Hargreaves



Wenxian Li

2008 Postgraduate Student Best Paper Award Recipients

Rashmi Nigam

Hao Liu

Best Poster Award

"Light as an indicator of magnetism: magneto-optical imaging"
D. L. Cortie and A. V. Pan, awarded at the *32nd Annual Condensed Matter and Materials Meeting*, 30th January – 1st February 2008, Wagga Wagga, Australia.

Best Poster Paper Award

"Developing the multilayer coated conductors wires on the base of YBaCuO superconductor thin films"
S. V. Pysarenko, A. V. Pan and S. X. Dou, awarded at the *International Conference on Electronic Materials* (IUMRS-ICEM 2008), 28th July – 1st August 2008, Sydney, Australia.

Scholarships

Sau Yen Chew, ECS Summer Scholarship (USA)
Wenxian Li, Chinese Government Scholarship (China)

Director's Report

Prof. Shi Xue Dou
PhD, DSc, FTSE
ARC Australian Professorial Fellow

In 2008 Institute for Superconducting and Electronic Materials (ISEM) has opened new chapter in its history as it has relocated to the newly built building – Australian Institute for Innovative Materials (AIIM). The $30M building consisting of world class facilities and state-of-the-art architecture is a highlight of the University of Wollongong effort to enhance its research potential, while introducing new environmental friendly solutions and concepts. The opening of the AIIM facility has attracted a lot of interest by both research and general public communities, and is believed to bring enormous socio-economic benefit to the Illawarra region. We are very proud of being a part of this great initiative by the University of Wollongong.

The relocation helped us to further improve our research quality and maintain our aspiration to be among world leaders in materials science and engineering as well as to be one of the key research areas identified by the University of Wollongong. ISEM has continued to grow bigger and better in terms of research teams, quality and facilities. We kept on attracting high calibre personnel to maintain our targets in ARC fellows, full time researchers, postgraduate students, publications in higher impact journals and ARC funding. Year 2008 was another strong year in all of these categories: *(1)* the total ARC funding obtained in 2008 round exceeded $3.3 million; *(2)* we maintained our high publication rate counting more than 120 publications in various international journals, *(3)* we had 43 enrolled postgraduate students and we are confident that this number will increase in the years to come.

Major advancements in the study of superconductivity in various materials have been achieved. For MgB_2 superconductor, we applied new technique to fabricate highly dense MgB_2 bulks at ambient pressure. Enhancement of superconducting properties of MgB_2 was further achieved by investigating the influence of quality of boron powder for preparation of the MgB_2 material. A record high critical current density has been achieved through carbohydrate doping into MgB_2 wires. For Ru-based high temperature superconductors we were able to explain origins of peculiar magnetic properties of these superconductors. The experimental results suggest that Ru-based samples always contain a small amount of at least one additional magnetic phase with its own magnetic behaviour, which is similar yet distinct from the main Ru phase. The proposed magnetic behaviour model does not contradict but rather unifies the existing scenarios for the Ru-based systems in a common picture, which is crucial to understand the mechanisms of superconductivity and magnetism in these complicated systems. For newly discovered FeAs ($FeAsO_{0.89}F_{0.11}$) we showed that the upper critical field (H_{c2}) values can exceed 80-230T and superior performance of supercurrent density in fields, which further proves that these materials have tremendous potential for practical applications. In energy materials, numerous directions have produced significant and exciting results. For example, spherical porous vanadium pentoxide phase was synthesized by a spray-pyrolysis method. The fabricated particles showed that the initial specific capacity is ~400 $mAhg^{-1}$ and they exhibit good cycleability during the charge and discharge processes. Further, with increasing demand on flexible batteries we were successful in preparing highly flexible, paper-like, free-standing poly-pyrrole/$LiFePO_4$ films. The composite films have high discharge capacity beyond 50 cycles. The free-standing films can be used as electrode materials to satisfy new market demand for flexible batteries. In electronic materials, a major theoretical work performed by Prof. X. L. Wang resulted in proposal of new class of materials: spin gapless semiconductors. The concept is based on the possibility to have a class of materials where both electron and hole can be fully spin-polarized without presence of energy gap. This theoretical proposal opens new research direction in the field of spintronic materials. Practically spin gapless behaviour was already found in graphene

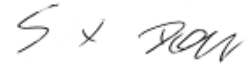
and, recently, for the first time observed in thin films of Co-doped $PbPdO_2$ oxide. Furthermore, this material exhibits colossal electroresistance (up to 10^7) at intermediate temperatures. Our research program has further extended to sensors and super capacitors.

In 2008 our staff remained very active in their research despite lengthy relocation process, and we are thankful to all who have contributed to the setting up equipment and facilities during this tedious period. Xiao Lin Wang was promoted to Professor in 2008 after 8 years of PhD graduation. In July 2008 ISEM organized *Symposium R* under the International Conference on Electronic Materials (ICEM 2008, Sydney). Being the largest symposium in terms of presenters and participants, the symposium was a huge success, which was followed by a one day workshop in AIIM also organized by ISEM. An international workshop on fabrication and characterisation of battery cells was organised jointly by ISEM, ARC Center of Excellence on Electromaterials, and IPRI. More than 50 researchers visited ISEM and new links and research partnerships were established as a result of these three big events. Throughout the year more than twenty internationally renowned researchers visited our group. Our visitors, such as Prof. E. W. Collings from Ohio State University (USA), Prof. H.W. Weber from Atomic Institute of Viena (Austrian), Dr. O. Mukhanov from Hypres (USA), Prof. Y. M. Kang from Kongju University (Korea), Prof. M. Gu from Swinburne Universtity of Technology (Australia), Prof. D. Jiles from Cardiff University (UK), and many others gave a number of interesting and exciting talks on various topics. We are grateful to these researchers for sharing their knowledge and experience with our staff and students.

Yet again we have been excellent in the national competitive grant bids in the 2008 round with a total of $2,459,000 awarded. This includes, three Discovery Projects (R. A. Lewis/J. Horvat; J. Z. Wang; X. L. Wang/D. P. Chen/Z. X. Cheng), three Linkage Projects (S. X. Dou/X. L. Wang/C. Cook; G. Wang/J. Horvat/D. Wexler, Z. P. Guo/H. K. Liu), two International Linkage Fellowships (J. H. Kim/S. X. Dou; A. V. Pan), and US-Australia special link grant (C.Zhang). In addition, we have attracted contract project grants from Redoc Ltd.

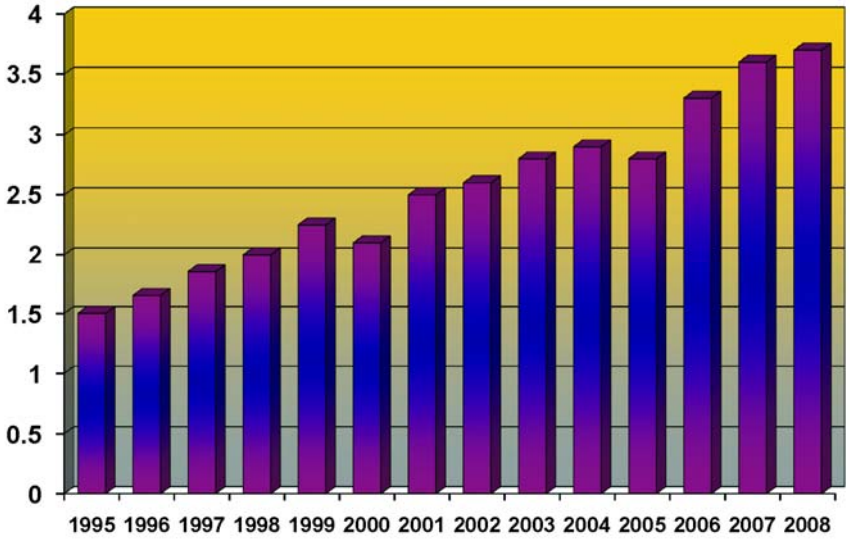
All our postgraduate students worked hard on their projects and achieved many significant results. The best achievers have been commended to receive annual Excellence and Best paper awards. Five of our postgraduate students have completed their studies and successfully graduated. M. S. Park took a position in Samsung Advanced Institute of Technology (Korea), M. S. A. Hossain was accepted as research fellow in a world leading research group at Geneva University (Switzerland), and Z. W. Zhao is now working in Innovation Management Department of Bayer Technology and Engineering Co. Ltd. (China). We also want to welcome our new students and believe that excellent achievements of our current students will motivate them to achieve even better results in their scientific endeavours.

ISEM has benefited strongly from the relocation to the AIIM facility in terms of improvement of infrastructure. We have purchased a state-of-the-art single crystal growth facility, new x-ray diffraction equipment, TG/DTA system, 15T and 9T magnets for transport and characterization of samples. We improved our EBE/XPS system through National Cooperative Research Infrastructure Scheme (NCRIS). While we prepared this report ISEM and IPRI have jointly received a new fund of $44 million from Education Investment Fund of Australian Government to build a Processing and Device building including $10 m for facilities. This will siginificantly boost the international standing of our institute as a world-class materials research establishment.

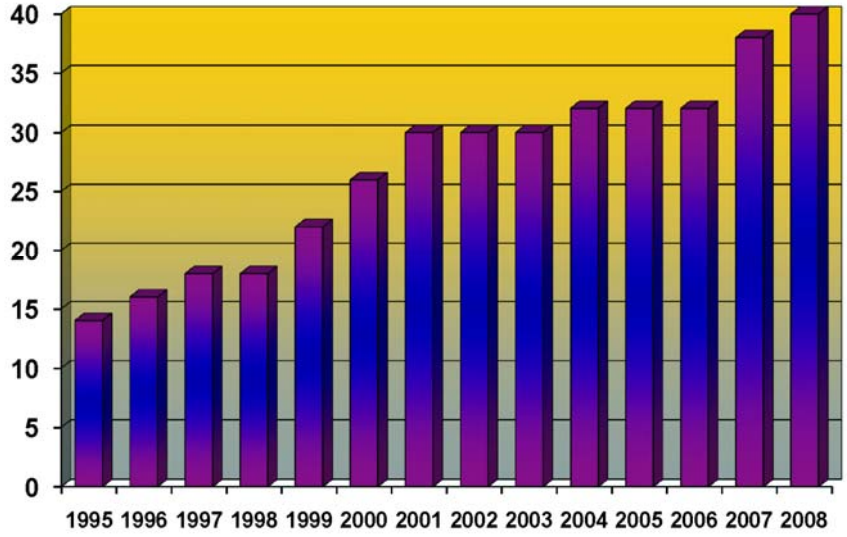


Shi Xue DOU
Director

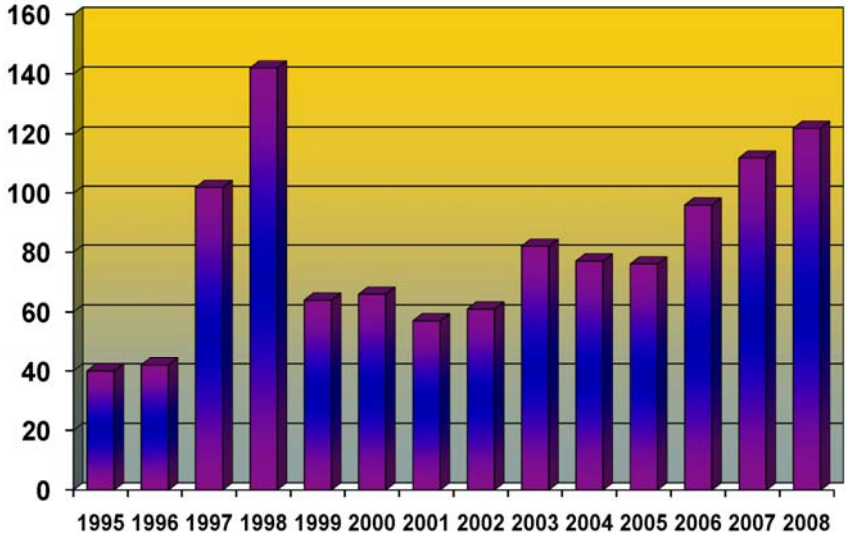
Research Grant Funds ($M)



Postgraduate Student Numbers



Refereed Publications (DETYA Categories)



Management 2008

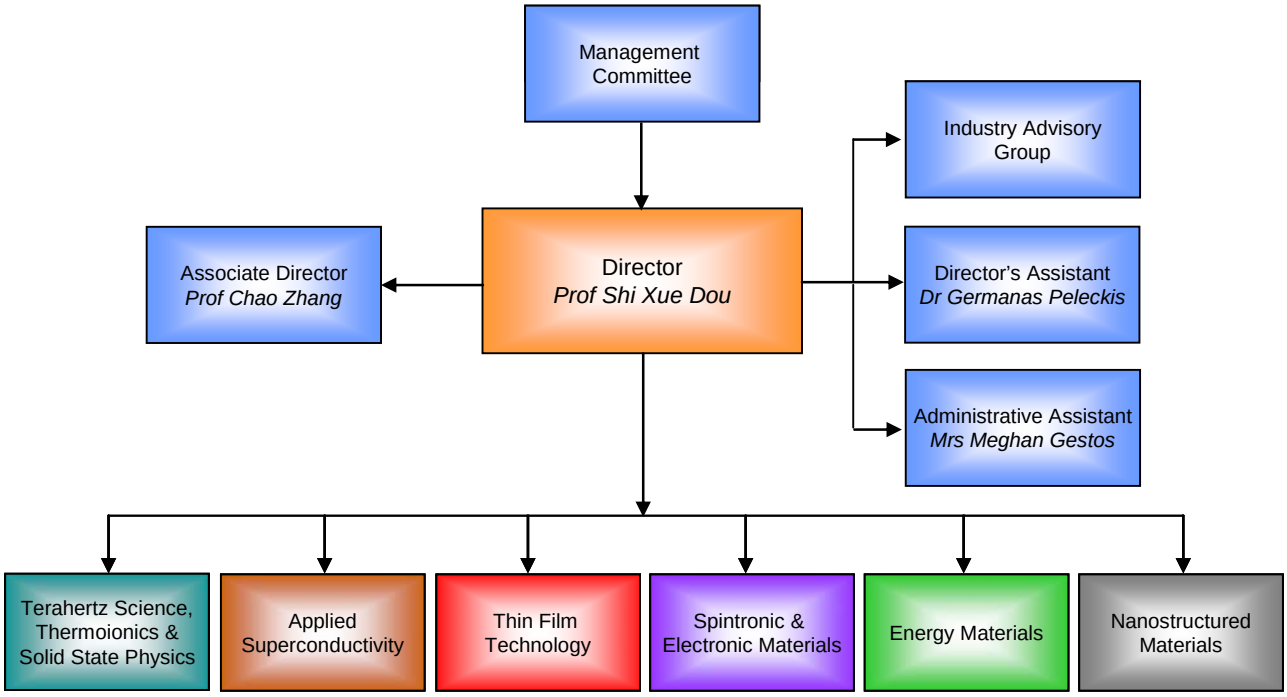
Management Committee

Chairperson:	Prof. Judy Raper	Deputy Vice Chancellor, UoW
	Prof. Shi Xue Dou	Director, ISEM
	Prof. Chris Cook	Dean, Faculty of Engineering, UoW
	Prof. Chao Zhang	Associate Director, ISEM
	Prof. Hua Kun Liu	Research Co-Coordinator, ISEM

Industry Advisory Group

Mr. R. Neale	Managing Director	Alphatech International Ltd
Mr. J. F. Wu	Marketing Manager	DLG Battery Co Ltd, Shenzhen, P. R. China
Dr. S. Zhong	Managing Director	Guangzhou Delong Energy Technology, Guangzhou, P. R. China
Mr. M. Tomsic	Managing Director	Hyper Tech Research Ltd, Ohio, USA,
Dr. O. Mukhanov	Chief Technological Officer	Hypres Ltd, USA
Dr. X. F. Gao	General Manager	Lexel Batteries Co. Ltd, Shenzhen, P. R. China
Dr. R. Taylor	Chief Technological Officer	Mesaplexx Ltd, Brisbane, QLD, Australia
Mr. A. Kittel	Managing Director	Redoc Ltd, Adelaide, SA, Australia

ISEM Organisational Chart



Personnel

Director

- Prof. Shi Xue Dou *(Dipl, PhD, DSc, FTSE, Australian Professorial Fellow)*

Associate Director

- Prof. Chao Zhang *(BSc, PhD, MA, MPhil, FAIP)*

Senior Program Co-Coordinators

- Dr. Josip Horvat (BSc, PhD)
- Dr. Kosta Konstantinov (BSc, MSc, PhD)
- Prof. Hua Kun Liu (Dipl. for PGS, APF)
- A/Prof. Alexey Pan (MSc, PhD, ARC Australian Research Fellow within ARC Centre)
- A/Prof. Guoxiu Wang (MSc, PhD ARC QE-II Fellow)
- Prof. Xiaolin Wang (BSc, MSc, PhD, ARC QE-II Fellow)
- Prof. Chao Zhang (BSc, PhD, MA, MPhil, FAIP)

ARC Fellows

- Prof. Hua Kun Liu (Dipl. For PGS, Dipl. AQC, Australian Professorial Fellow)
- A.Prof. Alexey Pan (BSC, MSc, PhD, ARC Australian Research Fellow)
- Dr. Dongqi Shi (BSC, MSc, PhD, ARC Postdoctoral Fellow)
- A.Prof. Guoxiu Wang (BSc, MSc, PhD, ARC QE-II Fellow)
- Dr. Xiaolin Wang (BSc, MSc, PhD, ARC QE-II Fellow)
- Dr. Sihai Zhou (BSc, MSc, PhD, ARC Postdoctoral Fellow)
- Dr. Yue Zhao (MSc, PhD, ARC Postdoctoral Fellow)
- Dr. Xuebin Yu (BSc, MSc, PhD, ARC Postdoctoral Fellow)

Research Staff

- Dr. Zhenxiang Cheng (BSc, MSc, PhD)
- Dr. Feng Gao (BSc, PhD)
- Dr. Tania Silver (BSc, PhD)
- Dr. Jung Ho Kim (BSc, PhD)
- Dr. Rong Zeng (BSc, MSc, PhD)
- Dr. Germanas Peleckis (PhD)
- Dr. Olga Shcherbakova (PhD)
- Prof. Xiaoping Shen
- Dr. Chunchang Wang
- Dr. JiazhaoWang (BSc, MSc, PhD)
- Dr. Shouyu Wang
- Dr. Yueping Yao
- Dr. Xuebin Zhu

Faculty Staff

- Prof. Chris Cook (BSc, PhD, FIEAust)
- Dr. Carey Freeth (MSc, PhD, MAIP)
- Prof. Roger Lewis (BSc (Hons), PhD, FAIP, FRMS)
- Dr. David Martin (MSc, PhD, MAIP)
- A/Prof. Rodney Vickers (MSc, PhD, MAIP)
- Dr. Zaiping Guo (BSc, MSc, PhD)

Visiting Staff

- Prof. Edward Collings (Ohio State University)
- Dr. Shi Zhong (Delong Energy Technology, China)
- Dr. Gustavo Alvarez
- Dr. Hai Bo Lu
- Dr. Jieqiang Wang
- Dr. Xianlong Wang
- Dr. Xibin Xu
- Dr. Yunlong Xu
- Dr. Xunxian Yang
- Dr. Xianjun Zhu

Technical Staff

- Mr. Ron Kinnel
- Mr. Jason Knust
- Mr. Darren Attard

Administration Assistant

- Mrs. Meghan Gestos

Honorary Fellows

- Dr. Scott Needham

Postgraduate Students

Current

PhD	Thesis Title	Supervisors
Mr. Mislav Mustapic	Enhancement of MgB_2 superconductor by magnetic nanoparticle doping	Dr. J. Horvat Prof. Shi Xue Dou
Mr. Dieter Beaven	FPGA architecture for numerical computations	Prof. John Fulcher, Prof. Chao Zhang
Mrs. Fargol Bijarbooneh	Nanowires in arrays based nanostructures	Dr. Yue Zhao, Prof. Shi Xue Dou
Mr. Colin Bleasdale	Electromagnetic properties of superconducting films and multilayers	Prof. Chao Zhang, A/Prof. Alexey Pan
Mr. Dapeng Chen	Crystal growth, magnetism, transport and superconductivity of two dimensional sodium cobalt oxide single crystals	Prof. Xiaolin Wang. Prof. Shi Xue Dou
Ms. Sau Yen Chew	Advanced materials for electrodes and electrolyte in rechargeable lithium batteries	Prof. Hua Kun Liu, Dr. Jiazhao Wang
Mr. Shulei Chou	Nanostructured / composite materials for rechargeable Li-ion battery and supercapacitor	Prof. Hua Kun Liu, Prof. Shi Xue Dou, Dr. Jiazhao Wang
Mr. Jyotish Debnath	Nanostructure control of MgB_2 by chemical doping	Prof. Shi Xue Dou, Dr. Jung Ho Kim, Dr. Rong Zeng
Mr. Guodong Du	Performance improvement of cathode materials for Li-ion battery	Dr. Zaiping Guo, Prof. Hua Kun Liu
Mr. Yi Du	Diluted magnetic semiconductors (DMS's)	Prof. Xiaolin Wang, Dr. Zhenxiang Cheng
Mr. Mohammad Faroudi	Studies of structures, transport and magnetic properties of doped novel three-dimensional perovskite compounds	Prof. Xiaolin Wang, Prof. Shi Xue Dou
Mr. Mohd Faiz Hassan	Nanostructured materials for lithium ion battery	Prof. Hua Kun Liu, Dr. Zaiping Guo
Mrs. Nurul Idris	Nanomaterials for lithium rechargeable batteries	Prof. Hua Kun Liu, Dr. Jiazhao Wang
Mr. Mohammad Ismail	Hydrogen storage materials	Prof. Shi Xue Dou, Dr. Yue Zhao, Dr. Xuebin Yu
Ms. Priyanka Jood	Oxide thermoelectric materials for high temperature power generation	Dr. Germanas Peleckis, Prof. Xiaolin Wang
Mr. Philip Lavers	Electronic structure of perovskite and related materials	Prof. Shi Xue Dou
Mr. Reagan Gang Lee	Numerical analysis of electromagnetic behaviour of high T_c superconductors under magnetic field	Prof. Hua Kun Liu, Dr. Meng Qin
Mr. Qi Li	Research on superconducting films and buffer layers for electronic applications	Prof. Shi Xue Dou, Dr. Dongqi Shi
Mr. Wenxian Li	Carbohydrate doping effect on the superconductivities and microstructure of MgB_2 superconductor	Prof. Shi Xue Dou, Dr. Rong Zeng

PhD	Thesis Title	Supervisors
Mr. Hao Liu	Nanostructured materials for lithium ion batteries	Dr. Guoxiu Wang, Prof. Chao Zhang
Mr. Minoru Maeda	Critical current of MgB_2	Prof. Shi Xue Dou, Dr Yue Zhao
Mr. Jianfeng Mao	Study on hydrogen storage behavior of $LiBH_4$	Dr. Zaiping Guo, Prof. Hua Kun Liu
Miss. Rashmi Nigam	Study of magnetic behaviour of Ru-based superconducting ferromagnets	A/Prof. Alexey Pan, Prof. Shi Xue Dou
Mr. Jinsoo Park	Synthesis of nanowires and their application as nanosensors for chemical detection	Dr. Guoxiu Wang, Prof. Hua Kun Liu
Mr. Min Park	Synthesis and characterization of nanostructured electrode materials for rechargeable lithium ion batteries	Prof. Hua Kun Liu, Prof. Shi Xue Dou, A/Prof. Guoxiu Wang
Mr. Chung Kiak Poh	Spintronic materials	Dr. Zaiping Guo, Prof. Hua Kun Liu
Mr. Serhiy Pysarenko	HTS multi-layers thin films fabrication	A/Prof. Alexey Pan, Prof. Shi Xue Dou
Mr. Syed Quddus	Fabrication and the study of MgB_2 superconductor	Dr. Sihai Zhou, Prof. Shi Xue Dou
Mr. MD Mokhlesur Rahman	Nanostructured active materials for lithium-ion batteries	Prof. Hua Kun Liu, Dr. Jiazhao Wang
Mr. Abbas Ranjbar	Effect of catalysts on hydrogen storage properties of MgH_2	Prof. Hua Kun Liu, Dr. Zaiping Guo
Mr. Ali Ranjbartoreh	A study of hydrogen storage and hydrogen-fed PEM fuel cells	A/Prof. Guoxiu Wang
Mrs. Precious Shamba	High T_c superconductivity	Prof. Shi Xue Dou Dr. Rong Zeng
Mr. Andrey Shcherbakov	Development of MgB_2 wires with aluminium as a stabilizer	Prof. Shi Xue Dou, Dr. Josip Horvat
Miss. Ying Wang	Research on $LiFePO_4$ preparation and application	Dr. Guoxiu Wang
Mr. Brad Winton	Magnetoresistive effect in Bi-2212	Prof. Shi Xue Dou, Prof. Xu-Feng Huang
Mr. Anthony Wright	Charge and energy transport in carbon nanotubes	Prof. Chao Zhang, A/Prof. Guoxiu Wang
Ms. Huimin Wu	New catalyst materials for hydrogen fed fuel-cells	Dr. Guoxiu Wang
Mr. Xun Xu	Effect of the starting boron powder on the superconducting properties of MgB_2	Prof. Shi Xue Dou, Dr. Jung Ho Kim
Mr. Qiwen Yao	Study of newly discovered two dimensional cobalt based perovskite compounds doped with various rare earth elements	Prof. Xiaolin Wang, Prof. Shi Xue Dou

PhD	Thesis Title	Supervisors
Mr. Peng Zhang	Thin film electrodes for lithium ion battery	Dr. Zaiping Guo, Prof. Hua Kun Liu
Mrs. Yun Zhang	Nano-doping of MgB_2	Prof. Shi Xue Dou, A/Prof. Alexey Pan, Dr. Sihai Zhou

Master's	Thesis Title	Supervisors
Mrs. Lin Lu	Conducting polymer composites and ionic liquid electolytes for lithium batteries	Dr. Jiazhao Wang, Prof. Hua Kun Liu
Mr. Bei Wang	Nanostrusctured materials for advanced supercapacitors	Dr. Guoxiu Wang
Miss. Lin Wang	YBCO coated conductor through chemical solution deposition	Prof. Shi Xue Dou, Dr. Dongqi Shi
Mr. Chao Zhong	Nano electrode materials for energy storage	Prof. Hua Kun Liu, Dr. Jiazhao Wang

Completions

PhD Name	Thesis Title	Awarded	Position	Appointed
Y. P. Yao	A study of electro materials for lithium-ion batteries	2008	Part Time Associate Fellow, ISEM, University of Wollongong	2008
Z. W. Zhao	The liquid-phase synthesis and electrochemical application of novel inorganic nanocomposites	2008	Innovation Management Department, Bayer Technology and Engineering Co., Ltd., Shanghai, China	2008
O. Shcherbakova	Development of $MgB_{2-x}C_x$ superconductors and understanding their electromagnetic behaviour	2008	Part Time Associate Fellow, ISEM, University of Wollongong	2008
M. S. Park	Synthesis and characterization of nanostructured electrode materials for rechargeable lithium ion batteries	2008	Energy Group, Emerging Center, Samsung Advanced Institute of Technology, South Korea	2008
MD. S. A. Hossain	Study of superconducting and electromagnetic properties of un-doped and organic compound doped MgB_2 conductors	2008	Applied Superconductivity Group, University of Geneva, Switzerland	2008
S.H. Ng	Nanostructured materials for electrodes in lithium-ion batteries	2008	Postdoctorate Fellow, Electrochemistry Laboratory, Paul Scherrer Institute, Switzerland	2008
			Technical Customer Support Manager, Asia Pacific, Changzhou Timcal Graphite Corp. Ltd, Shanghai, China	2009

PhD Name	Thesis Title	Awarded	Position	Appointed
Z. G. Huang	Effects of compositions and mechanical milling modes on hydrogen storage properties	2008	Research Fellow, Department of Materials Science and Engineering, OHIO State University, USA	2008
S. A. Needham	Development of advanced electrode materials for lithium-ion batteries	2007	Commercialization Manager, University of Wollongong	2007
G. Peleckis	Studies on diluted oxide magnetic semiconductors for spin electronic applications	2007	Research Fellow, ISEM, University of Wollongong	2007
M. Roussel	Magneto-optical imaging in superconductors	2007	Director of the Capacity Building Department, BlueEnergy, Nicaragua	2008
L. Yuan	Investigation of anode materials for lithium-ion batteries	2007	CEO	2006
M. O'Dwyer	Solid-state refrigeration and power generation using semiconductor nanostructures	2007	Trading Analytics, Energy Australia	2007
Y. Chen	Investigation on advanced active materials for lithium-ion batteries	2006	General Manager, DLG Battery Shanghai CO.LTD	2006
S. Bewlay	Investigation on Li-Co-Ni system for lithium ion batteries	2006	Patent Officer, Canberra	2006
A. Li	A study of the fabrication and characterization of high temperature superconductor $YBa_2Cu_3O_7$ thin films	2006	Associate Research Fellow, ISEM, University of Wollongong	2006
S. H. Pilehrood	Electronic properties of semiconductor nanostructures under intense terahertz radiation	2006		
W. K. Yeoh	Control of nanostructure for enhancing superconductor performance through chemical doping	2006	Research Fellow, Cambridge University, U.K.	2007
Y. Zhao	Fabrication and characterization of superconducting PLD MgB_2 thin films	2006	APD Fellow ISEM, University of Wollongong Lecturer, University of Wollongong	2006 2008
S. Keshavarzi	Investigation of vortex dynamics of $(Tl,Pb)(Sr,Ba)_2Ca_2Cu_3O_y$ and an alternative method for determination of the lock-in angle in twinned superconductors	2005	Lecturer, Shahrekord University, Iran	2005
F. Gao	Studies on the synthesis, characterization and properties of colossal magnetoresistive (CMR) materials	2004	Research Fellow, ISEM, University of Wollongong	2004

PhD Name	Thesis Title	Awarded	Position	Appointed
M. Lindsay	Data analysis and anode materials for lithium ion batteries	2004	Postdoctoral Research Fellow, University of New South Wales	2004
			Research Staff , ANSTO	2006
B. Lough	Investigations into thermionic cooling for domestic refrigeration	2004	Quantitative Analyst, ABN AMRO, UK	2005
D. Milliken	Uranium doping of silver sheathed bismuth-strontium-calcium-copper-oxide superconducting tapes for increased critical current density through enhanced flux pinning	2004	Knowledge Transfer Partnership Associate, University of Leeds and AVX Ltd	2005
S. Soltanian	Development of superconducting magnesium diboride conductors	2004	Pro-Vice Chancellor, Kurdistan University, Iran	2005
C. Wang	Cathodic materials for nickel-metal hydride batteries	2004	Research Fellow, IPRI, University of Wollongong	2004
S. H. Zhou	Processing and characterization of MgB_2 superconductors	2004	APD Fellow, ISEM, University of Wollongong	2005
Z. P. Guo	Investigation on cathode materials for lithium-ion batteries	2003	APD Fellow, ISEM, University of Wollongong	2003
			Lecturer, University of Wollongong	2007
J. McKinnon	The fundamental mechanisms involved in the production of thin films by Pulsed laser	2003	Teacher, New South Wales Education Department	2003
D. Marinaro	A study into the effects of fission-fragment damage on activation Energies in Ag/Bi2223 tapes	2003	Scientist, DSTO Melbourne	2003
D. Q. Shi	Buffer layers for YBCO superconducting films on single crystal YSZ substrates and cubic texture Ni substrates	2003	Research Fellow, Korean Electrical Technology Institute, Korea	2002
			Research Fellow, ISEM, University of Wollongong	2004
			APD Fellow, ISEM, University of Wollongong	2007
J. Wang	Development of a novel plate making processing technique for Manufacturing valve-regulated lead-acid batteries	2003	Research Fellow, IPRI, University of Wollongong	2003
			APD Fellow, ISEM, University of Wollongong	2004
			Research Fellow, ISEM	2007
R. Baker	Zeeman and piezo-spectroscopy of antimony and aluminium in germanium	2001	Professional Officer, University of Wollongong	2003

PhD Name	Thesis Title	Awarded	Position	Appointed
X. K. Fu	Fabrication and characterization of Bi-2223 current lead	2002	Research Fellow, Texas A&M University, USA	2002
			Research Fellow, University of Waterloo, Canada	2005
K. Uprety	Magnetic hysteresis and relaxation in Bi2212 single crystals doped with iron and lead	2002	Research Fellow, Argonne National Lab, USA	2002
G. X. Wang	Investigation on electrode materials for lithium-ion batteries	2001	APD Fellow, ISEM, University of Wollongong	2001
			ARC QEII Fellow, ISEM, University of Wollongong	2006
			Associate Professor, ISEM, University of Wollongong	
J. P. Chelliah	Optical spectroscopy of semiconductors	2000		
L. Sun	Amorphous and nanocrystalline hydrogen storage alloy materials for nickel-metal hydride batteries	2000	Research Associate, Hydro-Quebec Research Institute, Canada	2000
			Research Fellow, University Sherbrooke, Canada	2002
X. L. Wang	Spiral growth, flux pinning and peak effect in doped and pure Bi-2212 HTS single crystal	2000	Research Fellow, ISEM, University of Wollongong	2000
			ARC APD Fellow, ISEM, University of Wollongong	2002
			ARC QEII Fellow, ISEM, University of Wollongong	2005
			Associate Professor	2006
			Professor	2008
R. Zeng	Processing and characterization of Bi-2223/Ag superconducting tapes	2000	Research Fellow, ISEM, University of Wollongong	2000
J. Chen	High energy storage material for rechargeable nickel-metal hydride batteries	1999	NEDO Fellow, Osaka National Research Institute	1999
			Professor, Nankai University, China	2003
T. Silver	Near band-edge optical properties of MBE GaAs and related layered structures	1999	Research Fellow, ISEM, University of Wollongong	2000

PhD Name	Thesis Title	Awarded	Position	Appointed
G. Takacs	Spectroscopy of the effect of strains and magnetic field on shallow acceptor levels in germanium	1999	Lab Manager, University of Wollongong	1999
N. Cui	Magnesium based hydrogen storage alloy anode materials for Ni-MH secondary batteries	1998	Research Fellow, Alberta University, Canada	1997
			Electrochemist, Energizer Co, USA	2000
R. J. Heron	Far-infrared studies of semiconductors in large magnetic fields	1998	Postdoctoral Fellow, SUNY, Buffalo, USA	1997
			Research Fellow, Janis Research Company Inc., USA	2000
M. Ionescu	Growth and characterization of Bi-2212 crystals and improvement of Bi-2212/Ag superconducting tapes	1998	Assistant Director, ISEM, University of Wollongong	1997
			Senior Research Scientist, ANSTO	2004
J. X. Jin	$(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10+x}$/Ag high T_c superconductors and their applications in an electrical fault current limiter and an electronic high voltage generator	1998	Research Fellow, ISEM, University of Wollongong	1997
			ARC, APD Fellow, ISEM, University of Wollongong	2000
			Professor, University of Electronic Engineering	2003
M. Lerch	Optical & electrical studies of resonant tunnelling heterostructure	1998	Lecturer, School of Engineering Physics, University of Wollongong	2006
S. Stewart	Thermodynamic and dielectric properties in modulated two-dimensional electronic systems	1998	ARC APD Fellow	1998
			Teacher	1999
			Associate Professor	2002
W. G. Wang	Fabrication and improvement of silver sheathed $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10}$ tapes By powder-in-tube technique	1998	R&D Manager, Nordic Superconductor Tech. Denmark	1997
			Associate Director, Ningbo Materials Institute, Chinese Academy	2007
B. Zeimetz	High temperature superconducting tapes & current leads	1998	Research Fellow, Cambridge Univ., U.K.	1999

PhD Name	Thesis Title	Awarded	Position	Appointed
S. Zhong	Investigation on lead-calcium-tin-aluminium grid alloys for valve-regulated lead-acid batteries	1998	ARC Postdoc. Fellow, ISEM, University of Wollongong	1997
			CEO, Leadcel Dynamic Energy Ltd, P.R. China	2002
			CEO, Guangzhou Delong Energy Tech Ltd.	2003
B. L. Luan	Investigations on Ti_2Ni hydrogen storage alloy electrode for Rechargeable nickel-metal hydride batteries	1997	NRC Fellow, National Res. Council of Canada	1997
			Group Leader, Shape Transfer Process Integrated Manufacturing Technologies Institute, NRC, Canada	1999
N. Vo	Design and characterization of HTS coils	1997	Research Fellow, Los Alamos Nat. Lab, USA	1999
			Research Staff, Intermagnetics General Co., USA	1998
A. Warner	A spectroscopic study of acceptors in germanium	1997	Consultant, Computer Industry	1999
J. M. Xu	Phase formation and transformation in the R-Fe-T system (R=Nd, Gd, Tb, Dy, Er, Ho, T and Lu, T=Si, Ti & Zr	1997	Research Fellow, St. George Bank, Australia	1998
M. Yavus	Powder processing of Bi-Pb-Sr-Ca-Cu-O superconducting materials	1997	Ass. Professor, Texas A&M University, Texas USA	2000
			Ass. Research Professor, Tohoku University, Sendai, Japan	1997
			Ass. Professor, University of Waterloo, Canada	2004
Q. Y. Hu	Fabrication and enhancement of critical currents of silver sheathed $Bi,Pb_2Sr_2Ca_3Cu_3O_{10}$ tapes	1996	Research Fellow, Florida State University, USA	1997
			Research Scientist, Argonne National Lab., USA	1999
			Senior Engineer, Lucent, USA	2001
J. Yau	Ag/Bi-2223 tape processing and mechanical properties	1994	Assistant Professor, City Polytechnic University	2000
J. A. Xia	Characterization of melt-texture of YBCO HTS	1994	Research Fellow, Solar Cell Ltd	1995

PhD Name	Thesis Title	Awarded	Position	Appointed
Y. C. Guo	Investigation of silver-clad $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10-x}$ superconducting tapes	1994	STA Fellow, National Research Institute Of Metals, Japan	1997
			ARC Postdoctoral Fellow, ISEM, University of Wollongong	1998
			Senior IT Specialist, ITS, University of Wollongong	2002
A. Bourdillion	Microstructure, phase characterization and texture processing of HTS	1992	Senior Engineer, Hewlett Packard, Singapore	1993
			Hewlett Packard, USA	2000
M. Apperley	The fabrication of high T_c superconductor wire	1992	Chief Technologist, Australian Superconductors	1993
			Business Development Manager, University of Sydney	2004

Masters Name	Thesis Title	Awarded	Position	Appointed
Y. S. Wu	Fabrication of in-situ MgB_2 thin films on Al_2O_3 substrate using off-axis PLD technique	2007	PhD Candidate, ANU	2008
Z. J. Lao	New materials for supercapacitors	2006	Engineer, Sydney	2007
B. Winton	A study of the magnetoresistance effect in Bi-2212 for the purposes of utilisation in magnetic field sensors	2005	PhD Candidate, ISEM, University of Wollongong	2005
Q. Yao	MgB_2 thin films	2005	PhD Candidate, ISEM, University of Wollongong	2005
P. Lavers	The mobility of large anions in crystals with the fluorite Structure	2004	PhD Candidate, ISEM, University of Wollongong	2004
J. Yao	Carbon based anode materials for lithium-ion batteries	2004	PhD Candidate, ISEM, University of Wollongong	2004
Z. W. Zhao	Nano-oxides fabricated in-situ by spray pyrolysis technique as anode materials for lithium secondary batteries	2004	PhD Candidate, ISEM, University of Wollongong	2004
K. Ishida	Landau spectra of ZnH and neutral Zn in germanium	2004		
S. Lee	Multilayer thermionic cooling in GaAs-$Al_xGa_{1-x}As$ heterostructures	2003		

Masters Name	Thesis Title	Awarded	Position	Appointed
Z. Zhang	The comparative research on the Ag-alloy sheathed Bi-2223 tapes	2003	Senior Staff, China-URC Ltd, Shanghai. PR China	2003
A. Li	Fabrication and characterization of novel substrates and superconducting thick films	2002	PhD Candidate, ISEM, University of Wollongong	2002
M. Farhoudi	AC loss in Ag/Bi-2223 tape in AC field	2002	PhD Candidate, ISEM, University of Wollongong	2003
M. Ling	Mechanism of outgrowth in multifilament Bi-2223 tape	2001		
E. Sotirova	Investigation of colossal magnetoresistance materials	2001	Learning Centre Employee, Communications Assistant, Star CD Pty Ltd	2002
K. Uprety	Vortex properties of Bi-HTS	1999	PhD Candidate, ISEM, University of Wollongong	2000
			Research Fellow, Argonne National Lab., USA	2003
J. Z. Wang	Investigations on anode materials for rechargeable lithium-ion batteries	1999	PhD Candidate, ISEM, University of Wollongong	2000
			Research Fellow, ISEM, University of Wollongong	2003
F. Chen	The influence of selenium on lead-calcium-tin-aluminium	1998	PhD Candidate, University of Sydney, Australia	1999
G. Yang	Effect of element substitution on superconductivity	1997	Research Fellow, University of Melbourne	2000
N. Zahir	A new method for production and study of electrical properties of carbon foam	1996	PhD Candidate, Queensland University	1997
J. X. Jin	$(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10+x}$/Ag high T_c superconductors and their applications in an electrical fault current limiter and an electronic high voltage generator	1994	Research Fellow, ISEM, University of Wollongong	1997
			ARC, PDF, ISEM, University of Wollongong	2000

National and International Links

Australia

Australian Nuclear Science & Technology Organisation (ANSTO)
Australian National University
CSIRO Division of Applied Physics
Curtin University of Technology
James Cook University
Macquarie University
Monash University
University of Melbourne
University of New South Wales
University of Queensland
University of Sydney
University of Technology, Sydney

International

Austria

Atomic Institute of Austrian Universities, Vienna
L. Bolzmann Institute of Physics

Canada

'Ecole Polytechnique de Montreal
University of Alberta

Croatia

University of Zagreb

Germany

Max-Planck-Institut for Metalloforschung

India

National Physical Laboratory

Japan

National Institute of Advanced Industrial Science and Technology (AIST)
National Institute of Materials Science
Osaka National Research Institute
Tokai University
Yamagata University

New Zealand

University of Aukland
Industrial Research Lab

Peoples Republic of China

Beijing University of Science and Technology
Harbin University
Hubei University
Institute for Microsystem and Information Technology
Institute of Electrical Technology
Institute of Non-ferrous Metals
Nakai University
Nanjing University
Northeastern University
Shanghai Jiao Tong University
Shanghai University
Tienjun Uinversity
Institute of Physics

Russia

Institute of General Physics

Singapore

National University
Nanyang University of Technology

South Korea

Andong National University
Korea Advanced Institute of Science & Technology
Korea Aerospace Research Institute (KARI)
Korea Institute of Materials Science (KIMS)

Switzerland

University of Geneva

UKRAINE

Donetsk Physico-Technical Institute
Institute for Metal Physics

United Kingdom

Imperial College
Oxford University
Southhampton University
University of Cambridge

United States of America

Ames Lab, Iowa State University
Argonne National Laboratory
Brookhaven National Lab.
Houston University
Los Alamos Laboratory
National Institute of Standard Technology
New York Polytechnic University
Ohio State University
University of Wisconsin
Rensselaer Polytechnic Institute

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ARC Centre of Excellence Research

All solid-state lithium rechargeable batteries *(within the ARC Centre of Excellence for Electromaterials Science, Director: G. G. Wallace)*

Funded:	2005 2006 2007 2008 2009 2010
Project ID:	CE0561616
Chief Investigator:	H. K. Liu
Research Fellow:	J. Z. Wang
Associate investigators:	Z. P. Guo, K. K. Konstantinov, G. X. Wang, J. Y. Lee, J. H. Ahn
PhD students:	M. S. Park, S. Y. Chew, S. L. Chou, M. D. Rahman, N. H. Idris, C. Zhong

Progress made in 2008

A new mesoporous carbon-tin (MC-Sn) nanocomposite has been successfully prepared via a two-step method. From TEM observations, the tin nanoparticles were decorated on the as-prepared mesoporous carbons. The mesoprous structure of the carbon can effectively buffer the volume changes during the Li-Sn alloying and de-alloying cycles. The as-prepared MC/Sn nanocomposite electrodes exhibited extremely good cycling stability, with the specific capacity of Sn in the composite electrode calculated to be 959.7 mAh g^{-1}, which amounts to an impressive 96.9% of the theoretical value (990 mAh g^{-1}). The reversible capacity after 200 cycles is 96.1% of the first cycle reversible capacity, i.e. the capacity fade rate is only 0.0195% per cycle, which is even better than that of commercial graphite-based anodes.

Sulfur–mesoporous carbon composite was synthesized by heating a mixture of elemental sulfur and synthesized mesoporous carbon. A novel electrolyte was prepared by dissolving lithium bistrifluoromethanesulfonimidate (LiTFSI) in a synthesized ionic liquid consisting of 1-ethyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide (EMITFSI) at a concentration of 1 mol/L. The S–C composite was tested in both the ionic liquid and the organic solvent electrolytes. The capacity and cyclic stability of the S–C composite using ionic liquid electrolyte was improved when compared with a conventional organic solvent electrolyte of 1 mol/L LiTFSI– PEGDME.

Porous Co_3O_4 nanostructured thin films were electrodeposited by controlling the concentration of $Co(NO_3)_2$ aqueous solution on a nickel sheet, and then sintered at 300 °C for 3 h. The electrochemical measurements show that the porous Co_3O_4 thin film formed from big-nanoflakes with the highest electrochemical active specific surface area (68.64 $m^2 g^{-1}$) shows the best electrochemical performance including the highest capacity and long cycle life due to the porous and nanostructure, compared to other two kinds of smooth surface film and small-nanoflake formed film. The pores and nanostructures of sample formed from big-flakes showed little change after 50 cycles. The highest specific capacity of 513 mAh g^{-1} after 50 cycles was obtained from the thinnest film with the loaded Co_3O_4 of 0.05 mg cm^{-2}. This method could also be used to improve the performance properties of other metal oxide for lithium-ion batteries.

LiV_3O_8 nanoparticles with an average particle size of approximately 50 nm have been synthesized by flame spray pyrolysis for the first time. This is an attractive process as it can be scaled to industrial production levels. Material and electrochemical characterizations were conducted for the LiV_3O_8 nanoparticles. The LiV_3O_8 nanoparticles produced in the dry-phase by FSP have a relatively high maximum capacity (> 300 mAh g^{-1}) when compared to particles produced in the wet-phase, however, it is seen to have stronger capacity fading (> 2 % per cycle beyond 50 cycles) when compared to micron-sized particles and nanoparticles treated with conductive binders. Possible sources of the capacity fading of the electrodes containing the FSP-produced nanoparticles are the formation of a passivation layer at the electrode/electrolyte interface, dissolution of the active material into the electrolyte, and/or

insufficient engineering to optimize the electrode composition. Nevertheless, LiV_3O_8 nanoparticles are promising as cathode materials for use in lithium-ion batteries.

Publications

1. Z.W. Zhao, Z. P. Guo, P. Yao and H. K. Liu, "Mesoporous carbon-tin nanocomposites as anode materials for Li-ion battery", *Journal of Materials Science & Technology* **24** (04), 657 (2008) (invited paper)
2. M.S. Park, Y.M. Kang, G. X. Wang, S. X. Dou, and H. K. Liu, "The effect of morphological modification on the electrochemical properties of SnO_2 nanomaterials", *Advanced Functional Materials* **18**, 455 (2008) (IF:7.496)
3. S.H. Ng, S.Y. Chew, D.I. dos Santos, J. Chen, J. Z. Wang, S. X. Dou and H.K.Liu, "Hexagonal-shaped tin glycolate particles: A preliminary study of their suitability as Li-ion insertion electrodes", *Chemistry - An Asian Journal* **3** (5), 854 (2008) (new journal)
4. M.S. Park, Y.M. Kang, S. X. Dou and H. K. Liu, "Reduction-free synthesis of carbon-encapsulated SnO_2 nanowires and their superiority in electrochemical performance", *The Journal of Physical Chemistry C* **112**, 11286 (2008)
5. J. Wang, S.Y. Chew, Z.W. Zhao, A. Shenauda, D. Wexler, J. Chen, S.H. Ng, S.L. Chou and H. K. Liu, "Sulfur–mesoporous carbon composites in conjunction with a novel ionic liquid electrolyte for lithium rechargeable batteries", *Carbon* **46**, 229 (2008) (IF: 4.26)
6. S.Y. Chew, J.Z. Sun, J. Z. Wang, H. K. Liu, M. Forsyth and D.R. MacFarlane, "Lithium polymer battery based on an ionic liquid-polymer electrolyte composite for room temperature applications", *Electrochemical Acta* **53 (**22), 6460 (2008) (IF: 2.848)
7. S.L. Chou, J. Wang, H. K. Liu and S. X. Dou, "Electrochemical deposition of porous Co_3O_4 nanostructured thin film for lithium-ion battery", *Journal of Power Sources* **182**, 359 (2008) (IF: 2.809)
8. T.J. Patey, S.H. Ng, R. Büchel, N. Tran, F. Krumeich, J. Wang, H. K. Liu and P. Nováka**,** "Electrochemistry of LiV_3O_8 nanoparticles made by flame spray pyrolysis", *Electrochemical and Solid-State Letters* **11 (**4), A46 (2008) (IF: 2.109)
9. J. Z. Wang, S.L. Chou, J. Chen, S.Y. Chew, G. X. Wang, K. Konstantinov, J. Wu, S. X. Dou and H. K. Liu, "Paper-like free-standing polypyrrole and polypyrrole-$LiFePO_4$ composite films for flexible and bendable rechargeable battery", *Electrochemistry communications* **10**, 1781 (2008)

Discovery Projects

Current limiting mechanisms in magnesium diboride superconductors

Funded: 2007 2008 2009 2010 2011
Project ID: DP0770205
Chief Investigators: S. X. Dou
Partner Investigators: J. Driscoll, R. Flukiger, H. Kumakura, M. Sumption

Progress made in 2008

The objectives of this period:
1) Tackle the mechanisms responsible for significant enhancement in J_c, H_{irr} and Hc_2 of doping in MgB_2, and;
2) Understand and improve the connectivity and, hence, raising J_c throughout the entire field- and temperature range.

Enhancement of grain connectivity and flux pinning via strain engineering:
We have succeeded in strain engineering a highly dense MgB_2 composite by the thermal diffusion method. In contrast to the well-established C substitution induced enhancement of the superconducting properties, we have demonstrated that the residual thermal stress/strain in SiC-MgB_2 composite is caused by the difference in thermal expansion coefficients between MgB_2 and SiC, which represents a new mechanism that is responsible for the enhancement in flux pinning and Hc_2 in the SiC-MgB_2 composite. XRD and TEM results show that the SiC and MgB_2 coexist as two separate but strongly bonded phases. No change in the a-axis, a small increase in resistivity and a small decease in Tc as a result of SiC doping indicate a lack of C substitution. The residual thermal strain in the SiC-MgB_2 composite is evidenced through Raman measurements, XRD, TEM and the behavior of J_c temperature

dependence. The present findings have a significant implication, as they open up a new direction for numerous bulk composites that can be strain-engineered to achieve desirable materials properties without significant alteration in intrinsic properties, as compared to chemical substitution.

Excess Mg addition MgB_2/Fe wires with enhanced connectivity and critical current density:
MgB_2/Fe wires with 10% excess Mg produced by in-situ powder-in-tube processing was compared with normal stoichiometric MgB_2/Fe wires prepared by the same method. It was found that J_c and H_{irr}, were significantly enhanced for MgB_2/Fe wires with excess Mg. The transport J_c for 10% Mg excess samples sintered at 800 ^oC, measured in field up to 14T, increased by a factor of 2 compared to that for the normal MgB_2 wires. The best J_c results for the 10% Mg excess sample were obtained by heating the sample at 600 ^oC for 1 h, the J_c at field 8T and at temperature 10K reached 3 × 104 A/cm^2. The improvement in properties is due to the strong connectivity as a result of Mg access.

Effect of carbon doping on the Hc_2 and resistivity of MgB_2 by using sucrose ($C_{12}H_{22}O_{11}$) as the carbon source:
Sucrose was doped into MgB_2 samples to act as a carbon source. The sintering temperature varied from 850^{o}C to 1050^{o}C. The effects of sucrose doping and sintering temperature on the lattice parameters, microstrain, critical temperature (Tc), resistivity, and upper critical field (Hc_2) have been investigated in detail. It has been found that sucrose doping results in a small depression in Tc and high resistivity, while Hc_2 performance is improved. The best performance was shown in the sucrose doped sample sintered at 850^{o}C. The reason for the enhancement of Hc_2 is likely to be disorder caused by C substitution for B and/or diffusion of C atoms in the MgB_2 lattice as interstitial atoms.

Publications

1. J. Horvat, W. K. Yeoh, J. H. Kim and S. X. Dou, "Transport and magnetic critical current in superconducting MgB_2 wires", *Superconductor Science & Technology* **21**, 065003 (2008).
2. C.H. Jiang, X. Xu and S. X. Dou, "Properties of pure and carbon sphere doped MgB_2 prepared from low grade boron powders", *Superconductor Science & Technology* **21** (6), 065006 (2008).
3. J. H. Kim, S. X. Dou, S. Oh, M. Jercinovic, E. Babic, T. Nakane and H. Kumakura, "Correlation between doping induced disorder and superconducting properties in carbohydrate doped MgB_2", *Journal of Applied Physics* **104** (6), 063911-1 (2008).
4. *****J. H. Kim, X. Xu, M.S.A. Hossain, D. Q. Shi, Y. Zhao, X. L. Wang, S. X. Dou, S. Choi and T. Kiyoshi, "Influence of disorder on the in-field J_c of MgB_2 wires using highly active pyrene", *Applied Physics Letters* **92** (4), 042506 (2008).
5. W. X. Li, Y. Li, R. H. Chen, R. Zeng, S. X. Dou, M. Zhu and H. Jin, "Raman study of element doping effects on the superconductivity of MgB_2", *Physical Review B* **77** (9), 094517 (2008).
6. W. X. Li, R. Chen, Y. Li, M. Zhu, H. Jin, R. Zeng, S. X. Dou and B. Lu, "Raman study on the effects of sintering temperature on the J_c(H) performance of MgB_2 superconductor", *Journal of Applied Physics* **103** (1), 013511 (2008).
7. W. X. Li, Y. Li, R. Chen, R. Zeng, M. Zhu, H. Jin and S. X. Dou, "Electron-phonon coupling properties in MgB_2 observed by Raman scattering", *Journal of Physics: Condensed Matter* **20** (25), 255235 (2008).
8. M. Maeda, Y. Zhao, S.X Dou, Y. Nakayama, T. Kawakami, H. Kobayashi and Y. Kubota, "Fabrication of highly dense MgB_2 bulk at ambient pressure", *Superconductor Science & Technology* **21** (3), 032004 (2008).
9. *****X.B. Xu, H. Fangohr, X.N. Xu, M. Gu, Z.H. Wang, S.M. Ji, S.Y. Ding, D. Q. Shi and S. X. Dou, "Peak effect in the critical current of type II superconductors with strong magnetic vortex pinning", *Physical Review Letters* **101** (14), 147002 (2008).
10. X. Xu, J. H. Kim., M.S.A. Hossain, J.S. Park, Y. Zhao, S. X. Dou, W. K. Yeoh, M. Rindfleisch and M. Tomsic, "Phase transformation and superconducting properties of MgB_2 using ball-milled low purity boron", *Journal of Applied Physics* **103** (2), 023912 (2008).
11. R. Zeng, L. Lu, W. Li, J. L. Wang, D. Q. Shi, J. Horvat, S. X. Dou., M. Bhatia, M. Sumption, E. Collings, J. Yoo, M. Tomsic and M. Rindfleisch, "Excess Mg addition MgB_2 /Fe wires with enhanced critical current density", *Journal of Applied Physics* **103** (8), 083911 (2008).

12. R. Zeng, L. Lu and S. X. Dou, "Significant enhancement of the superconducting properties of MgB_2 by polyvinyl alcohol additives", *Superconductor Science & Technology* **21** (8), 085003 (2008).
13. Y. Zhang, X. Xu, Y. Zhao, J. H. Kim, C. Lu, S. H. Zhou and S. X. Dou, "Significant improvement of J_c in MgB_2 bulk superconductor using ball-milled high-purity crystalline boron", *Superconductor Science & Technology* **21**, 115004 (2008).

Development of conductive buffer layers for RABiTS-based coated conductors

Funded: 2006 2007 2008
Project ID: DP0666771
Chief Investigators: D. Q. Shi

Progress made in 2008

In 2008, we have continually conducted research on conductive buffer layers. Conductive $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) has been epitaxially grown on biaxially textured Ni substrates as a single buffer layer. The subsequent epitaxial growth of $YBa_2Cu_3O_{7-\delta}$ (YBCO) coatings by pulsed laser deposition yielded self-field critical current densities (J_c) of 0.5×10^6 A/cm^2 at 77 K, and provided good electrical connectivity over the entire structure (HTS + conductive-buffer + metal substrate). Property characterizations of YBCO/LSMO/Ni architecture revealed excellent crystallographic and morphological properties. These results have demonstrated that LSMO, used as a single, conductive buffer layer, may offer potential for use in fully stabilized YBCO coated conductors.

Besides LSMO films, chemical solution deposition was used to prepare $La_{1-x}Na_xMnO_3$ films. The results showed that under an oxygen or air annealing atmosphere, the $LaMnO_3$-based films were highly (h00)-oriented, when perovskite oxide single crystal substrates were used; however, when YSZ substrates were used, only $La_{1-x}Na_xMnO_3$ films were highly (h00)-oriented. When a wet reducing atmosphere was used for annealing, all the $LaMnO_3$-based films were highly (h00)-oriented on perovskite oxide single crystal substrates; however, the $LaMnO_3$-based films were (110)-oriented when Ni tapes were used as substrates. By using Ni tapes buffered with perovskite $SrTiO_3$ films, the orientation can be tuned to highly (h00)-oriented, which is suitable for subsequent growth of YBCO films.

Our research has been extended to the non- $LaMnO_3$-based films as conductive buffer layer. Metallic and transparent $La_{0.5}Sr_{0.5}TiO_{3+x/2}$ films were prepared by chemical solution deposition method using topotactic reducing processing. The usage of Si-powders as reducing precursors was facile and could be easy manipulation. It was observed that metallic (resistivity at 300K ~2.43 mΩ cm) and transparent (~80% transmittance at visible light) $La_{0.5}Sr_{0.5}TiO_{3+x/2}$ films could be obtained at annealing temperature of 900°C, which was rather lower than the hydrogen reducing temperature (~1400°C). The successful preparation of metallic and transparent $La_{0.5}Sr_{0.5}TiO_{3+x/2}$ films using chemical solution deposition provided a feasible route to deposit other perovskite-structured functional layers on $La_{0.5}Sr_{0.5}TiO_{3+x/2}$ films using low-cost all chemical solution deposition method.

A single $Ce_{0.8}Gd_{0.2}O_{1.9}$ (CGO) buffer layer was successfully grown on the textured Ni-5 at.%W (Ni-5W) substrates for YBCO coated conductors by a simple metal-organic deposition (MOD) technique. The precursor solution was prepared using a newly developed process and only contained common metal-organic salts of both Ce and Gd dissolved into a propionic acid solvent. r. X-ray studies indicated that the CGO films had good out-of-plane and in-plane textures with full-width-half-maximum values of 4.18 and 6.19, respectively. Atomic force microscope (AFM) investigations of the CGO films revealed that most of the grain boundary grooves on the Ni-5W surface were found to be well covered by CGO layers, which had a fairly dense and smooth microstructure without cracks and porosity. These results indicate that our MOD technique is very promising for further development of single buffer layer architecture for YBCO coated conductors, due to its low cost and simple process.

A new biaxially textured tape of Ni-0.1%Mn was used as a substrate for YBCO coated conductor through the RABiTS approach**.** Multi-layer $CeO_2/La_{0.7}Sr_{0.3}MnO_3$, $CeO_2/ La_{0.5}Sr_{0.5}TiO_{3+x/2}$ and single conductive $La_{0.7}Sr_{0.3}MnO_3$ buffer layers and YBCO film were successfully deposited on the substrate

by PLD. The optimal deposition conditions have been systematically studied. Nine papers funded by this project have been published in international journals.

Development of novel ferroelectric magnetic materials for multi-functional applications

Funded: 2006 2007 2008
Project ID: DP0665873
Chief Investigators: X. L. Wang, Z. X. Cheng
Partner Investigators: T. Shrout, W. Wen, K. Yamaura, K. D. Liss, R. Piltz

Progress made in 2008

Nb and La co-doped $BiFeO_3$ thin films were fabricated on oxide bottom electrodes, $LaNiO_3$/Si and IrO_2/Si, by the pulsed laser deposition method. The doped $BiFeO_3$ thin film capacitor on $LaNiO_3$ showed a remnant polarization of more than 75 $\mu C/cm^2$ in a saturated hysteresis loop. The same La and Nb co-doped $BiFeO_3$ thin film capacitors on IrO_2 showed a larger remnant polarization, with a significant contribution from the leakage current. Furthermore, the doped $BiFeO_3$ capacitor on the $LaNiO_3$ bottom electrode showed worse fatigue resistance than the film on IrO_2. All the doped $BiFeO_3$ thin films showed weak ferromagnetism at room temperature.

Perovskite solid solution ceramics with compositions of $0.9Pb(Fe_{0.5}Nb_{0.5})O_3$-$0.1PbTiO_3$, $0.6Pb(Ni_{1/3}Nb_{2/3})O_3$-$0.4PbTiO_3$, and $0.6Pb(Co_{1/3}Nb_{2/3})O_3$-$0.4PbTiO_3$ were synthesized by the traditional solid state reaction method. Ferroelectric measurements revealed that these samples have well saturated polarization-electrical field loops. Dielectric measurements showed that abnormal dielectric peaks at their Curie temperature were frequency dependent. Both characteristics indicate that these samples are relaxor type ferroelectric materials. Field cooled and zero field cooled magnetization measurements revealed that the $0.6Pb(Ni_{1/3}Nb_{2/3})O_3$-$0.4PbTiO_3$ and $0.6Pb(Co_{1/3}Nb_{2/3})O_3$-$0.4PbTiO_3$ samples are paramagnetic down to 5 K, while the $0.9Pb(Fe_{0.5}Nb_{0.5})O_3$-$0.1PbTiO_3$ sample shows an antiferromagnetic-like ordering, starting from around 40 K. Furthermore, a weak ferromagnetism is observed in the $0.9Pb(Fe_{0.5}Nb_{0.5})O_3$-$0.1PbTiO_3$ sample, as evidenced by the magnetic hysteresis loop measured at 10 K. The AC susceptibility measurement of this sample showed that the peak position around 40 K is strongly dependent on frequency, indicating a glassy or relaxor-type behaviour below that temperature. Therefore, relaxor type ferroelectric and magnetic $0.9Pb(Fe_{0.5}Nb_{0.5})O_3$-$0.1PbTiO_3$ is a magnetoelectric relaxor.

Rare earth element doped $BiFeO_3$ thin films were fabricated using the pulsed laser deposition method and various targets made from different starting Fe_2O_3 and Fe_3O_4 iron source material. The films fabricated using the targets made from Fe_3O_4 exhibit great enhancement in their ferroelectricity, due to greatly reduced electrical leakage, as well as enhanced magnetization compared to those films deposited using targets from Fe_2O_3. It is suggested that the Fe^{2+} ion plays an important role in compensating for the charge imbalance and reducing current leakage, as well as enhancing the magnetic moment through the introduction of antiferrimagnetic ordering at Fe^{2+} sites.

The structural, electronic, and optical properties of a piezoelectric material, Ga_3PO_7, were studied by first-principles calculations in the framework of density functional theory. The calculated structure is in agreement with the experimental data. The band structure reveals that Ga_3PO_7 has a band gap of 3.69 eV. Analysis of the partial density of states and Mulliken charge population indicates the existence of GaO_5 and PO_4 anion groups in Ga_3PO_7. Furthermore, its optical properties, including dielectric constant, absorption, reflectivity, refractive index, and electron loss were calculated and analysed. They show that Ga_3PO_7 has potential applications based on the combination of its piezoelectric and optical properties.

Publications

1. Z.X. Cheng, X. L. Wang, H. Kimura, K. Ozawa and S. X. Dou, "La and Nb codoped $BiFeO_3$ multiferroic thin films on $LaNiO_3$/Si and IrO_2 /Si substrates", *Applied Physics Letters* **92**, 92902 (2008).
2. Z.X. Cheng and X. L. Wang, MMM 2008, Texas, 2008.

3. Z.X. Cheng, X. L. Wang, S. X. Dou, S.J. Zhang and T.R. Shrout, *Journal of Applied Physics* (in press, accepted on 02/08/2008).
4. Z.X. Cheng, X. L. Wang, S. X. Dou. H. Kimura and K. Ozawa, "Enhancement of ferroelectricity and ferromagnetism in rare earth element doped $BiFeO_3$", *Journal of Applied Physics* **104**, 116109 (2008).
5. Z.X. Cheng and X. L. Wang, "Optical property and electronic band structure of a piezoelectric compound Ga_3PO_7 studies by the first-principles calculation", *Applied Physics Letters* **92**, 261915 (2008).
6. Z.X. Cheng et al., *The 4th Asian Conference on Crystal Growth and Crystal Technology (CGCT4),* Sendai, Japan, 2008.
7. Z.X. Cheng, X. L. Wang, et al., *The 25th Conference on Ferroelectric Materials and Applications* (*FMA 25)*, Kyoto, Japan, 2008.

Development of novel high efficiency thermoelectric oxides for high temperature power generation

Funded: 2008 2009 2010
Project ID: DP0879714
Chief Investigators: G. Peleckis

Progress made in 2008

The project started in July 2008. In May 2008 a PhD student was hired and arrived in Australia at the beginning of August 2008. A comprehensive literature survey was done in order to summarize progress and current status of research in the oxide thermoelectric community. Our investigations showed that the key research area to explore is the fabrication of oxide thermoelectric materials in nano-particle form as it significantly reduces thermal conductivity due to the phonon scattering. Therefore, after an extensive literature survey, the PhD student commenced work on the fabrication of parent Co-based compounds concentrating on fabrication of nano-sized oxide thermoelectric materials. The experimental work has been hindered by the fact that since May 2008 until October 2008 the host institution was relocated into a new building. All major equipment and sample preparation facilities were shut down and experiments were put on hold until the restart of operations in late October 2008.

Despite this forced break in operation we have performed preliminary work on parent sodium cobalt bronzes, which are one of the key materials for high temperature thermoelectric application. During the last quarter of 2008 we successfully synthesized pure and doped sodium cobalt bronzes in bulk form. X-ray diffraction studies revealed that all prepared samples are of hexagonal crystal structure and c axis of the material is elongating with the introduction of bigger cations such as potassium. We found that doped material is highly hygroscopic and is absorbing a large amount of water from the atmosphere, thus preparation of the samples was transferred into inert atmosphere, e.g. argon. SEM-EDS analysis showed that some of the alkali metals are lost due to the evaporation during sample preparation procedure; however, this loss is no more than 3 to 5 % of nominal chemical composition. Electrical transport measurements showed that samples are metallic in nature, i. e. electrical resistivity decreasing with temperature, with slight curvature in the low temperature region. Electrical resistivity measured was $\rho_{300K} \approx 2\ \Omega{\cdot}cm^{-2}$ and $\rho_{10K} \approx 300\ m\Omega{\cdot}cm^{-2}$, respectively. We also observed irreversibility in electrical resistivity curves at around 280 K, which can be attributed to a structural transformation of the Na-Co-O phase taking place in this temperature region.

Single crystalline Na-Co-O samples have been also grown. Single crystal growth is essentially controlled by evaporation of the flux in the pressed pellets and happens in a very short time around 1 to 2 hours. Our findings showed that whisker single crystals were formed although their length and amount after the growth is very low. Our investigations showed that formation of the whiskers is mainly occurring at the edge of the round pellets we are presently using. No crystals were found on the top surfaces of the pellets indicating that it is essential to decrease surface area of the pellets for pronounced growth of single crystals. Special rectangular dies have been ordered, which will allow fabrication of longer single crystals of higher quality and length.

As part of this project we prepared bulk and thin film samples of $PbPdO_2$. Electrical properties of the samples showed very interesting feature: metal-insulator transition at around 150 K. Furthermore, thin

film samples showed giant electroresistance in this temperature region. These findings were summarized in the journal article, which is accepted by Advanced Materials late December 2008 and is due to be published early 2009.

We are also developing a synthesis procedure, which will allow formation of nano-particle based composites highly needed to decrease thermal conductivity of Na-Co-O bronzes. First results indicated that using low temperature hydrothermal synthesis, nanocrystalline particles of $NaCoO_2$ can be synthesized. Low temperature hydrothermal synthesis is useful in order to decrease synthesis time and required sintering temperatures. However, the yield and amounts of material formed during the fabrication process is very small, which surely a key issue for use in industrial scale production. Thus, we are adjusting synthesis conditions to increase the amount of product during such synthesis.

Exploration for new materials for spintronics

Funded:	2005	2006	2007	2008	2009
Project ID:	DP0558753				
Chief Investigator:	X. L. Wang				

Progress made in 2008

The concept of the spin gapless semiconductor in which both electron and hole can be fully spin polarized is proposed, and its possibility is presented on the basis of first-principles electronic structure calculations. Possible new physics and potential applications in spintronic devices based on the spin gapless semiconductors are discussed. This work was published in *Physical Review Letters* **100**, 156404 (2008) and highlighted in an article published in *Nature-Asia Materials*, 2008.

Under the support of the QEII project, we have carried a pioneering study on the newly discovered Fe-based superconductors. We reported very high critical field and superior Jc-field performance in $NdFeAsO_{0.82}F_{0.18}$ with Tc of 51 K. This work has been treated as one of the pioneer study in this new field and the CI was invited to give invited talk on this work at the first international conference on the Fe-based superconductors held in Tokyo, Japan in July 2008. This work was published in *Advanced Materials,* X. L. Wang et al, Oct, 2008, online.

In collaboration with Prof. Max Lu's team at University of Queensland, we reported a novel synthesis and selective bioseparation of the composite of Fe_3O_4 magnetic nanocrystals and highly ordered MCM-41 type periodic mesoporous silica nanospheres. High magnetization values and superparamagnetic property of MSNs provide a convenient means to remove nanoparticles from solution and make the re-dispersion in solution quick following the withdrawal of an external magnetic field. This work was published in *Advanced Functional Materials* **18**, 3202 (2008).

We report the magnetic properties of single crystals of Na_xCoO_2 (x=0.42, 0.82, and 0.87). The magnetic susceptibility measurements revealed considerable anisotropy along H//*ab* and H//*c* for the as-grown single crystals. It was found that an antiferromagnetic transition with a Neel temperature *TN*=21 K occurred for the x=0.82 sample, and there was a paramagnetic phase for the x=0.87 sample over a wide temperature range from 2 to 300 K, but the sample with x=0.42 shows a monotonic increase of x with increasing temperature above 100 K. This work was published in *Journal of Applied Physics* **103**, 07C702 (2008).

We investigated the emission of terahertz frequency electromagnetic radiation from high-*TC* superconducting *c*-axis $NdBa_2Cu_3O_7/PrBa_2Cu_3O_7/NdBa_2Cu_3O_7$ trilayer thin film tunneling junctions when external electric and magnetic fields are applied. Our results provide a new insight into a solid-state quantum system with considerable potential for new solid-state terahertz emission sources. This work was published in *Journal of Applied Physics* **103** (7), 07C719 (2008).

We report the magnetic and magnetotransport properties of Ca doped $La_{1-x}Ca_xCrO_3$ (x=0, 0.1, 0.2, and 0.3). Both the magnetic and transport properties are very sensitive to Ca substitution. The Néel temperature *TN* decreases substantially with increasing calcium doping concentration from 290 to 160 K. A weak ferromagnetic state with large coercive fields of up to 3 T is present for the Ca doped $LaCrO_3$. The temperature dependence of the resistivity shows that all the Ca doped compounds are

semiconducting and their resistivities decrease with increasing Ca for low doping levels. The resistivity curves show thermally activated behavior and a variable range hopping behavior at high temperatures. The magnetotransport measurements show a negative magnetoresistance. Furthermore, an anomalous peak was observed in the field dependence of magnetoresistance for the LCCO materials. This work was published in *Journal of Applied Physics* **103** (7), 07B916 (2008).

First principles for development of novel hybrid electrochemical energy storage and conversion systems

Funded:	2007 2008 2009 2010 2011
Project ID:	DP0772999
Chief Investigators:	G. X. Wang, K. K. Konstantinov, C. Zhang, J. Z. Wang
Partner Investigators:	M. S. Islam, R. S. Liu, P. Novak, P. H. Notten

Progress made in 2008

This research project has proceeded as planned. The achievements and outcomes are summarised as follows:

SnO_2-CNT composite anode materials have been synthesized via chemical treatment followed by heating at high temperature. The solution-based chemical process enables Sn^{2+} ions to penetrate into the inner cavity of the carbon nanotubes. SnO_2 nanocrystals were observed to be homogeneously distributed on the carbon nanotube matrix by TEM and HRTEM analysis. The SnO_2-CNT composite electrodes exhibited stable cyclability with a lithium storage capacity of 410 $mAhg^{-1}$ after fifty cycles.

One dimensional (1D) SnO_2 nanowires were synthesised by a simple heat treatment of Sn-Ag alloys. The presence of Ag in the alloy and a small amount of oxygen in an inert gas played an important role in the growth of SnO_2 nanowires. The Li storage property of nano-sized SnO_2 particles and 1D SnO_2 nanowires was evaluated in lithium-ion cells. The SnO_2 nanowires exhibited a better electrochemical performance as an anode than that of spherical powders.

Carbon coated magnetite (Fe_3O_4) core-shell nanorods were synthesized by a hydrothermal method using Fe_2O_3 nanorods as the precursor. Transmission electron spectroscopy (TEM) and high resolution TEM (HRTEM) analysis indicated that a carbon layer was coated on the surfaces of the individual Fe_3O_4 nanorods. The electrochemical properties of Fe_3O_4/carbon nanorods as anodes in lithium-ion cells were evaluated by cyclic voltammetry, a.c. impedance spectroscopy, and galvanostatic charge/discharge techniques. The as-prepared Fe_3O_4/C core-shell nanorods show an initial lithium storage capacity of 1120 mAh/g and a reversible capacity of 394 mAh/g after 100 cycles, demonstrating better performance than that of the commercial graphite anode material.

Carbon nanotube/cobalt oxide core-shell one-dimensional nanostructures were prepared via a hydrothermal synthesis method, in which nanosize cobalt oxide crystals were homogeneously coated on the surface of carbon nanotubes. The morphologies and crystal structures of the as-prepared core-shell nanocomposites were analyzed by X-ray diffraction, field emission gun scanning electron microscopy, and transmission electron microscopy. When applied as anodes in lithium-ion cells, carbon nanotube/cobalt oxide core-shell nanostructures exhibited an initial lithium storage capacity of 1250 mAh/g and a stable capacity of 530 mAh/g over 100 cycles. The good electrochemical performance could be attributed to the nanocrystalline cobalt oxide and the unique core-shell one-dimensional nanostructures.

Publications

1. G. X. Wang, J. Yang, J.S. Park, X.L. Gou, H. Liu, B. Wang and J. Yao, "Facile synthesis and characterization of grapheme nanosheets" *The Journal of Physical Chemistry* C **112**, 8192 (2008).
2. H. Liu, G. X. Wang, J. Z. Wang and D. Wexler, "Magnetite/carbon core-shell nanorods as anode materials for lithium-ion batteries", *Electrochemistry Communications* **10**, 1879 (2008).
3. J. H. Ahn, Y.J Kim and G. X. Wang, "Electrochemical properties of SnO_2 nanowires prepared by a simple heat treatment of Sn-Ag alloys", *Journal of Alloys and Compounds* (in press, doi:10.1016/j.jallcom.2008.07.227).

Giant magnetocaloric materials and room temperature refrigeration

Funded: 2006 2007 2008
Project ID: DP0879070
Chief Investigators: S. X. Dou, J. H. Kim, T. H. Johansen, E. Bruck

Progress made in 2008
We have characterised and analysis the magnetic phase transformation and its effects on magnetocaloric effects in three systems metallic alloys: $Pr_{1-x}M_xMn_2Ge_{2-x}Si_x$ with M (Lu, Y, etc) substituting Pr and Si substitute Ge series compounds, $(Mn_{1-x}Sn_x)_3Sn_2$ with Ni substituting Mn series compounds and with Mn substituting Fe series compounds.

(i) The effects of replacing Pr by Lu in $Pr_{1-x}Lu_xMn_2Ge_2$ (x=0.2, x=0.4) on magnetic structure have been investigated using X-ray diffraction, Mössbauer spectroscopy, magnetisation and neutron diffraction measurements. Four and five magnetic phase transitions have been detected within the temperature range of 4.5 – 550 K for $Pr_{0.8}Lu_{0.2}Mn_2Ge_2$ and $Pr_{0.6}Lu_{0.4}Mn_2Ge_2$, respectively with re-entrant ferromagnetism being detected around TCPr ~ 31 K for $Pr_{0.6}Lu_{0.4}Mn_2Ge_2$.

(ii) The structural and magnetic properties of the re-entrant ferromagnet $PrMn_2Ge_{0.8}Si_{1.2}$ have been investigated using x-ray diffraction, magnetic and DSC measurements. Similar to the canonical reentrant ferromagnet $SmMn_2Ge_2$, multiple magnetic phase transitions have been detected in $PrMn_2Ge_{0.8}Si_{1.2}$ over the temperature range 10 K to 550 K with re-entrant ferromagnetism occurring around ~ 54 K.

(iii) Three first order magnetic phase transitions (FOMTs) have been detected and evaluated over the temperature range from 5 K to 340 K at fields up to 9 T in $PrMn_{1.4}Fe_{0.6}Ge_2$. A interesting phenomenon was observed that magnetic field can induce AFmc to Fmc+F(Pr) transition, and dwindle the re-entrant magnetic transition behavior as well. Based on systematical measurements and analysis, a magnetic phase diagram has been determined.

(iv) The effects of Ni substitution on the magnetic properties and magnetocaloric effect (MCE) of $(Mn_{1-x}Ni_x)_3Sn_2$ compounds(x = 0 to 0.5) have been investigated by x-ray diffraction and magnetisation measurements. It was found that Ni substitution decreases the crystal cell volume and the magnetic transition temperatures compared with pure Mn_3Sn_2.

(v) A series of samples of $Tb_2Fe_{17-x}Mn_x$ (x = 0.01, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5) ferromagnets have been prepared by arc melting following a week annealing. XRD patterns show that all samples present well single phase features. The Tc, magnetic phase transition, magnetic structure and MCE have being characterizing by magnetic measuring and neutron diffraction methods.

Publications:

1. J. L. Wang, R. Zeng, J. H. Kim, L. Lu and S. X. Dou, "Effects of C substitution on the pinning mechanism of MgB_2", *Physical Review B* **77** (17), 174501 (2008).
2. J. L. Wang, S. Campbell, A. Studer, M. Avdeev, M. Hofmann, M. Hoelzel and S. X. Dou, "Magnetic structures and phase transitions in $PrMn_{2-x}Fe_2Ge_2$", *Journal of Applied Physics* **104**, 103911 (2008).
3. R. Zeng, J.L Wang, W. X. Li, L. Lu, S.J. Campbell and S. X. Dou, "Temperature and field induced grant magnetocaloric effect in re-entrant ferromagnet $PrMn_{1.4}Fe_{1.6}Ge_2$ in re-entrant ferromagnet $PrMn_{1.4}Fe_{0.6}Ge_2$", Submitted to Applied Physics Letters.
4. R. Zeng, J.L Wang, W. X. Li, S.J. Campbell and S. X. Dou, "Three first order magnetic phase transitions in re-entrant ferromagnet $PrMn_{1.4}Fe_{0.6}Ge_2$", Submitted to Journal of Physics D: Applied Physics.

Two more papers are under preparation.

High efficiency terahertz emitters

Funded: 2006 2007 2008
Project ID: DP0665292
Chief Investigators: R. A. Lewis

Progress made in 2008

R. A. Lewis was the sole CI. S. Hargreaves was the full-time PhD student paid from the grant. J.C. Knott was a part-time Research Assistant paid from the grant. UOW electrical (P. Anthony), electronic (P. Ihnat) and mechanical workshop (R. Marshall *et al*.) technical staff also contributed.

Terahertz (THz) time-domain spectroscopy (TDS) was advanced during the year, with a variety of candidate emitter materials, sourced from the University of Nottingham, UK, and the Technical University of Darmstadt, Germany, being studied. Much experimental data was collected, analysed and prepared for publication. Five journal papers were published in high-impact journals such as *Applied Physics Letters* and *Physical Review B*, as well as four refereed conference papers.

Publications:

1. R. E. M. Vickers, R. A. Lewis, P. Fisher and Y.J. Wang, "Terahertz Zeeman spectroscopy of boron in germanium to high magnetic fields", *Physical Review B* **77**, 115212 (2008). Also selected for the April 7, 2008 issue of *Virtual Journal of Nanoscale Science & Technology*; also selected for the April 2008 issue of *Virtual Journal of Quantum Information*.
2. G.A. Alvarez, T. Puzzer, X. L. Wang, R. A. Lewis, C.A. Freeth and S. X. Dou, "Subterahertz Josephson plasma emission in layered high-T_C superconducting tunnel junctions", *Journal of Applied Physics* **103**, 07C719 (2008).
3. S. Hargreaves, L. J. Bignell, R. A. Lewis, D. Schoenherr, M. Sağlam and H. L. Hartnagel, "Investigation of p-GaAsSb as a THz emitter", *Journal of the Electrochemical Society* **155** (10), H734 (2008).
4. D. Schoenherr, H. L. Hartnagel, S. Hargreaves, R. A. Lewis and M. Henini, "Time-domain THz spectroscopy using acceptor-doped GaAs photoconductive emitters", *Semiconductor Science and Technology* **23**, 105012 (2008).
5. S. Hargreaves and R. A. Lewis, "Single-cycle azimuthal angle dependence of terahertz radiation from (100) *n*-type InP", *Applied Physics Letters* **93**, 242101 (2008).
6. *Proceedings of 'Wagga 2008': The 32nd Annual Condensed Matter and Materials Meeting*:
   i. F. Gao, R. A. Lewis, M. Ionescu, X. L. Wang and S. X. Dou, "Electrical and optical properties of $La_{0.7}Ca_{0.3}MnO_3$ polycrystalline and thin film".
   ii. M.L. Smith, R. Mendis, R. E. M. Vickers and R. A. Lewis, "Terahertz emission from mercury cadmium telluride".
7. *Proceedings of the Australian Institute of Physics 18th National Congress*:
   i. R. A. Lewis and F. Gao, "High-field far-infrared magnetospectroscopy of cobaltite/manganites"
   ii. R. A. Lewis, Paul Spizzirri, Nik Stavrias and Steven Prawer, "Far-infrared spectroscopy of P ion-implanted Si".

New concepts with multidisciplinary approach: novel functionalised nanostructures for hydrogen storage

Funded: 2007 2008 2009
Project ID: DP0771193
Chief Investigators: Z. P. Guo, H. K. Liu
Partner Investigators: P. H. Notten, J. Chen, A. Zuettel

Progress made in 2008

The hydrogen storage properties of $2NaBH_4 + MgH_2$ system were studied. It was found that the presence of MgH_2 could destabilize the decomposition of $NaBH_4$, decreasing the dehydrogenation temperature about 40 ˚C compared with the pure $NaBH_4$. It is believed that the formation of MgB_2 upon dehydrogenation stabilizes the dehydrogenated state and, thereby, destabilizes the $NaBH_4$. For the desorption the following two-step reaction was observed: $2NaBH_4 + MgH_2 \rightarrow 2NaBH_4 + Mg + H_2 \rightarrow 2NaH + MgB_2 + 4H_2$. Furthermore, various catalysts such as TiF_3, TiO_2, Zr, Si and BCC alloy were doped to the $NaBH_4$-MgH_2 system. Among these catalysts, TiF_3 exhibited the optimum behavior in terms of fast kinetics and lowering the dehydrogenation temperature of the $NaBH_4$-MgH_2 system. The rehydrogenation experiments of TiF_3 doped $NaBH_4$-MgH_2 system was investigated at 600 ˚C with an initial hydrogen pressure of about 4 Mpa. It showed that 5.89 wt % hydrogen was recharged within 12 h. XRD results demonstrated the formation of $NaBH_4$ and MgH_2 in the rehydrogenated sample.

The effect of the addition of SiC in the range of 5-20 wt% on the hydrogen storage properties of MgH_2 prepared by ball milling has been studied for the first time. It has been found that a small amount of SiC reduces the grain size and leads to an improvement in the absorption/desorption kinetics of MgH_2. However, heavy SiC doping introduces negative effects as well, such as lower capacity, high hysteresis, and a decreased absorption rate compared to the lightly doped sample. The large amount of SiC in the heavily doped samples introduced high strain and disorder into the MgH_2 lattice. SiC could also be covering the surface of MgH_2 particles, blocking H_2 diffusion paths to some extent. It is believed that the improvement in hydrogen storage performance for the MgH_2-5wt% SiC sample is mainly due to the smaller grain size and higher surface area of the MgH_2, not the catalytic effects of the SiC.

We had attempted to synthesize $Mg(BH_4)_2$ directly from its elements by soaking the constituent elements in hydrogen at an elevated temperature. Raman spectroscopy, DSC, and hydrogen capacity measurements using the volumetric method suggested that the target material, $Mg(BH_4)_2$, is not present in our sample at any significant level. Nevertheless, our samples show a broad Raman peak centered around 2300 cm^{-1}, which coincides with the B-H stretching mode of $Mg(BH_4)_2$. Future work will involve the optimization of the synthesis parameters in an attempt to directly synthesize $Mg(BH_4)_2$ in appreciable quantities.

The hydrogen storage properties of $LiBH_4$ ball milled with TiF_3 were also investigated. It was found that the $LiBH_4$-TiF_3 mixture exhibited significantly improved hydrogenation/rehydrogenation properties. For example, the $LiBH_4$-TiF_3 (mole ratio:3:1) sample started to release hydrogen at around 100°C, and the hydrogen desorption capacity reached to 5.0 wt. % at 250 °C. Furthermore, the dehydrogenated product can be rehydrogenated partly at 100 atm H_2 and 350°C. Investigations revealed that the decreased dehydrogenation conditions in $LiBH_4$-TiF_3 system resulted from an exothermic reaction of $3LiBH_4+TiF_3 \rightarrow 3LiF+TiB_2+B+6H_2$, which improved both its thermodynamics and kinetics.

Publications

1. J.F. Mao, X.B. Yu, Z. P. Guo, H. K. Liu and Z. Wu, "Enhanced hydrogen storage performances of NaBH4-MgH_2 system", *Journal of Alloys and Compounds* (in press, accepted on 05/01/2009).
2. Y.H. Guo, L. Gao, G.L. Xia, Z. P. Guo and H. K. Liu, "Role of TiF_3 on improving the dehydrogenation of $LiBH_4$", *submitted to The Journal of Physical Chemistry C*.
3. C.K. Poh, Z. P. Guo, X.B. Yu, Z. Huang and H. K. Liu, "Attempt to directly synthesize $Mg(BH_4)_2$ from its constituent elements", submitted to *Journal of Materials Science*.

Superconducting MgB_2 thin films and structures for electronic devices and telecommunication applications

Funded: 2006 2007 2008
Project ID: DP0666853
Chief Investigators: Y. Zhao
Partner Investigators: M. Ionescu, J. Du, E. W. Collings

Progress made in 2008

There are some modifications and delay of original plan, but generally the research project proceeded as planned. The delay is due to an extended period of decommissioning of Key facilities in this project during and after the moving of the APD's host institute, ISEM. Despite the delay in experimental works at ISEM, we still managed to carry out researches on MgB_2 film preparation and phase transformation study in MgB_2 through inter-institutional and international collaborations.

Further optimization of deposition conditions for 2 inch off-axis MgB_2 film preparation in the UHV PLD system has be carried out. We found the deposition rate reduced severely when applying the self-rotation of the 2inch substrate to the off-axis deposition geometry, thus the phase-purity of the resultant MgB_2 film is more sensitive to the impurity level in the background atmosphere. It was also found that a large 2 inch sapphire substrate coated with MgB_2 film is subject to cracking during the post-annealing. We then mounted smaller sapphire substrates on 2 in silicon substrates and the silicon substrate handles the heat treatment well. The results indicate that silicon substrates with an oxygen-passivated surface layer could be more suitable for large-size MgB_2 film synthesis.

Deposition of insulating layer of AlN and TiB_2 as barrier layer for tri-layer sandwich-type Josephson junction has been preliminarily tested. We deposited the thin insulating films from metallic Al and Ti targets using pulsed laser deposition with nitrogen atmosphere. Further structural characterization of the insulating layer and optimization of the interlayer fabrication method is being carried out.

Fabrication of Prototype micro-bridge style Josephson junction on the MgB_2 film has been designed based on hard-mask photolithography and focused-ion-bean techniques. Dr Jia Du (PI, CSIRO-Materials science & Engineering) has dedicated to the design based on the expertise from Nb-series superconducting devices. The fabrication and test of prototype Josephson junctions has been scheduled in 2009 at Jia Du's CSIRO Superconducting Electronics Laboratories.

The APD carried out further investigation on MgB_2 films prepared with hybrid physical-chemical vapour deposition (HPCVD) method in collaboration with the Superconducting MgB_2 Film Group at SungKyunKwan University in Korea. The films were deposited on sapphire substrates with different buffer materials, including Ag, Ni, Ti, and Cu. The microstructure and flux pinning behaviour of the HPCVD MgB_2 films are found to be significantly influenced by the buffer layer composition and thickness.

Publications

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2. M. Ionescu, Y. Zhao, R. Siegele et al., *Nuclear Instruments & Methods in Physics Research Section B*, **266** (8), 1701 (2008).
3. M. Maeda, Y. Zhao, S. X. Dou et al., *Superconductor Science & Technology* **21** (3), 032004 (2008).
4. T.G. Lee, M. Ranot, W.K. Seong, S.G. Jung, W.N. Kang, J.H. Joo, C.J. Kim, B.H. Jun, Y. Kim, Y. Zhao and S. X. Dou, *Superconductor Science & Technology* **22**, 045006 (2009).

Tailoring superconducting hybrid multilayered film systems for electric and electronic applications

Funded: 2008 2009 2010 2011 2012
Project ID: DP0879933
Chief Investigators: A. V. Pan
Partner Investigators: C. Foley, T. H. Johansen, H. Hilgenkamp

Progress made in 2008

The main aim of the project is to develop new tailored superconducting multilayered systems and junctions, consisting of superconductor/ferromagnet combinations, exhibiting novel properties and phenomena for various applications, ranging from quantum electronics to effective charge transport. The project has been substantially delayed due to negotiations associated with signing the agreement between the University of Wollongong and CSIRO (CSIRO is the host institution of one of the PIs). The corresponding approval request was submitted to and approved by the ARC. Thus, the project has formally commenced at the end of October 2008. Nevertheless, substantial progress has been achieved as a result of the extensive preliminary research work.

We have investigated layered superconducting ferromagnets $RuSr_2Eu_{1.5}Ce_{0.5}Cu_2O_{10}$ (Ru-1222) and $RuSr_2EuCu_2O_8$ (Ru-1212) with alternating superconducting CuO_2 and ferromagnetic RuO_2 layers by using x-ray diffraction, scanning electron microscopy, dc magnetization, ac susceptibility, and resistivity measurements. Based on the results obtained, we have proposed a general explanation of the magnetic behaviour of the Ru-based systems. Our model is capable of describing controversial observations of multiple magnetic transitions on temperature dependent dc magnetization measurements as well as the re-entrance of irreversibility in hysteresis loops at high temperatures, which enables the bell-shaped behaviour of the coercive field. The presence of different materials with different magnetic properties led to features that are inherent to various magnetic states, such as ferromagnetic, antiferromagnetic, and spin glass, and still exhibit a coexistence of magnetism and superconductivity at low temperatures. The model proposed in this work unifies the existing scenarios for the Ru-based systems in a common picture. The results has been published in Phys. Rev. B (IF>3) and presented at the MMM-08 conference in Austin (USA).

At the same time, the vortex pinning model based on the presence of the large number of edge dislocations in high quality $YBa_2Cu_3O_7$ (YBCO) films and multilayers has been refined. By introducing the pinning potential of a chain of individual edge dislocations, we have been able not only to describe the critical current density dependence on the applied magnetic field over its entire range, but also to extract the microstructural parameters in the films, such as interdislocation spacing and average domain size, without employing sophisticated microstructural analysis. The model applicability and its results have been verified with the help of microstructural characterisation combined with magneto-optical imaging in YBCO films and multilayers with different properties. This work has been accepted for publication.

High quality YBCO thin film and particularly multilayers possessing enhanced structural and electromagnetic properties have been proposed for application in terahertz emission and detection. Some preliminary micro-structures presumably capable of perform these operations have been manufactured. The progress has been reported in the invited presentation at an international workshop.

Publications

1. R. Nigam, A. V. Pan and S. X. Dou, "Explanation of magnetic behavior in Ru-based superconducting ferromagnets", *Physical Review B* **77**, 134509 (2008). (IF>3)
2. A. V. Pan, S. Pysarenko and S. X. Dou, "Quantitative description of critical current density in YBCO films and multilayers", *IEEE Transactions on Applied Superconductivity* (accepted on 12/12/2008), in press.

Conference presentations

1. R. Nigam, A. V. Pan and S. X. Dou, "Coexistence of ferromagnetism and cluster glass state in superconducting ferromagnet $RuSr_2Eu_{1.5}Ce_{0.5}Cu_2O_{10}$", *53rd Annual Conference on Magnetism and Magnetic Materials (MMM 2008), 10-14 November, 2008, Austin, Texas, USA.*
2. A. V. Pan (INVITED), "Superconductivity, thin films and terahertz radiation", *Australia-China Workshop on Terahertz Science and Technology, 13-14 November 2008, Wollongong, Australia.*

Linkage Projects

Development of high performance second generation superconductors

Funded:	2006 2007 2008
Project ID:	LP0669456
Chief Investigators:	S. X. Dou, A. V. Pan, D. Q. Shi
Partner Investigators:	R. Taylor, T. Yaminshita, J. Barry
Industry Partners:	Mesaplexx Pty Ltd (Australia)

Progress made in 2008

The research has proceeded as planned and some significant results have been achieved as described below:

Continually deposit CeO_2 buffer layer using rf. magnetron sputter. Large area CeO_2 buffer layer of $30x30mm^2$ has been epitaxially deposited onto single crystal YSZ and sapphire substrate.

Successful deposition double-side large area $YBa_2Cu_3O_{7-\delta}$ (YBCO) films using the trifluoroacetate metal– organic deposition (TFA-MOD) method for microwave application, the surface resistance (Rs) of $20x20mm^2$ YBCO/$LaAlO_3$ was 4.1 μΩ at 1 GHz, which is simular to that of Theva sample that was deposited by physical vapour deposition (PVD).

YBCO films with Zr doping have been prepared successfully by the TFA-MOD method through dissolving Zr acetylacetonate in the precursor solution. Yttria-stabilized zirconia (YSZ) nanoparticles were detected in the doped YBCO films by x-ray diffraction (XRD) and scanning electron microscopy (SEM). From the analysis of XRD ω and φ scans, the doped films have better out-of-plane and in plane textures than those of the un-doped YBCO film. A very significant enhancement of critical current density (J_c) is displayed as compared to the undoped film at high applied fields. A high J_c near 106 A cm^{-2} at 1 T and a J_c of 105 A cm^{-2} at 5 T were observed in 6% doped Zr film, which are 5 times and 25

times the J_c values of the un-doped film in the same applied fields, respectively, indicating an optimal defect density created by 6% Zr doping.
YBCO films with $SrZrO_3$ (SZO) doping have been prepared successfully by TFA-MOD method, and their microstructures and physical properties were investigated. From the analysis of x-ray diffraction and φ-scan results, the doped films had sharp biaxial textures. The critical current density, J_c, was significantly enhanced under applied fields as compared to the un-doped film. Furthermore, the ratio of J_c, doped to J_c, un-doped became gradually larger with increasing temperature and magnetic field, indicating that an effective pinning force was created by SZO doping. These results clearly demonstrate that there are appealing prospects for applications of the doped film in high magnetic fields and temperatures.
Pinning effect and vortex dynamics of Type-II superconductor have been studied and analysed. In our outcome, we found the PE can take place for any circumstance associated with certain pinning strengths, densities of pinning centres and driving forces. The PE is a dynamical phenomenon and thermal fluctuations can speed up the process for the formation of the PE. In this proposed Discovery Project, we will pursue further study on PE, not only for the mechanism, but also to modify and manipulate the PE.

Publications

1. M. Liu, D. Q. Shi, H.L. Suo, S. Ye, Y. Zhao, Y.H. Zhu, Q. Li, L. Wang, M.L. Zhou and S. X. Dou, "A simple MOD method to grow a single buffer layer of CGO for coated conductors", accepted by *Physica C* Available online 10 February 2009 .
2. M. Liu, D. Q. Shi, Q. Li, L. Wang, S. Ye, H.L. Suo and S. X. Dou, "YBCO films with szo doping grown by chemical solution deposition" accepted by *Journal of Morden Physics B*.
3. M. Liu, H.L. Suo, S. Ye, D. Q. Shi, Y. Zhao, X. Tang, L. Ma, Q. Li, L. Wang, M.L. Zhou and S. X. Dou, "Preparation and properties of YSZ-doped YBCO films grown by the TFA-MOD Method", *Superconductor Science and Technology* **21**, 115012 (2008).
4. X.B. Xu, H. Fangohr, S.Y. Ding, M. Gu, T.B. Tang, Z.H. Han, D. Q. Shi and S. X. Dou, "Apparent negative mobility of vortex matter due to inhomogeneous pinning" *Physical Review B* **75**, 224507 (2007).
5. D. Q. Shi, X. B. Zhu, J. H. Kim, H.C. Lei, L. Wang, Y.P. Sun, R. Zeng, S. X. Dou, "Chemical solution deposition of $LaMnO_3$-based films for coated conductors", *Journal of Physics* **97**, 012054 (2008).

Development of superconducting leads with ultra-low thermal conductivity for cryoelectronic applications

Funded:	2008 2009 2010
Project ID:	LP0882832
Chief Investigators:	A. V. Pan, S. X. Dou
Partner Investigator:	O. Mukhanov

The project aim is to develop novel technologies for new superconducting current leads, carrying large channels of digital information with minor attenuation and ultra-low thermal conductivity for high-sensitivity, low-noise superconductive cryogenic electronics. The successful outcome will be the realisation of multi-line heat-switches based on multilayer thin/thick-film techniques, which would minimise heat generation and its transfer to cryoelectronic components.

Project commencement was delayed due to the negotiation between the University of Wollongong and both industry partners on terms in the agreement. The project started in July 2008.

The novelty of the task set within the project requires that the existing pulsed laser deposition chamber is substantially modified to incorporate the possibility of deposition of 5-10 times larger substrates, as well as on polycrystalline substrates. These tasks are extremely demanding. On one hand there is a stringent requirement to the film homogeneity, so an uniform scanning mechanism has to be developed for films deposition, which has to incorporate a new heater which is capable of supplying uniform temperature of substrates. On the other hand, an ion gun has to be installed in the chamber to enable ion beam assisted deposition in order to overcome polycrystalline nature of substrates. This modification work has been substantially advanced in all three directions: substrate scanning, new heater, and ion gun installation.

At the same time, the general approach of film deposition on polycrystalline substrates with a buffer layers has been successfully attempted on the base of the existing achievement. As a result, the quality superconducting $YBa_2Cu_3O_7$ (YBCO) films and $(Y/Nd)Ba_2Cu_3O_7$ multilayered film structures have been grown by pulsed laser deposition on metallic templates with magnesium oxide (MgO) buffer layer grown by incline substrate deposition. Different supplementary buffer layers have been deposited between the superconductor and MgO buffer layer. This additional buffer layer reduces the crystal structure misalignment of the superconducting layers. The critical current density has been observed to be higher in the multilayered structures in comparison with the same thickness of monolayer YBCO films. The origin of this enhancement is in improved microstructure of the multilayered systems obtained. This work has been presented at different conferences, received the Best Poster Paper Award, as well as it is accepted to I. J. Mod. Phys. B.

The necessary techniques associated with optical lithography, which is necessary for fabrication multiline channels of data transfer, has been successfully developed and also presented at the conferences. In order to attach electrical wiring to such multiline thin film cables, corresponding wire bonding techniques were successfully trialled. However, a more wok needs to be done in order to develop a direct bonding technique to the ceramic-like YBCO superconducting films.

The day-to-day progress report is discussed and adjusted on monthly meetings with the industry partners.

Publications

1. S. V. Pysarenko, A. V. Pan, S. Downing and S. X. Dou, "Development of multilayer coated conductors with simplified buffer structure", *Journal of Modern Physics B* (accepted on 15/12/2008), in press.

Conference Presentations

1. A. V. Pan, S. V. Pysarenko and S. X. Dou, "Pinning regimes in YBaCuO films and multilayers", *Applied Superconductivity Conference (ASC-2008), August 17–22, Chicago, USA*.
2. S. V. Pysarenko, A. V. Pan and S. X. Dou, "Developing the multilayer coated conductor wires on the base of YBaCuO superconductor thin films", *International Conference on Electronic Materials (IUMRS-ICEM 2008), 28 July – 1 August 2008, Sydney, Australia* (Received: Best Poster Paper Award).

Exploration of new catalyst materials for hydrogen/air fed proton exchange membrane fuel cells

Funded: 2007 2008 2009
Project ID: LP0775109
Chief Investigators: G. X. Wang, H. K. Liu, K. Konstantinov, J. Z. Wang, D. Wexler
Partner Investigators: O. Savadogo

Progress made in 2008

The overall goal of this project is to explore new catalyst materials for PEM fuel cells, including synthesis, characterisation, and electrochemical testing of novel catalyst materials for oxygen reduction and hydrogen oxidation.

High surface area activated carbon materials are currently used in PEM fuel cells. In this project, we proposed to employ carbon nanotubes as supporting matrix for nanosized catalyst particles. Therefore, we did theoretical research on mechanical properties of single walled and multiwalled carbon nanotubes. The variations of critical axial forces for the inner and outer tubes of the double-walled carbon nanotube (DWCNT) in different bucking modes are studied. We found that a surrounding elastic medium has positive effects on the axial stability of DWCNT, and the van der waals interaction increases the axial stability of the inner tube of a DMCNT. The axial stability of the inner tube of a DWCNT is approximately two times greater than the axial stability of a SWCNT, showing the positive effect of the van der Waals interaction on the inner tube. The study demonstrates that the critical force of DWCNT is larger than for SWCNT, and it rises as the radius and aspect ratio increase.

We also investigated the effects of bending moment on the structure of double-walled carbon nanotube (DWCNT). Two types of DWCNTs with almost the same aspect ratio (length/ radius) are selected. Also continuum modeling is utilized to study the bending stability of inner and outer tubes. Due to the van

der Waals interaction between layers, inner tube of DWCNT has higher bending stability than outer tube and its cross section doesn't collapse under bending moment that it distorts one sine wave in circumference edge. Although the aspect ratios of the two types of DWCNTs are approximately the same but based on the growth of cross section area, the critical bending moments of inner and outer tubes of DWCNT raise as the radius of DWCNT increases.

A series of Pt_xNi/C (*x= 1, 2, 3*) nanoparticle catalysts were prepared using a chemical reduction method, aiming to reduce the Pt loading and maintain high catalytic reactivity for oxygen reduction reaction. The as-prepared catalysts have a uniform distribution on carbon matrix with a particle size in the range of 3-5 nm. The catalysts were characterized by X-ray diffraction, field emission scaning electron microscopy and transmission electron microscopy. The electrochemical performance of Pt_xNi/C alloy catalysts was evaluated by cyclic voltammetry, steady-state measurement and chronoamperometric testing. We found that the catalytic reactivity of Pt catalysts towards oxygen reduction can be maintained or even enhanced by partially replacing platinum with nickel.

Carbon-supported Pt_xCo_y (x, y = 0.8, 0.2; 0.7, 0.3; 0.55, 0.45) electrocatalysts were prepared by a chemical reduction method using sodium borohydride ($NaBH_4$) as the reduction agent. Transmission electron microscopy examination showed uniform dispersion of Pt_xCo_y alloy catalysts, with the particle size less than 10 nm. Structures of the Pt_xCo_y/C electrocatalysts were characterized by X-ray diffraction, and the electrochemical characteristics were also studied by cyclic voltammetry, steady-state measurements, and chronoamperometric testing. We found that the prepared Pt_xCo_y/C nanoparticles could be promising cathode catalysts in proton exchange membrane fuel cells with much reduced Pt content, but significantly increased catalytic activity.

Publications

1. A.R. Ranjbartoreh, G. X. Wang, A.G. Arani and A. Loghman "Comparative consideration of axial stability of single and double-walled carbon nanotube and its inner and outer tubes", *Physica E: Low dimensional Systems and Nanostructures* **41**, 202 (2008).
2. A. Ranjbartoreh and G. X. Wang, "Bending stability of inner and outer tubes of double-walled carbon nanotube", *International Journal of Nanoscience* (accepted on Dec 10, 2008).
3. H.M. Wu, D. Wexler, H. K. Liu, O. Savadogo and G. X. Wang, "Preparation of Pt_xCo_y nanoparticles as cathode catalyst for proton exchange membrane fuel cells" (in preparation).

Miniature lithium ion battery for implantable medical device applications

Funded: 2007 2008 2009
Project ID: LP0775456

Chief Investigators: Z. P. Guo, H. K. Liu, J. Z. Wang, K. Konstantinov, M. Forsyth

Progress made in 2008

Uniform α-Fe_2O_3 submicron-sized flowers have been synthesized by a simple hydrothermal process conducted at 160ºC for 24 h. The highly crystalline α-Fe_2O_3 submicro-flowers were composed of nanospheres with an average size of 20-30 nm. The electrochemical performance as anode material for lithium-ion batteries was evaluated by cyclic voltammetry (CV) and by electrochemical impedance and charge-discharge measurements. It was demonstrated that the material could provide an initial reversible capacity of 959.6 mAh/g at a current density of 20 mA/g over the voltage range from 0.01 to 3.0V. The capacity retention upon the 50th cycle was 44.4% and 35.9% at 60 and 100 mA/g, respectively. The superior electrochemical performance may be resulted from the high surface area and the small and uniform grain size.

By carefully tuning the concentration of the reactants and reaction time, crystalline α-Fe_2O_3 with different shape and particle size were selectively synthesized by a simple hydrothermal method. Based on the evidence of electron microscope images, the shape evolution mechanism of the nanowire-structure was proposed. The electrochemical performance as anode materials for lithium-ion batteries was further evaluated by cyclic voltammetry, electrochemical impedance and charge-discharge measurements. It was demonstrated that both the morphology and the particle size had the influence on the performance. Compared with that of cube material, nanowire electrode displayed higher discharge

capacity and better cycling reversibility, which may result from the 1D nanostructure and high surface area.

In addition, a novel $NiCo_2O_4$/C nanocomposite has been synthesized by a hydrothermal method followed calcination in argon at 3000C for 2h. X-ray powder diffraction (XRD) and transmission electron microscope (TEM) measurements demonstrated the composite was composed of crystalline $NiCo_2O_4$ and amorphous carbon, and $NiCo_2O_4$ and carbon particles amalgamated together with good affinity. The electrochemical results showed as high as 914.5mAh/g reversible capacity could be achieved at 40mA/g current density in the range of 0.01~3.0V. The initial coulombic efficiency of the composite was 79.2% and the capacity retention was 78.3% up to 50 cycles. The superior electrochemical performance indicates that the $NiCo_2O_4$/C nanocomposite might be a promising alternative to conventional graphite-based anode materials for lithium-ion batteries.

Publications

1. N. Yanna, P. Zhang, Z. P. Guo and H. K. Liu, "Shape evolution of a-Fe_2O_3 and its size-dependent electrochemical properties for lithium-ion batteries", *Journal of the Electrochemical Society* **155**, A196 (2008).
2. N. Yanna, P. Zhang, Z. P. Guo and H. K. Liu, "Preparation of α-Fe_2O_3 submicro-flowers by a hydrothermal approach and their electrochemical performance in lithium-ion batteries", *Electrochimica Acta* **53**, 4213 (2008).
3. N. Yanna, P. Zhang, Z. P. Guo and H. K. Liu, "Nickel-cobalt oxide/carbon nanocomposites as anode materials for lithium-ion batteries", *Materials Research Bulletin*, in press (available on line).

International Linkage Award Projects

Development of nano-structured thermoelectric materials for power generation from heat

Project ID: LX0881969
Funded: 2008
Chief Investigators: S. X. Dou, Y. Zhao, G. Peleckis
Partner Investigators: X. X. Xi, G. Ramanath, Q. J. Li

Progress made in 2008

On of the key aims of this project is to bring together three world-renowned groups in materials engineering, solid state physics, and thin film technology, to investigate completely new types of thermoelectric heterostructures to enable the development of novel thermal-energy harvesting electric power generation devices. Extensive sharing in theoretical knowledge, sample preparation and analysis techniques, as well as ideas for prototype device construction is essential for development and investigation of brand new thermoelectric structures and assemblies. Arranged inter-institutional visits of researchers and postgraduate students are necessary for strong and effective collaboration, as well as to strengthen the links between Australian and USA research institutions.

This collaborative project started as planned in July 2008. CIs from UOW have performed an extensive literature survey to establish progress in fabrication and characterization of nano-structured thermoelectric materials. It was identified that thin film superlattice assemblies have significant advantages compared to other nanostructured materials from a thermoelectric conversion point of view. It was chosen to fabricate thin film oxide thermoelectric samples to investigate enhanced phonon scattering in such structures by specific heat and thermal transport characterization techniques. However, between May and October 2008 the host institution moved from the main University of Wollongong campus to a newly built building at the Innovation Campus. During this transitional period, operation of all of the equipment and sample preparation facilities was halted and experimental work put on hold until it was restarted in the new building. This relocation has also delayed the installation and re-installation or commissioning of existing and newly purchased instruments which are necessary for this project. Despite this setback, we have fabricated oxide thermoelectric materials in bulk form, which are to be used as precursors for thin film fabrication.

Collaborators at Rensselaer Polytechnic Institute have successfully synthesized nano-wire based Bi-Te thermoelectric materials and tested their performance for production of electricity using hot spot approach. Bi-Te is a very promising class of materials for this sort of application. Theoretical investigation of the nano-wired assemblies revealed that thermal transport in such assemblies is highly one directional and phonon scattering increases due to decreased size of the particles.

Mechanism and enhancement of supercurrent carrying ability in magnesium diboride superconductor

Project ID: LX0882225
Funded: 2008 2009 2010
Chief Investigators: X. L. Wang
Partner Investigators: S. I. Lee

Progress made in 2008

Note: This project was started in July 2008 due to the interruption from moving into a new campus. The following are the outcomes achieved from the second half year of 2008

Flux-pinning mechanism in silicone-oil-doped MgB_2: Evidence for charge-carrier mean free path fluctuation pinning:
Flux-pinning mechanism of MgB_2 doped with 10 wt % silicone-oil sintered at low and high temperatures has been investigated by magnetic measurements. The field dependence of the critical current density, $j_c(B)$, was analyzed within the collective pinning model. A crossover field, B_{sb}, from the single vortex to the small vortex bundle-pinning regime was observed. For both types of sintered samples, the temperature dependence of $B_{sb}(T)$ at low temperature is in good agreement with the δl pinning mechanism, i.e., pinning associated with charge-carrier mean free path fluctuation. At temperatures close to the critical temperature, however, there is evidence for δT_c pinning, which is associated with spatial fluctuations of the transition temperature. These results provide strong evidence that the liquid precursor, silicone oil, produces very small pinning centers and enhances the $j_c(B)$. *This work was published in Physical Review B* **78**, 184502 (2008)

High field performance of nanodiamond doped MgB_2 superconductor:
The results from magnetotransport and magnetization of nanodiamond doped $MgB_{2-n}D_x$ are reported. Superconducting transition temperature *Tc* is not affected significantly by *x* up to *x* =0.05 and latter decreases slightly for higher *x*=0.05. *R* vs *H* measurements show higher T_c values under same applied magnetic fields for the nanodiamond added samples, resulting in higher estimated H_{c2} values. From the magnetization measurements, it was found that irreversibility field value *H*irr for the pristine sample is 7.5 T at 4 K and the same is increased to 13.5 T for 3 wt % *n*D added sample at the same temperature. The J_c *(H)* plots at all temperatures show that J_c value is lowest at all applied fields for pristine MgB_2 and the sample doped with 3 wt % *n*D gives the best J_c values at all fields. These results are discussed in terms of extrinsic pinning due to dispersed *n*-diamond in the host MgB_2 matrix along with the intrinsic pinning due to possible substitution of C at boron site and increased interband scattering for highly doped samples resulting in extraordinary performance of the doped system. *This work was published in Journal of Applied Physics* **103**, 07C708 (2008).

Unconventional superconductivity of $NdFeAsO_{0.82}F_{0.18}$ indicated by the low temperature dependence of the lower critical field *Hc1*:
We measured the initial M-H curves for a sample of the newly discovered superconductor $NdFeAsO_{0.82}Fe_{0.18}$, which had a critical temperature, T_c, of 51 K, and was fabricated at the high pressure of 6 GPa. The lower critical field, *Hc1*, was extracted from the deviation point of the Meissner linearity in the M-H curves, which show linear temperature dependence in the low temperature region down to 5 K. The *Hc1*(T) indicates no s-wave superconductivity, but rather an unconventional superconductivity with a nodal gap structure. Furthermore, the linearity of *Hc1* at low temperature does not hold at high temperature, but shows other characteristics, indicating that this superconductor might have multi-gap features. Based on the low temperature nodal gap structure, we estimate that the

maximum gap magnitude Δ0 = (1.6 ± 0.2) kBTc. Available online: Published on arxiv:CondMat (arXiv:0808.3398v1).

CSIRO Flagship grants

"Hydrogen storage in carbon" project with National Hydrogen Materials Alliance

Years funded: 2007 2008 2009
Chief Investigators: H. K. Liu, Z. P. Guo
Associate Fellows: X. B. Yu, H. B. Lu

Progress made in 2008
A series of MgH_2-CNT-Ni and MgH_2-CNT-Bcc samples have been prepared by low energy ball milling. From high resolution TEM images, it is found that the large Mg particles with particle size range from a few micro-meters to 300 nm, actually contain large amount of grains around 10 nm in size. The carbon nanotubes (CNTs) could play an important role for hydrogen diffusion. During ball-milling, some CNTs retain their specific tubular structure, and aggregated along the grain boundaries inside the Mg particles. The existence of these CNTs at the grain boundaries of Mg will facilitate the diffusion of hydrogen inside the large Mg particles (a few micro-meters).

There are endothermic peaks in the DSC curves, which certify the existence of hydrides in the composites. The DSC curves reveal that the endothermic peak temperature (340^{o}C) of MgH_2-Ni is higher than that (285 ^{o}C) of MgH_2-Ni-CNT. Presumably, this is associated with CNT that can shed light on the decrease of the decomposition temperature of MgH_2.

"Mg-based hydrogen storage materials" and "Hydrogen storage in carbon", with National Hydrogen Materials Alliance

Funded: 2007 2008 2009
Chief Investigators: H. K. Liu, Z. P. Guo
Associate Fellows: X. B. Yu, H. B. Lu
PhD Students: Z. G. Huang, A. Ranjbar, C. K. Poh

Progress made in 2008
Ti- and Ni/Ti-catalyzed Mg hydrides were synthesis by hydrogen-induced ball milling. The desorption capacity, thermodynamic, and kinetics were investigated systemically using Sieverts-type apparatus and DSC measurements. The overall activation energy and the reaction order of the desorption kinetics are also calculated based on the Johnson-Mehl-Avrami (JMA) model and the Kissinger equation. Results show that the addition of Ti and Ni/Ti can significantly decrease the hydrogen desorption temperature and enhance the hydrogen desorption rate, although these elements have decreased the hydrogen storage capacity of MgH_2 composite. It is suggested that Ti and Ni/Ti atoms dispersed in the MgH_2 grains can catalyze the dissociation of the hydride phase and enhanced the H atomic migrations.

We have demonstrated that the hydrogen desoption in $NaBH_4$-MgH_2 mixture include three steps: first, MgH_2 decomposes to Mg and H_2, Second the Mg reacts with the $NaBH_4$ to form NaH and MgB_2 and last the NaH decomposes to Na element. Compared with pure $NaBH_4$, the dehydrogeation temperature of $NaBH_4$ in $NaBH_4$/MgH_2 was decreased about 40 ˚C. However, $NaBH_4$ depressed the decomposition of MgH_2. The doping of TiF_3 exhibited superior catalysis, lowering the decomposition temperature by 100 ˚C and exhibiting fast kinetics. The presence of TiF_3 also expedites the dehydrogenation of NaH before 600 ˚C.

Publications
1. A. Ranjbar, Z. P. Guo, X.B. Yu, D. Wexler, A. Calka, C.J. Kim, H. K. Liu, "Hydrogen storage properties of MgH_2 – SiC compounds", *Materials Chemistry and Physics*, available online.

2. H.B. Lua, C.K. Poh, L.C. Zhang, Z. P. Guo, X.B. Yu, H. K. Liu, "Dehydrogenation characteristics of Ti- and Ni/Ti-catalyzed Mg hydrides", *J Alloy Comp*, available online.

ARC Centre of Excellence

Nano-materials for energy storage

Years funded:	2006	2007	2008	2009	2010
Amount funded:	$230,000	$230,000	$230,000	$230,000	$230,000
Chief Investigator:	H. K. Liu				
Research Fellow:	J. Z. Wang				
Postgrad Students:	S. H. Ng, M. S. Park, S. Y. Chew, S. L. Chou, M. D. Rahman				

ARC Large/Discovery Grants Scheme

Charge transfer mechanism in 3-dimensional pore-solid nanoarchitectures for electrochemical systems

Years Funded:	2008	2009	2010
	$100,000	$100,000	$100,000
Total Funding:	$300,000		
Project ID:	DP0878611		
Chief Investigator:	Z. P. Guo		

Project Summary: This project represents a significant scientific and economic advance for Australia because: 1) it is likely to create advanced energy storage and conversion devices, with excellent working efficiency and kinetics, which will induce dramatic improvements to our environment 2) the project will establish local expertise and scientific know-how on electrochemical energy storage and conversion systems, which will place Australia at the forefront of this important area of lithium ion battery and PEM fuel cells; 3) relevant Australian enterprises in electric vehicle and portable device manufacturing will reap the benefits of these discoveries.

Current limiting mechanisms in magnesium diboride superconductors

Year Funded:	2007	2008	2009	2010	2011
	$320,000	$330,000	$390,000	$180,000	$210,000
Total Funding:	$1,430,000				
Project ID:	DP0770205				
Chief Investigators:	S. X. Dou				
Partner Investigators:	J. Driscoll, R. L. Flukiger, H. Kumakura, M. D. Sumption				

Project Summary: Numerous important applications have already been identified for MgB_2 wire: power transmission cables, fault current limiters, transformers and magnets for motors and generators, as well as MRI. The significant increase in current carrying capacity of one order of magnitude expected to result from the proposed program will enable MgB_2 to replace presently existing low-temperature superconductors (LTS) and expensive high-temperature superconductors (HTS) in numerous important applications. MgB_2 technology, coupled with renewable energy sources, has the potential to provide a long-term solution to the energy crisis and global warming threat.

Development of conductive buffer layers for RABiTS-based coated conductors

Year Funded:	2006	2007	2008
	$80,000	$60,000	$60,000
Total Funding:	$200,000		
Project ID:	DP0666771		
Chief Investigator:	D. Q. Shi		

Project Summary: YBCO coated conductor has already been identified and developed as far as second generation HTS wire in power applications. Major advances have been made in the last 10 years in coated conductor development mainly in all aspects: substrate, buffer layer and YBCO layer. The research on conductive buffer layer will improve and expand the R&D on coated conductor in Australia. On the economic side, dramatic advantages and savings could be achieved if the coated conductors can be put to use. Superconductivity can have a significant role in deregulated electricity markets and in lessening CO_2 emissions and other environmental impacts.

Development of novel ferroelectric magnetic materials for multi-functional applications

Year Funded:	2006	2007	2008
	$130,000	$100,000	$100,000
Total Funding:	$330,000		
Project ID:	DP0665873		
Chief Investigators:	X. L. Wang, Z. X. Cheng		
Partner Investigators:	T. Shrout, W. Wen, K. Yamaura, K. Liss, R. O. Piltz		

Project Summary: Ferroelectric magnets having simultaneous ferroeletricity and ferromagnetism is an area of emerging scientific interest. This project is to develop novel ferroelectric magnetic materials for multifunctional applications and falls into National Research Priority, Frontier Technologies for Building and Transforming Australian Industries. This project will provide trainings for postgraduate students and develop patentable science and technologies. The scope for use of the novel multifunctional materials will be enormous with great markets in the fields of magneto-electronics, magnetic electromechanical industrial devices. It will benefit Australian manufacturing industry in the long term.

Development of novel high efficiency thermoelectric oxides for high temperature power generation

Years Funded:	2008	2009	2010
	$35,000	$35,000	$35,000
Total Funding:	$105,000		
Project ID:	DP0879714		
Chief Investigator:	G. Peleckis		

Project Summary: Thermoelectric materials are considered as a key factor in clean energy production, based on the conversion of waste heat emitted by power plants and automobiles to electricity. A series of novel high performance Co-based oxide thermoelectric materials will be developed by this project using nanotechnology and advanced material processing techniques. Significant improvement of the heat-to-electricity conversion factor is expected to result from the proposed program. The novel thermoelectric oxides with high thermoelectric performance will be practically used for high temperature power generation. This will provide a long-term solution to the global warming threat through decreasing amounts of waste heat presently generated.

Exploration for new materials for spintronics

Years Funded:	2005	2006	2007	2008	2009
	$210,000	$210,000	$120,000	$120,000	$120,000
Total Funding:	$870,000				
Project ID:	DP0558753				
Chief Investigator:	X. L. Wang				

Project Summary: The scope for use of spintronic materials in practical applications will be enormous and there will be a huge market for spintronic devices. In fact, giant magnetoresistance spintronic materials are already used in practical applications such as magnetic recording and storage devices. The success of this project will certainly lead to a discovery of novel magnetic semiconductor spintronic materials and better understanding of spin dependent magnetic interactions. It will enhance the international competitiveness and export power of Australian industry in the areas of information technology, quantum computing, magnetic recording and magneto-electronics.

Fabrication of high quality MgB_2 superconductor

Years Funded:	2008	2009	2010
	$40,000	$40,000	$40,000
Total Funding:	$120,000		
Project ID:	DP0879843		
Chief Investigator:	S. H. Zhou		

Project Summary: Superconductors are electrical resistance free materials. They have great potential for power applications. Nowadays, superconductors have been used in applications such as Magnetic Resonance Imaging and other R&D equipment. This project deals with newly discovered MgB_2 superconductor. The process outlined in this project will produce MgB_2 superconductor with better superconducting properties. The application of MgB_2 superconductor will save energy, and enhance the performance of existing electrical devices such as magnet and power line.

First principles for development of novel hybrid electrochemical energy storage and conversion systems

Year Funded:	2007	2008	2009	2010	2011
	$210,000	$210,000	$220,000	$130,000	$130,000
Total Funding:	$900,000				
Project ID:	DP0772999				
Chief Investigators:	G. X. Wang, C. Zhang, K. K. Konstantinov, J. Z. Wang,				
Partner Investigators:	M. S. Islam, R. S. Liu, P. Novak, P. H. Notten				

Project Summary: Electrochemical energy is regarded as an alternative green energy/power source. The breakthrough technologies to be developed will allow us to realise the great goal of widespread usage of electric vehicles and hybrid electric vehicles, inducing dramatic improvements to our environment. It will also help us to reduce our dependence on the current oil-driven economy, and increase national energy security and energy independence. The project will establish indigenous expertise and scientific know-how on electrochemical energy storage and conversion technology. The competitive results from this research will provide an incentive to the Australian automobile and energy industries.

Giant magnetocaloric materials and room temperature refrigeration

Years Funded:	2008	2009	2010	2011
	$210,000	$210,000	$120,000	$120,000
Total Funding:	$660,000			
Project ID:	DP0879070			
Chief Investigators:	S. X. Dou; J. H. Kim			
Partner Investigators:	T. H. Johansen; E. Bruck			

Project Summary: The objectives of this project are to develop new magnetocaloric materials, study their properties and their potential as components of advanced magnetic refrigeration systems. The outcomes of this project will provide an opportunity for Australian industry to produce magnetocaloric materials and magnetic refrigeration systems with higher quality, to embark on this novel innovation technology in an effective way, and to access the international magnetic refrigeration market. In the longer term, the successful outcome of this research could lead to energy savings and an overall reduction in greenhouse gas emissions, as well as contributing to the associated economic and social goals.

Improvement and synthesis of advanced hydrogen storage materials for fuel cellapplications

Years Funded:	2008	2009	2010
	$96,148	$96,148	$96,148
Total Funding:	$288,444		
Project ID:	DP0878661		
Chief Investigator:	X. B. Yu		

Project Summary: Energy systems of the future must be cleaner and much more efficient, flexible, and reliable to meet the growing global demand for energy. A hydrogen economy offers a potential solution to satisfying the global energy requirements while reducing carbon dioxide and other greenhouse gas emissions and improving energy security. The enhanced hydrogen storage materials to be investigated will have higher hydrogen storage capacity, which can have applications in a variety of areas, including the storage and transport of hydrogen, fuel cells and electric automobiles.

New concepts with multidisciplinary approach: novel functionalised nanostructures for hydrogen storage

Year Funded:	2007	2008	2009
	$100,000	$100,000	$100,000
Total Funding:	$300,000		
Project ID:	DP0771193		
Chief Investigators:	Z. P. Guo, H. K. Liu		
Partner Investigators:	P. H. Notten, J. Chen, A. Zuettel		

Project Summary: This project addresses National Research Priorities in the areas of breakthrough science, frontier technologies and advanced materials. Developing new methodologies to fabricate novel functionalised nanostructured materials with tailored properties has great potential in areas including energy storage, novel catalysts, novel sensors, micro/nano-electronics, etc. This project will enhance the international reputation and impact of Australian research in the internationally focused fields of nanotechnology and hydrogen energy technology. Applying innovative nanotechnology to the area of hydrogen energy will add to Australia's export potential and reduce Australia's reliance on foreign fuel sources.

Novel graphene nanostructures: modelling, synthesis, fabrication and characterization

Years Funded:	2008	2009	2010
	$150,000	$145,000	$145,000
Total Funding:	$440,000		
Project ID:	DP0878661		
Chief Investigators:	C. Zhang;		
Partner Investigators:	D. Li; F. Liu; R. B. Kaner; Y. Jiang		

Project Summary: As a key nanomaterial for future electronics, graphene is rapidly becoming one of the most promising frontier areas of nanotechnology throughout the world. This project aims to develop a new class of graphene nanostructures that hold great potential for large-scale applications in the next generation nanoelectronic devices, sensors, solar cells and light emitting devices. This project will significantly enhance the international competitiveness of Australia in the areas of new materials and nanotechnology and will help place Australia at the forefront of nanotechnology. This project will produce high quality PhD students in nanotechnology.

Superconducting MgB_2 thin films and structures for electronic devices and telecommunication applications

Year Funded:	2006	2007	2008
	$125,000	$100,000	$100,000
Total Funding:	$325,000		
Project ID:	DP0666853		
Chief Investigators:	Y. Zhao, M. Ionescu, J. Du		
Partner Investigator:	E.W. Collings		

Project Summary: Two important directions of electronic application for MgB_2 films are superconducting Josephson junction (JJ) technology and passive microwave devices. Superconducting JJ technology will have a small but important niche in high-performance digital signal and data processing applications for civilian, commercial, and military terrestrial, as well as space deployment. With superconducting passive microwave devices, the potentially largest market in this segment are filter systems for ground - or satellite based wireless communication systems. The research outcome could support Australian companies to develop corresponding products, as well as broaden Australia's knowledge of the physics of the new MgB_2 superconductor.

Tailoring superconducting hybrid multilayered film systems for electric and electronic applications

Years Funded:	2008	2009	2010	2011	2012
	$165,000	$164,000	$159,000	$120,000	$105,000
Total Funding:	$713,000				
Project ID:	DP0879933				
Chief Investigators:	A. V. Pan;				
Partner Investigators:	C. P. Foley, T. H. Johansen; H. Hilgenkamp				

Project Summary: This project focuses on the development of new scientific and technological aspects of the fabrication, properties and operation of novel hybrid systems for revolutionizing electricity handling and electronics. It will also solve some existing problems of film structures with promising multilayer technology. Hybrid systems often make the headlines in science and are gaining an increasingly promising outlook in materials engineering, nanotechnology and electronics, promising eventual application in a broad range of industries. This project will establish Australia's capability at the forefront in this area. The outcomes predicted will benefit existing Australian companies and may establish new companies dealing with these hybrid systems.

ARC Linkage Projects

Development of high performance second generation superconductors

Years funded:	2006	2007	2008	2009
Amount funded:	$115,000	$218,000	$193,000	$90,000
Total funding:	$616,000			
Project ID:	LP0669456			
Chief Investigators:	S. X. Dou, A. V. Pan, D. Q. Shi,			
Partner Investigators:	R. Taylor, J. Barry, T. Yamashita			
Industry Partners:	Mesaplexx Pty. Ltd.			

Project Summary: Robust, high performance high temperature superconductor (HTS) wire underpins a worldwide opportunity to revolutionize the electric power grid, transportation, electronics and many other industries with a new generation of high efficiency, compact, and environmentally friendly electrical equipment. This program combines our expertise in superconductor thin film fabrication and characterization and expertise of a local industrial partner in the development of superconducting wires. The success of the proposed project will bring benefit to local industry and employment, and significantly enhance the international competitiveness in HTS of Australian industry.

Development of superconducting leads with ultra-low thermal conductivity for cryoelectronic applications

Year Funded:	2008	2009	2010
	$151,000	$141,000	$146,000
Total Funding:	$438,000		
Project ID:	LP0882832		
Chief Investigators:	A. V. Pan; S. X. Dou		
Partner Investigator:	O. Mukhanov		

Project Summary: Superconducting systems are revolutionary technologies that have the potential to make a significant impact on society. The development of the new technology of superconducting wiring, which would effectively eliminate heat generation and its transfer to the cryogenic electronics, and its subsequent employment will enable superconductive electronics to become price competitive, significantly outperforming conventional systems. The establishment of this new frontier technology of heat-switch current leads will benefit Australian industries and have a dramatic impact in the future on the field of cryogenic quantum electronics (such as quantum computing), which is currently under profound exploration in Australia.

Exploration of new catalyst materials for hydrogen/air fed proton exchange membrane fuel cells

Years funded:	2007	2008	2009
Amount funded:	$110,000	$100,000	$90,000
Total funding:	$300,000		
Project ID:	LP0775109		
Chief Investigators:	G. X. Wang, H. K. Liu, K. K. Konstantinov, J. Z. Wang, D. Wexler		
Partner Investigators:	O. Savadogo		
Industry Partners:	Lead Power Battery Co., Ltd.		

Project Summary: Fuel cell technology is the most critical technology for the hydrogen economy. Hydrogen/air fed fuel cells can provide pollution-free power sources for vehicles and distributed power generation. A breakthrough in fuel cell technology using hydrogen as fuel will supply us with clean and sustainable energy sources, dramatically improve our environment, and maintain national energy security. The success of fuel cell technology will also significantly reduce our dependence on oil. This research project is expected to establish local expertise, and scientific and industrial know-how on fuel-cell technology.

Miniature lithium ion battery for implantable medical device applications

Years funded:	2007	2008	2009
Amount funded:	$110,000	$100,000	$100,000
Total funding:	$310,000		
Project ID:	LP0775456		
Chief Investigators:	Z. P. Guo, H. K. Liu, J. Z. Wang, K. K. Konstantinov, M. Forsyth		
Industry Partners:	DLG Battery Co., Ltd.		

Project Summary: This project addresses National Research Priorities in the areas of breakthrough science, frontier technologies and promoting and maintaining good health. Substantial national benefit could be derived from this project: (i) Australia will innovate in an important and intensely active area in which the results will have long-lasting significance in implantable rechargeable battery development; (ii)The development of new scientific knowledge related to this project will place Australia at the forefront of an emerging domain of research body batteries; (iii) In the long term, the successful outcome of this research will lead to more reliable batteries for implantable devices, thereby promoting health care.

Novel electric field induced coupling technique for liquid-phase heteroepitaxial growth of carbon thin films with diamond-like structure

Years funded:	2005	2006	2007	2008
Amount funded:	$12,000	$24,000	$24,000	$12,000
Total funding:	$72,000			
Project ID:	LP0561605			
Chief Investigators:	S. X. Dou, A. V. Pan			
APA(I) Award(s):	1			
Industry Partner(s):	Polarised Technology Pty Ltd			

Project Summary: The aim of the project is the growth of carbon thin films with a robust diamond-like structure for high performance electronic applications via the development of a new growth technique: Electric Field Induced Coupling (EFIC), which is based on liquid-phase layer-by-layer heteroepitaxial growth. The EFIC technique employing unique polarization-induced growth will significantly enhance technological output compared to existing technologies by overcoming current difficulties with expensive and complicated production methods. Ambient temperatures and pressures employed by the technique will enable us to form diamond-based semiconductors at low cost with sufficient speed and the properties required for industrial production.

Novel methods for enhancing room temperature figure of merit of thermoelectric/thermionic materials for refrigeration applications

Year Funded:	2008	2009	2010
	$81,000	$79,000	$87,000
Total Funding:	$247,000		
Project ID:	LP0882282		
Chief Investigators:	C. Zhang; X. L. Wang; G. X. Wang;		
Partner Investigator:	T. Toyoda		

Project Summary: With global warming and an increased awareness of climate change, devices such as thermoelectric modules can be part of the solution, particularly if their relative power and efficiency can be increased. The aim of this project is to bring together theoreticians, experimentalists, materials scientists, and industrial partners with complementary expertise to develop new techniques and methods for fabricating novel thermoelectric/thermionic materials with high figure of merit, ZT, for solid state refrigeration applications. The success of the project will lead to a 3 to 5 fold increase in the market share of thermoelectric cooler and will have a significant impact on the Australian economy and reduce greenhouse emissions and global warming.

ARC Linkage Infrastructure, Equipment and Facilities Proposals (LIEF)

High field magnet for materials processing and characterization

Year Funded:	2008
	$340,000
Total Funding:	$340,000
Project ID:	LE0882347
Chief Investigators:	S. X. Dou, L. Wang, R. K. Zheng, X. L. Wang, Z. X. Cheng, J. Horvat, G. Peleckis, A. V. Pan, Y. Zhao, K. K. Konstantinov, R. A. Lewis, J. Wang, D. Q. Shi, Z. P. Guo, D. Wexler, S. Zhou, D. Li, R. J. Dippenaar, S. J. Campbell, J. Zou, X. Liao, S. S. Li, E. Pereloma

Project Summary: The proposed infrastructure project will bring many Australian-based researchers together to create a completely new niche of materials processing research. Such a facility will be the first of its kind in Australia. This facility will be located in Australia and thus the time required to process and characterize materials will be significantly reduced without a need to send them overseas. As a consequence of the proposed collaboration, a large number of high quality papers and patents are expected. The facility will increase Australia's position in the field of advanced materials processing and will also provide new ideas and concepts, which will be used in practical applications.

Linkage International Awards

Advanced materials and structures for terahertz science and technology

Years funded:	2007	2008	2009
Amount funded:	$6,500	$10,000	$10,000
Total funding:	$26,500		
Project ID:	LX0776043		
Chief Investigator:	R. A. Lewis, R. Mendis, R. E. M. Vickers		
Partner Investigator:	H. L. Hartnagel, C. Sydlo		

Project Summary: Anthrax, explosives, water, and cancer all have characteristic signatures in the terahertz (THz) part of the electromagnetic spectrum. Security, defence, agriculture, medicine are some of the fields where THz science and technology are booming. THz developments offer enhanced national security, prosperity and quality of life. The lack of strong sources of THz radiation is the main factor hampering wider application of THz methods. In this project two university research teams come together to develop more efficient THz emitters. The Darmstadt team will prepare novel materials and structures and the Wollongong team will evaluate them and provide feedback for the next iteration.

Development of nano-structured thermoelectric materials for power generation from heat

Year Funded:	2008	2009	2010
	$18,200	$20,200	$20,200
Total Funding:	$58,600		
Project ID:	LX0881969		
Chief Investigators:	S. X. Dou; Y. Zhao; G. Peleckis		
Partner Investigators:	X. X. Xi; G. Ramanath; Q. J. Li;		

Project Summary: To make thermoelectric technology attractive for practical power generation purposes, new high efficiencymaterials have to be developed. Our fabricated nanostructured thermoelectric materials will have improved performance due to the peculiarities in electrical and thermal transport. The novel thermoelectric materials and constructed prototype devices with high thermoelectric performance will be practically used for various power generation purposes. This offers a

long-term solution to the global warming threat through decreasing amounts of waste heat presently generated. It will also strengthen Australia's position in world-wide research on thermoelectricity.

Mechanism and enhancement of supercurrent carrying ability in magnesium diboride superconductor

Year Funded:	2008	2009	2010
	$12,900	$18,350	$18,350
Total Funding:	$49,600		
Project ID:	LX0882225		
Chief Investigators:	X. L. Wang,		
S. Lee			

Project Summary: The newly discovered MgB_2 superconductor has great potential to replace the existing conventional superconductors for uses in various medical and industrial applications. This project brings together two world leading groups with complementary expertise to develop a fundamental understanding of the factors controlling MgB_2 performance and to find effective ways to significantly improve its supercurrent carrying capabilities for practical applications. The outcome of this project will be of benefit to both countries and will lead to many practical applications such as transformers, rotors, and transmission cables, as well as magnetic resonance imaging without using liquid helium, reducing greenhouse gas emissions and global warming.

Linkage International Fellowships

Design and creation of nanomechanical architectures from folding of ultrathin bi-layer films

Year Funded:	2008
	$117,972
Total Funding:	$117,972
Project ID:	LX0881899
Chief Investigators:	C. Zhang
Partner Investigator:	F. Liu

Project Summary:

The project will achieve progress in designing, modelling, analyzing, and characterization of nanomechanical architectures that will have broad application in Australian science and industry. If successful, our research will revolutionize nanofabrication technology and nano-design methods. The project will lead to a scientific understanding of atomic interaction and stress field effect in the formation of nanosystems. The result of this research will significantly lower fabrication costs and enhance the potential of nanomaterials in various areas such as electronics and bioelectronics, telecommunication, medical instrumentations, and pharmaceutical design.

URC Small Grants & ARC Near-Miss Grants 2008

Development of room temperature sodium/sulfur batteries for electric vehicles

Total Funding: $11,500
Chief Investigators: J. Z. Wang, K. Konstantinov

Exploration of novel highly effective electrocatalysts for proton exchange membrane fuel cells

Total Funding: $14,000
Chief Investigators: Z. P. Guo

Synthesis of $ZnCr_2Se_4$ nanoparticles

Total Funding: $14,000
Chief Investigators: J. Horvat

The evolution of solar energy in photoelectrochemical cells using nano-materials

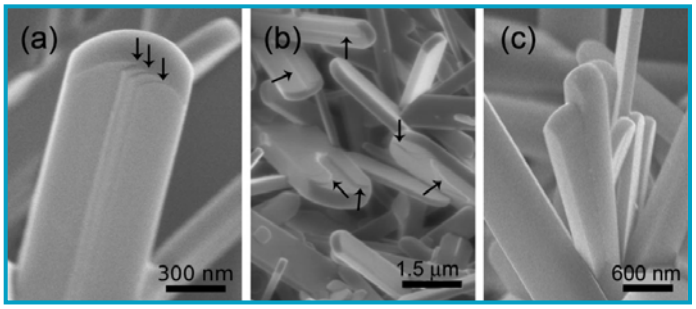
Total Funding: $12,000
Chief Investigators: J. H. Kim, Y. Zhao

$YBa_2Cu_3O_{7-x}$ thin film prepared by sol-gel method for electronic device applications

Total Funding: $9,000
Chief Investigators: J. H. Kim

Selected Abstracts

A Novel approach for real mass transformation from V_2O_5 particles to nanorods

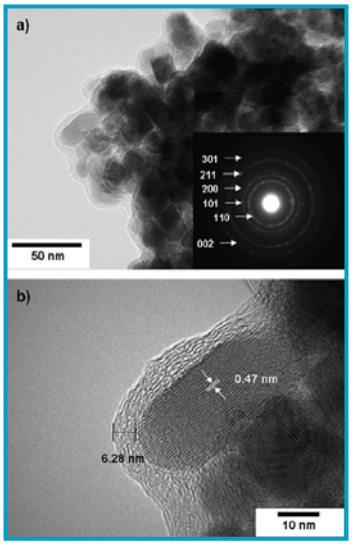


A solid-state, mass-quantity transformation from V_2O_5 powders to nanorods has been realized via a two-step approach. The nanorods were formed through a controlled nanoscale growth from the nanocrystalline V_2O_5 phase created by a ball milling treatment. The nanorods grow along the [010] direction and are dominated by {001} surfaces. Surface energy minimization and surface diffusion play important roles in their growth mechanism. Real large quantity production can be achieved when the annealing process is conducted in a fluidized bed which can treat large quantities of the milled materials at once. The crystal orientation of nanorods provides an improved cycling stability for lithium intercalation. (A.M. Glushenkov et al, *Crystal Growth & Design* **8**(10), 3661 (2008))

Effects of C substitution on the pinning mechanism of MgB_2

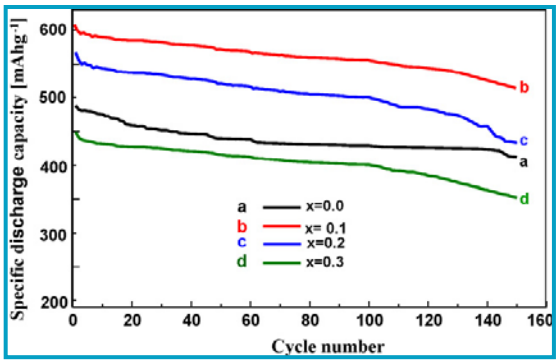
The temperature and magnetic field of the critical current density of four selected pure and C-doped MgB_2 samples have been investigated in detail and the flux pinning mechanism has been analyzed. It was found that the sintering temperature and the substitution of carbon can significantly modify the flux pinning mechanism. Below 30 K, the reduced field dependences of the reduced pinning force for all investigated samples were found to closely obey one scaling law, reflecting the presence of only one dominant pinning mechanism. The delta T_c pinning mechanism was found to be mainly responsible in pure MgB_2 samples while the delta l pinning mechanism becomes dominant for C-doped samples. (J. L. Wang, R. Zeng, J. H. Kim, L. Lu and S. X. Dou, *Physical Review B* **77**, 174501 (2008))

Effects of low-temperature carbon encapsulation on the electrochemical performance of SnO_2 nanopowders



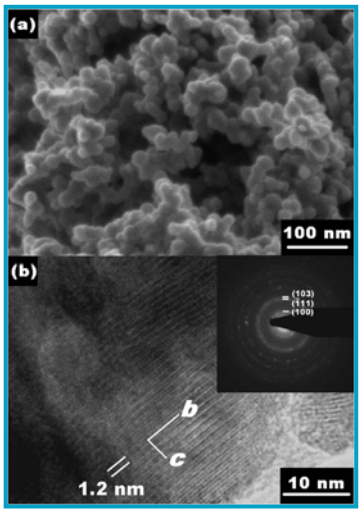
Carbon encapsulated SnO_2 composites were prepared by a thermal evaporation and decomposition of malic acid ($C_4H_6O_5$) at low temperature to demonstrate their potential use for application in lithium ion batteries. The solution-based chemical approach was effective for coating amorphous C layers on the surface of SnO_2 nanopowders without significant oxygen reduction. The desirable crystalline structure and oxygen stoichiometry of SnO_2 were maintained, while amorphous C homogeneously encapsulated SnO_2 nanopowders. The strong enhancement on the anodic reversible capacity and cyclic performance was discussed for the C-encapsulated SnO_2 composites. It is expected that the low-temperature processing can be a new general route for preparing composites with C from economic point of view. (M.S. Park et al, *Carbon* **46**, 35 (2008))

Electrochemical behaviour of tin borophosphate negative electrodes for energy storage systems



Tin borophosphate compounds doped with antimony, $Sn_2BP_{1-x}Sb_xO_6$ (x = 0–0.3), have been prepared and studied by X-ray diffraction (XRD), scanning electron microscopy (SEM), Fourier transmission infrared spectroscopy (FTIR), electrochemical impedance spectroscopy (EIS), and cyclic voltammetry (CV) and galvanostatic measurements. XRD patterns of all the samples were indexed to the tetragonal system. The EIS showed that the conductivities are enhanced by antimony doping. It was observed that the Warburg impedance coefficient (w) was 1163.265 $cm^2/s^{0.5}$ for the $Sn_2BP_{0.9}Sb_{0.1}O_6$ (x = 0.1) sample, and this was the lowest value compared to those of the other samples. $Sn_2BP_{0.9}Sb_{0.1}O_6$ (x = 0.1) showed the highest specific discharge capacity of 1050 mAh/g among all the samples and a reversible capacity of 540 mAh/g at the 150 th cycle. (A.Y. Shenouda et al, *Journal of Power Sources* **185** (2), 1386 (2008))

Electrochemistry of LiV_3O_8 nanoparticles made by flame spray pyrolysis



LiV_3O_8 nanoparticles primary particles with ca. 50 nm diameter have been synthesized by flame spray pyrolysis (FSP). The powder was characterized by X-ray diffraction, scanning electron microscopy, transmission electron microscopy, and galvanostatic cycling. The initial discharge capacity of the LiV_3O_8 nanoparticles is 271 mAh/g when discharged from its open-circuit potential to 2.0 V vs Li/Li+ at a specific current of 100 mA/g under ambient conditions. The nanoparticles retained a specific discharge capacity of 180 mAh/g beyond 50 cycles. This paper describes the synthesis route as well as the characterizations of the FSP-produced LiV_3O_8 nanoparticles. (T. J. Patey et al, *Electrochemical and Solid-State Letters* **11** (4), A46 (2008))

Electrodeposition of MnO_2 nanowires on carbon nanotube paper as free-standing, flexible electrode for supercapacitors

MnO_2 nanowires were electrodeposited onto carbon nanotube (CNT) paper by a cyclic voltammetric technique. The as-prepared MnO_2 nanowire/CNT composite paper (MNCCP) can be used as a flexible electrode for electrochemical supercapacitors. Electrochemical measurements showed that the MNCCP electrode displayed specific capacitances as high as 167.5 F g^{-1} at a current density of 77 mA g^{-1}. After 3000 cycles, the composite paper can retain more than 88% of initial capacitance, showing good cyclability. The CNT paper in the composite acted as a good conductive and active substrate for flexible electrodes in supercapacitors, and the nanowire structure of the MnO_2 could facilitate the contact of the electrolyte with the active materials, and thus increase the capacitance. (S.L. Chou et al, *Electrochemistry Communications* **10**, 1724 (2008))

Enhancement of ferroelectricity and ferromagnetism in rare earth element doped $BiFeO_3$

Rare earth element doped $BiFeO_3$ thin films were fabricated using the pulsed laser deposition method and various targets made from different starting Fe_2O_3 and Fe_3O_4 iron source material. The films fabricated using the targets made from Fe_3O_4 exhibit great enhancement in their ferroelectricity, due to greatly reduced electrical leakage, as well as enhanced magnetization compared to those films deposited

using targets from Fe_2O_3. It is suggested that the Fe^{2+} ion plays an important role in compensating for the charge imbalance and reducing current leakage, as well as enhancing the magnetic moment through introducing of antiferrimagnetic ordering at Fe^{2+} site. (Z. X. Cheng et al, *Journal of Applied Physics* **104**, 116109 (2008))

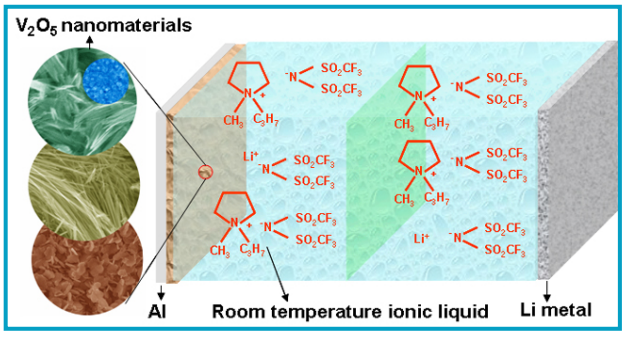
Explanation of magnetic behavior in Ru-based superconducting ferromagnets

We have investigated $RuSr_2Eu_{1.5}Ce_{0.5}Cu_2O_{10}$ (Ru-1222) and $RuSr_2EuCu_2O_8$ (Ru-1212) samples by using x-ray diffraction, scanning electron microscopy, dc magnetization, ac susceptibility, and resistivity measurements. Based on the results obtained, we propose an explanation of the magnetic behavior of the Ru-based systems. Our model is capable of describing controversial observations of multiple magnetic transitions on temperature dependent dc magnetization measurements as well as the reentrance of irreversibility in hysteresis loops at high temperatures, which enables the bell-shaped behavior of the coercive field within temperature from 90 to 200 K. The experimental results suggest that Ru-based samples always contain a small amount of at least one additional magnetic phase with its own magnetic behavior, which is similar yet distinct from the main Ru phase. The presence of these phases and the superposition of their magnetic contributions can produce different transport properties and lead to features that are inherent to various magnetic states, such as ferromagnetic, antiferromagnetic, and spin glass, and still exhibit a coexistence of magnetism and superconductivity at low temperatures. This variety of possible states has led to different controversial models proposed in the literature, reflecting one or another feature observed. The model proposed in this work does not contradict but rather unifies the existing scenarios for the Ru-based systems in a common picture. (R. Nigam et al, *Physical Review B* **77**, 134509 (2008)) (Received Best Paper Award at ISEM)

Fabrication of highly dense MgB_2 bulk at ambient pressure

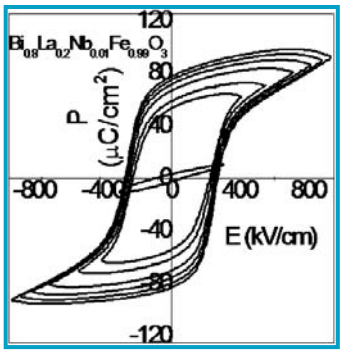
We report an *in situ* heat-treatment technique for the preparation of near-fully-dense un-doped MgB_2 bulks that also provides very strong in-field pinning. The high density was achieved without using high-pressure apparatus. The heat-treatment of compacted boron sealed in a Ta tube with Mg pellets employs a short high-temperature sintering at 1100 °C first, followed by a low-temperature annealing below 660 ◦C. A high density of 2.5 g cm^{-3} (95% of the theoretical density) was achieved in the bulks treated by the two-step process. The in-field J_c is nearly one order of magnitude higher than for the samples prepared by single-step sintering at high or low temperature. Microstructural analysis suggested a unique feature of well-connected small grains with a high level of disorder in the MgB_2 samples created by the two-step process. (M. Maeda et al, *Superconductor Science & Technology* **21**, 032004 (2008))

High capacity, safety and enhanced cyclability of lithium metal battery using V_2O_5 nanomaterials cathode and room temperature ionic liquid electrolyte



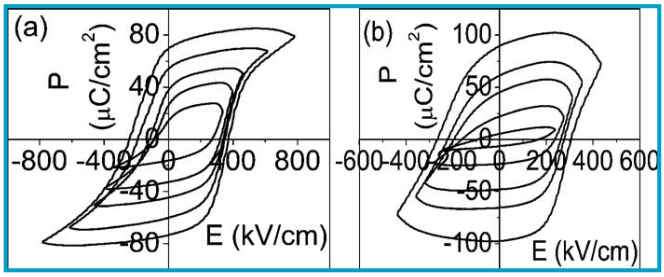
The lithium metal battery is one of the most promising high energy density storage devices due to the most negative potential of the Li^+/Li couple and its high theoretical capacity (more than 3860 $mAhg^{-1}$). To achieve safe and practical high-energy-density rechargeable lithium battery requires selection of an optimum electrolyte and a compatible and high-capacity cathode material. Here, the rechargeable lithium battery using porous V_2O_5 nanoribbons as cathode materials and RTIL ([C3mpyr][NTf2] containing 1M LiNTf2) as electrolyte could be the next generation lithium battery in terms of high capacity of 430 mAh g^{-1} for initial discharge, long life (270 mAh g^{-1} for the 50th cycle), good high-rate performance (119 mAh g^{-1} at 2 C current density) and safety. (S. L. Chou et al., *Chemistry of Materials* **20**, 7044-7051 (2008))

Improved ferroelectric properties in multiferroic $BiFeO_3$ thin films through La and Nb codoping



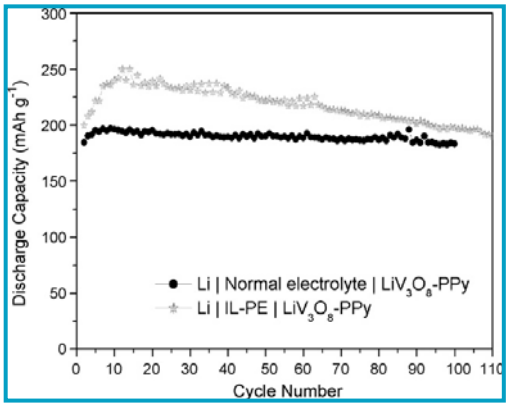
We report the significant improvement of the ferroelectric properties of $BiFeO_3$ thin film through control of electrical leakage by Nb doping. A very large remanent electrical polarization value of 80 μC/cm^2 was observed in $Bi_{0.8}La_{0.2}Nb_{0.01}Fe_{0.99}O_3$ thin film on Pt/Ti/SiO_2/Si substrate. The doping effect of Nb in reducing the movable charge density due to oxygen vacancies in $BiFeO_3$ was confirmed by the dielectric measurements. A very small loss was observed in the Nb and La co-doped $BiFeO_3$ thin film. As well as the improvement in the ferroelectric properties, the magnetic moment was also enhanced due to the doping of La. (Z. X. Cheng et al, *Physical Review B* **77**, 092101 (2008))

La and Nb codoped $BiFeO_3$ multiferroic thin films on $LaNiO_3$/Si and IrO_2 /Si substrates



Nb and La co-doped $BiFeO_3$ thin films were fabricated on oxide bottom electrodes, $LaNiO_3$/Si and IrO_2/Si, by pulsed laser deposition method. The doped $BiFeO_3$ thin film capacitor on $LaNiO_3$ showed a remnant polarization of more than 75μC/cm^2 in a saturated hysteresis loop. The same La and Nb co-doped $BiFeO_3$ thin film capacitor on IrO_2 showed a larger remnant polarization, while with a significant contribution from the leakage current. Furthermore, the doped $BiFeO_3$ capacitor on the $LaNiO_3$ bottom electrode showed worse fatigue resistance than the film on IrO_2. All the doped $BiFeO_3$ thin films showed weak ferromagnetism at room temperature. (Z. X. Cheng et al, *Applied Physics Letters* **92**, 092902 (2008))

Lithium-polymer battery based on an ionic liquid–polymer electrolyte composite for room temperature applications



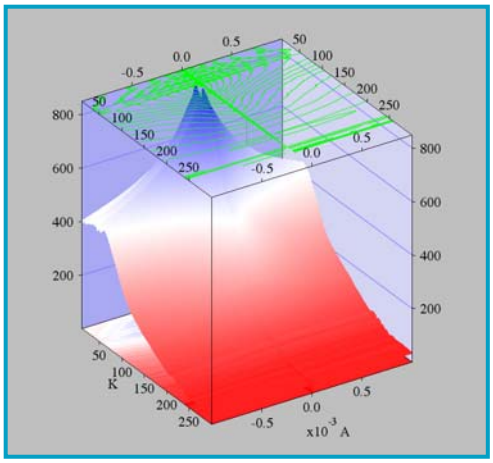
A lithium-polymer battery based on an ionic liquid–polymer electrolyte (IL–PE) composite membrane operating at room temperature is described. Utilizing a polypyrrole coated LiV_3O_8 cathode material, the cell delivers >200 mAh/g with respect to the mass of the cathode material. Discharge capacity is slightly higher than those observed for this cathode material in standard aprotic electrolytes; it is thought that this is the result of a lower solubility of the LiV_3O_8 material in the IL–PE composite membrane. (S.Y. Chew et al, *Electrochemical Acta* **53** (22) 6460 (2008))

Magnetic structures and phase transitions in $PrMn_{2-x}Fe_xGe_2$

The magnetic properties and magnetic structures of $PrMn_{2-x}Fe_xGe_2$ compounds (space group *I*4/*mmm*) ave been investigated using magnetic, Fe Mössbauer effect (x=1.0, 1.3, 1.6), and neutron diffraction easurements (x=0.4, 0.6, 0.8, 1.3) over the temperature range of 3–410 K. This has enabled the existing magnetic phase diagram for $PrMn_{2-x}Fe_xGe_2$ to be extended from Fe concentration x=0–1 to the full ange x=0–2 in terms of concentration and $d_{Mn–Mn}$, the intralayer distance. Analysis of the Mössbauer spectra (4.5–300 K) using a model which takes nearest-neighbor environments into account confirms the nonmagnetic nature of Fe atoms in these compounds, and leads to hyperfine parameters which

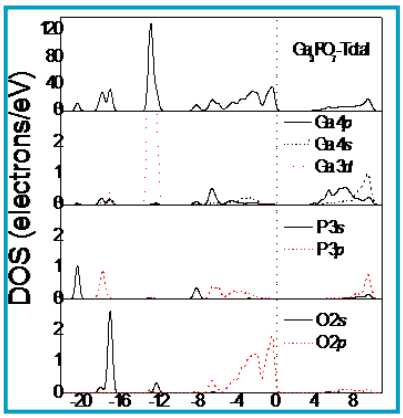
deviate around the magnetic transition temperatures derived from the magnetic and neutron investigations while also enabling the Debye temperatures of $PrMn_{2-x}Fe_xGe_2$ (x=0.4–1.6) to be determined. The experimental values for T_C^{inter} are found to decrease rapidly with increasing Fe concentration in the range x=0.0–0.6 compared with calculated T_C^{inter} values due to pressure (and therefore geometric) effects only. This behaviour demonstrates that electronic effects and replacement of the magnetic Mn atoms with nonmagnetic Fe atoms contribute to the overall magnetic behavior of $PrMn_{2-x}Fe_xGe_2$ compounds. Compared with intralayer Mn–Mn interactions, the interlayer Mn–Mn interactions play the major role in the anomalous thermal expansion observed at magnetic transition in these layered systems, with the interlayer Mn–Mn interactions governing the significant magnetovolume effects. (J. L. Wang et al, *Journal of Applied Physics* **104**, 103911 (2008))

Metal-insulator transition and electroresistance in eanthanum/calcium manganites $La_{1-x}Ca_xMnO_3$ (x=0-0.5) from voltage-current-temperature surfaces



Terahertz technology and science was advanced through 2008. Acceptor-doped GaAs and p-GaAsSb were a particular focus. A unique single-cycle azimuthal dependence of THz radiation from InP was discovered [1]. THz technology was applied to the study of impurity states in semiconductors at high magnetic fields. Another area of research was electroresistance of various oxides [2], including the first publication in the journal *PMC Physics B*. (R. A. Lewis, *Applied Physics Letters* **92**, 184102 (2008))

Optical property and electronic band structure of a piezoelectric compound Ga_3PO_7 studied by the first-principles calculation



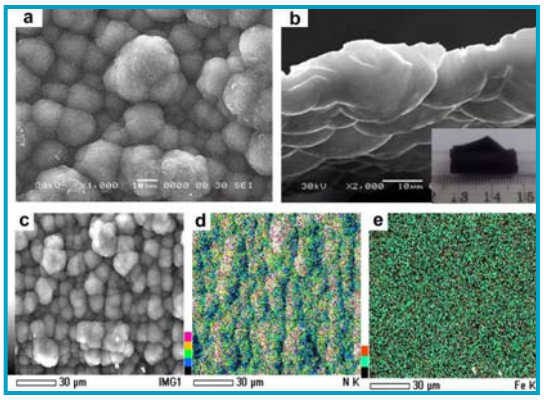
The structure, electronic and optical properties of a new piezoelectric material, Ga_3PO_7, were studied by first-principles calculations in the framework of density functional theory. The calculated structure is in agreement with the experimental data. Band structure reveals that Ga_3PO_7 has a band gap of 3.69 eV. Analysis of partial density of states and Mulliken charge population indicates existence of GaO_5 and PO_4 anion groups in Ga_3PO_7. Furthermore, its optical properties, including dielectric constant, absorption, reflectivity, refractive index, and electron loss, were calculated and analyzed, which show that Ga_3PO_7 has potential applications based on combination of its piezoelectric and optical properties. (Z.X. Cheng et al, *Applied Physics Letters* **92**, 261915 (2008))

Orientation dependence of the optical spectra in graphene at high frequencies

On the basis of the Kubo formula we evaluated the optical conductivity of a graphene sheet. The full behavior of frequency as well as temperature dependence of the optical conductivity is presented.We show that the anisotropy of conductivity can be significantly enhanced at high frequencies. The photon absorption depends on the field polarization direction. At the frequency comparable to the maximum separation of upper and lower bands the photon-induced conduction of electrons is strongly suppressed if the polarization of field is along the zigzag direction. The corresponding optical conductivity is several orders of magnitude weaker than that when the light is polarizing along the armchair direction.

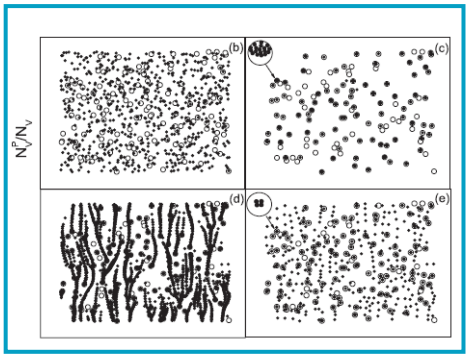
We propose that the property of orientation selection of absorption in the graphene can be used as a basis for a high-frequency partial polarizer. (C. Zhang, L. Chen, Z.S. Ma, *Physical Review B* **40,** *241402-1 (2008))* [Selected for Virtual Journal of Nanoscale Science & Technology, June 30, 2008]

Paper-like free-standing polypyrrole and polypyrrole–$LiFePO_4$ composite films for flexible and bendable rechargeable battery



Highly flexible, paper-like, free-standing polypyrrole and polypyrrole–$LiFePO_4$ composite films were prepared using the electropolymerization method. The films are soft, lightweight, mechanically robust and highly electrically conductive. The electrochemical behavior of the free-standing films was examined against lithium counter electrode. The cell with PPy–$LiFePO_4$ composite film had a higher discharge capacity beyond 50 cycles (80 mA h/g) than that of the cell with pure PPy (60 mA h/g). The free-standing films can be used as electrode materials to satisfy the new market demand for flexible and bendable batteries that are suitable for the various types of design and power needs of soft portable electronic equipment. (J. Z. Wang et al., *Electrochemistry Communications* **10**, 1781 (2008)**)**

Peak effect in the critical current of type-II superconductors with strong magnetic pinning



We perform 2D Langevin simulations studying the peak effect (PE) of the critical current taking into account the temperature dependence of the competing forces. We observe and report that the PE results from the competition of vortex-vortex interactions and vortex-pin interactions which have different temperature dependencies. The simulations reveal that the PE can take place only for certain pinning strengths, densities of pinning centers, and driving forces, which is in good agreement with experiments. No apparent vortex order-disorder transition is observed across the PE regime. In addition, the PE is a dynamical phenomenon, and thermal fluctuations can speed up the process for the formation of the PE. (X. B. Xu et al, *Physical Review Letters* **101,** 14002 (2008))

Proposal for a New Class of Materials: Spin Gapless Semiconductors

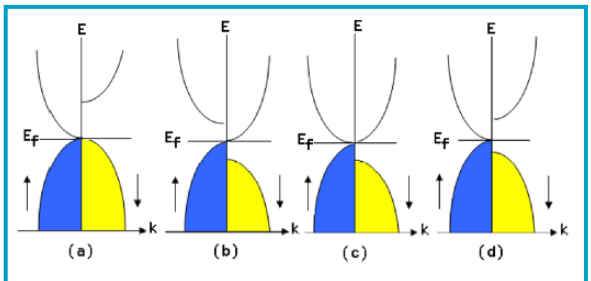
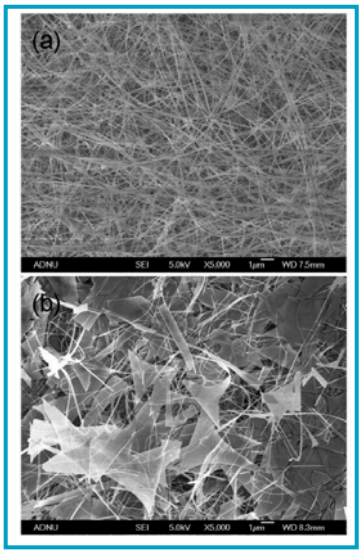


FIG. 3 (color online). Energy band diagrams for spin gapless semiconductors with parabolic dispersion between energy and momentum.

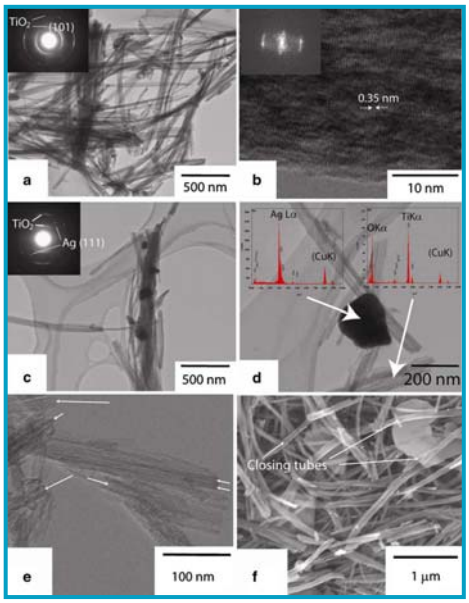
The concept of the spin gapless semiconductor in which both electron and hole can be fully spin polarized is proposed, and its possibility is presented on the basis of first-principles electronic structure calculations. Possible new physics and potential applications in spintronic devices based on the spin gapless semiconductors are discussed. (X. L. Wang, *Physical Review Letters* **100** (15), 156404 (2008))

Sensors using 1D nanostructure



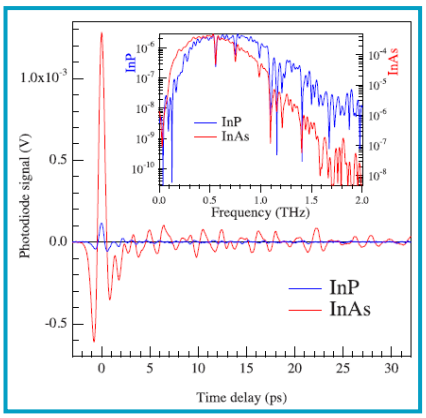
One dimensional (1D) nanostructures such as nanotubes, nanowires, nanorods and nanoribbons have been extensively investigated worldwide. Chemical sensors play an important role in the areas of emissions control, environmental protection, public safety, anti-terrorism, and human health. In particular, the large surface-to-volume ratios of 1D nanostructures and the congruence of the carrier screening length with their lateral dimensions make them excellent candidates for gas-sensing. We have successfully developed various semiconducting 1D nanostructures for gas sensing applications with ultrahigh sensitivity. (G. X. Wang et al., *Crystal Growth & Design* **8**, 1940 (2008))

Silver-coated TiO_2 nanostructured anode materials for lithium ion batteries



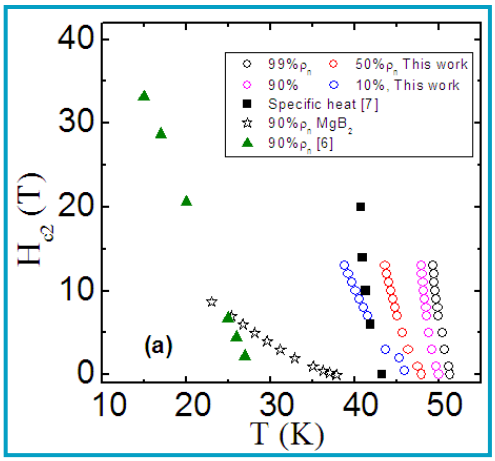
Anatase TiO_2 nanoribbons/nanotubes (TiO_2-NRTs) have been synthesised successfully via a reflux method followed by drying in a vacuum oven, and then, silvercoated TiO_2 NRTs (Ag/TiO_2-NRTs) were prepared by coating silver particles onto the TiO_2-NRTs surface by the traditional silver mirror reaction. The physical properties of the synthesised products were examined in detail using X-ray diffraction, field emission gun scanning electron microscopy, energy dispersive X-ray spectroscopy, and transmission electron microscopy, respectively. The results indicated that the Ag nanoparticles were uniformly deposited on the surface of the TiO_2 nanoribbons/nanotubes. The electrochemical properties were investigated by a variety of techniques. The rate capability and cycle durability for the Ag/TiO_2-NRTs were improved compared with TiO_2-NRTs. It is speculated that the Ag-coated TiO_2 nanoribbons/nanotubes are an effective anode candidate for lithium ion batteries. (M. M. Rahman et al., *Journal of Solid State Electrochemistry*, DOI 10.1007/s10008-009-0807-4)

Single-cycle azimuthal angle dependence of terahertz radiation from (100) n-type InP



We have observed that the terahertz power emitted by (100) n-type InP exhibits a single maximum and a single minimum as the crystal is rotated through 360 degrees about its surface normal. This stands in contrast to other semiconductor terahertz emitters for which two, three, or four maxima per rotation have been observed. We have investigated the terahertz emission as a function of sample doping, optical excitation fluence, and applied in-plane magnetic field. The data cannot be accounted for by bulk optical rectification. We suggest that the origin of the phenomenon may be related to crystal twinning. (S. Hargreaves et al., *Applied Physics Letters* **93**, 242101 (2008))

Very high critical field and superior J_c-field performance in $NdFeAsO_{0.82}F_{0.18}$ with T_c of 51 K

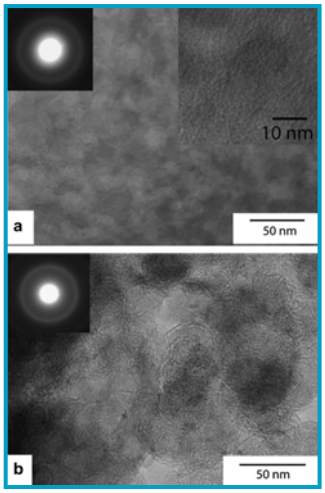


In this work, we show that the H_{c2} (48 K) = 13 T and the $H_{c2}(0)$ values can exceed 80-230 T in a high pressure fabricated $NdO_{0.82}F_{0.18}FeAs$ bulk sample with T_c of 51 K. We also demonstrate that the supercurrent density in fields from 1 up to 9 T only drops by a factor of 2-6 for T < 30 K, much weaker than MgB_2 and high T_c cuprate superconductors. The very high H_{c2} far-surpassing those of MgB_2 and classical low temperature superconductors and the superior J_c-field performance pave the way to use the new $NdFeAsO_{0.82}F_{0.18}$ superconductors for high-field applications. (X. L. Wang et al, *Advanced Materials* **21** (2), 236 (2009))

Sugar as an optimal carbon source for the enhanced performance of MgB_2 superconductor at high magnetic fields

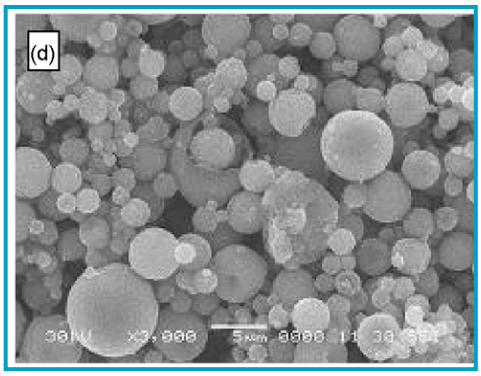
In this paper we report the results of an extended study of the effect of sugar doping on the structural and electromagnetic properties of MgB_2 superconductors. High values of the upper critical field (B_{c2}) of 36 T and the irreversibility field (B_{irr}) of 27 T have been estimated at the temperature of 5 K in a bulk MgB_2 sample with the addition of 10 wt% of sugar. The critical current density [$Jc(B_a)$] of sugar-doped samples has been significantly improved in the high field region. The value of transport *J*c has reached as high as 10^8 A m^{-2} at 10 T and 5 K for Fe-sheathed sugar-doped MgB_2 wire. The analysis of the pinning mechanism in the samples investigated indicated that dominant vortex pinning occurs on the surface type of pinning defects, such as grain boundaries, dislocations, stacking faults etc, for both pure and doped MgB_2. In sugar-doped samples, pinning is governed by numerous crystal lattice defects, which appear in MgB_2 grains as a result of crystal lattice distortion caused by carbon substitution for boron and nano-inclusions. The drastically improved superconducting properties of sugar-doped samples are also attributed to the highly homogeneous distribution and enhanced reactivity of this dopant with host Mg and B powders. The results of this work suggest that sugar is the optimal source of carbon for doping MgB_2 superconductor, especially for application at high magnetic fields. (O. V. Shcherbakova et al, *Superconductor Science & Technology* **21**, 015005 (2008))

Sulfur–mesoporous carbon composites in conjunction with a novel ionic liquid electrolyte for lithium rechargeable batteries



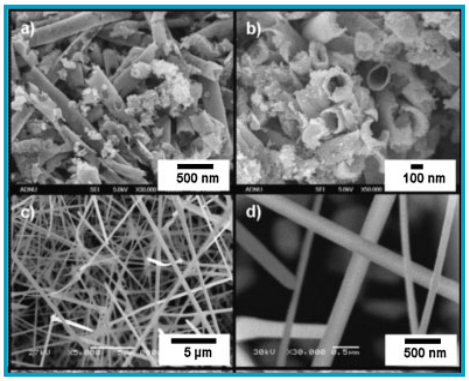
Sulfur coated mesoporous carbon (S–C) composites have been synthesized. Firstly, the electrochemical properties of the S–C composite cathode materials were tested in a conventional electrolyte consisting of 1 mol/L lithium bistrifluoromethanesulfonimidate in poly(ethylene glycol) dimethyl ether to compare them with pure sulfur electrode. The capacity and cyclic stability of the S–C composite were improved. Then the S–C composites were tested in a novel ionic liquid electrolyte consisting of 1-ethyl-3-methylimidazolium bis(trifluoromethanesulfonyl)imide and lithium bistrifluoromethanesulfonimidate. The capacity and cyclic stability of the S–C composite using the ionic liquid electrolyte were much better than for the sample tested in a conventional organic solvent electrolyte. (J. Z. Wang et al., *Carbon* **46**, 229 (2008))

Synthesis of spherical porous vanadium pentoxide and its electrochemical properties



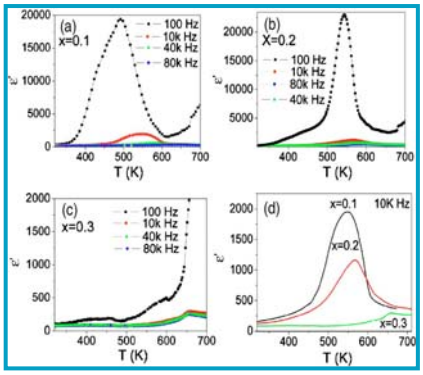
Spherical porous vanadium pentoxide (V_2O_5) phase is synthesized by a spray-pyrolysis method followed by heat-treatment, as confirmed by powder X-ray diffraction. Under high-resolution electron microscope observation, the as-prepared particles are spherical and porous, with uniform particle size. On investigation of the electrochemical properties of V_2O_5 synthesized by this method, it is found that the initial specific capacity of the V_2O_5 is 399 mAh/g, and it exhibits good cycleability during the discharge and charge processes. The experimental results suggest that V_2O_5 synthesized by this method could be a promising electrode material for lithium-ion batteries. (C. Q. Feng et al, *Journal of Power Sources* **184**, 485 (2008))

The Effect of morphological modification on the electrochemical properties of SnO_2 nanomaterials



The electrochemical performances of 1D SnO_2 nanomaterials, nanotubes, nanowires, and nanopowders, are compared to define the most favorable morphology when SnO_2 nanomaterials are adopted as the electrode material for lithium-ion batteries. Changes in the morphology of SnO_2 are closely related with its electrochemical performance. Some SnO_2 nanomaterials feature not only an increased energy density but also enhanced Li^+ transfer. The correlation between the morphological characteristics and the electrochemical properties of SnO_2 nanomaterials is discussed. The interesting electrochemical results obtained here on SnO_2 nanomaterials indicate the possibility of designing and fabricating attractive nanostructured materials for lithium-ion batteries. (M.S Park et al, *Advanced Functional Materials* **18**, 455 (2008))

Structure, ferroelectric properties, and magnetic properties of the La-doped bismuth ferrite



$Bi_{1-x}La_xFeO_3$ ceramics with x=0, 0.1, 0.2, and 0.3 have been synthesized by solid state reaction, starting from metal oxides. A series of structure transformations is found to depend upon the doping level. Below 10% La doping, $Bi_{1-x}La_xFeO_3$ maintains the rhombohedral structure of $BiFeO_3$. However, for $Bi_{0.8}La_{0.2}FeO_3$ and $Bi_{0.7}La_{0.3}FeO_3$, the structures change to the orthorhombic and tetragonal, respectively. La doping significantly reduces electric leakage and leads to successful observation of electrical polarization hysteresis loops. Doping with La also enhances the ferromagnetic moment, due to the broken cycloid spin structure caused by the changes in the crystalline structure. (Z. X. Cheng et al, *Journal of Applied Physics* **103**, 07E507 (2008

Properties of pure and carbon sphere doped MgB_2 prepared from low grade boron powders

Low grade boron powders were used to fabricate pure and submicron-sized carbon sphere doped MgB_2 superconductor. The boron powders used showed low reactivity towards MgB_2 formation, as compared to high purity (99%) amorphous boron, which might result from the larger grain size, and the existence of crystalline boron or boron oxide in the former. However, the samples prepared from this boron

powder showed comparable J_c values at 20 K and in low field (<1 T) to those from a sample prepared from the high quality boron. Doping submicron-sized carbon spheres had successfully introduced carbon substitution for boron, and so improved the H_{c2}, H_{irr}, and in-field J_c properties of MgB_2. (C. H. Jiang, X. Xu, and S. X. Dou, *Superconductor Science & Technology* **21**, 065006 (2008))

Strong photon-mixing of terahertz waves in semiconductor quantum wells induced by Rashba spin–orbit coupling

We demonstrate that due to the Rashba spin–orbit coupling in semiconductor quantum wells, there is strong photo-mixing by mobile carriers in the terahertz frequency regime. The third order nonlinear current is of the same order of magnitude as the linear order current for an electric field intensity of $10^4 Vcm^{-1}$ at frequency around 1 THz, a situation easily achievable in a laboratory system. Unlike other nonlinear effects, the nonlinear current density due to the spin–orbit coupling is inversely proportional to the concentration of mobile carriers. (F. Gao, G. X. Wang, and C. Zhang, *Nanotechnology* **19***, 465401-1 (2008))*

Conferences

Australian Institute of Physics Condensed Matter Meeting (29th to 1st February 2008, Wagga Wagga, Australia)

"Electrical and optical properties of $La_{0.7}Ca_{0.3}MnO_3$ polycrystalline and thin film", F. Gao, R. A. Lewis, M. Ionescu, X. L. Wang, and S. X. Dou

"Electroresistance of perovskite manganites", D. C. Pond and R. A. Lewis

"Terahertz emission from mercury cadmium telluride" M.L. Smith, R. Mendis, R. E. M. Vickers, and R. A. Lewis

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Annual Condensed Matter and Materials Meeting (30th January to 1st February 2008, Wagga Wagga, Australia)

"Light as an indicator of magnetism: magneto-optical imaging", D. L. Cortie, and A. V. Pan (Received: Best Poster Award)

Workshop on Recent Advances of Low Dimensional Structures and Devices (7th to 9th April 2008, Nottingham, UK)

Member of International Program Committee, R. A. Lewis

The first International Conference on Fe-based superconductors, (23rd May 2008, Tokyo, Japan)

"Flux pinning mechanism of NdFeAsO superconductor", X. L. Wang

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14th International Meeting on Lithium Batteries (IMLB) (22nd to 28th June 2008, Tianjin, China)

Member of Scientific Advisory Committee and Awarding Committee; Co-chair poster session #2, H. K. Liu

"One dimensional nanostructures as electrode materials for lithium ion batteries with improved electrochemical performance", G. X. Wang (Invited)

Third International Conference on Optical, Optoelectronic and Photonic Materials and Applications (20th to 25th July 2008, Edmonton, Canada)

Member of International Program Committee, R. A. Lewis

International Workshop on Preparation and Characterization of Battery Cells (24th to 25th July 2008, University of Wollongong, Australia)

Chair, H. K. Liu

Organising Committee, H. K. Liu, G. G. Wallace, G. X. Wang, Z. P. Guo, K. Konstantinov, J. Z. Wang, S. X. Dou, and P. Cooper

"One dimensional nanomaterials for lithium-ion batteries with improved performance", G. X. Wang

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International Conference on the Physics of Semiconductors (27th July to 1st August 2008, Rio de Janeiro, Brazil)

"Terahertz emission from InP", R. A. Lewis and S. Hargreaves

The International Conference on Electronic Materials (IUMRS-ICEM) (28th July to 1st August 2008, Sydney, Australia)

Chair, X. L. Wang

"Comprehensive study of carbohydrate doping on the superconductivity of MgB_2/Fe wire", J. H. Kim, J. Y. Lee, X. Xu, H. W. Park, and S. X. Dou

"The critical current density in $MgB_{2-x}C_x$ superconductors", O. V. Shcherbakova, A. V. Pan, J. L. Wang, A. V. Shcherbakov, S. X. Dou, and D. Wexler

"Developing the multilayer coated conductors wires on the base of YBaCuO superconductor thin films", S. Pysarenko, A. V. Pan, and S. X. Dou (Received: Best Poster Paper Award)

"Infiltration of Mg in porous B skeletons", J. H. Ahn, S. J. Oh, X. L. Wang, and S. X. Dou

"Latest development of Fe-based superconductors", X. L. Wang (Invited)

"Latest development on MgB_2 superconductors", S. X. Dou

"Microstructure, current-carrying ability and quantitative pinning model in YBCO superconducting films and multilayers", A. V. Pan

"Microstructural modifications and superconducting property control in multilayered thin films", A. V. Pan, S. Pysarenko, and S. X. Dou

"Nonlinear susceptibility behaviour of superconducting ferromagnet: $RuSr_2Eu_{1.5}Ce_{0.5}Cu_2O_{10}$", R. Nigam, A. V. Pan, and S. X. Dou

"Research on MOD processes for $YBa_2Cu_3O_{7-x}$ films and buffer layers", D. Q. Shi, M. Liu, L. Wang, Q. Li, X. B. Zhu, J. H. Kim, R. Zeng, and S. X. Dou

"Significant improvement of Jc in MgB_2 bulks superconductor by ball-milled high-purity crystalline boron", Y. Zhang, X. Xu, S. H. Zhou, Y. Zhao, J. H. Kim, and S. X. Dou

"Temperature effect on performance of polycarbosilane and sugar doped MgB_2 wires", A. V. Shcherbakov, J. Horvat, O. V. Shcherbakova, J. L. Wang, S. X. Dou, M. Jercinovic, and E.Babic

"Transport and magnetic critical current in two sintering step of in situ MgB_2/Fe wire", X. Xu, J. H. Kim, S. X. Dou, W. K. Yeoh, S. Choi, and T. Kiyoshi

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The International Workshop on Innovative Materials and their Applications (1st August 2008, Wollongong, Australia)

Chair, X. L. Wang

High Magnetic Fields in Semiconductor Physics (3rd to 8th August 2008, Sao Paulo, Brazil)

"Terahertz magnetospectroscopy of highly-doped Si(P)", R. A. Lewis and R. E. M. Vickers

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Applied Superconductivity Conference 2008 (17th to 22nd August 2008, Chicago, Illinois, USA)

"Increased superconductivity for CNT doped MgB_2 sintered in 5T pulsed magnetic field,", W. X. Li, Y. Li, R. H. Chen, R. Zeng, L. Lu, Y. Zhang, M. Tomsic, M. Rindfleisch, and S. X. Dou

"Pinning regimes in YBaCuO films and multilayers", A. V. Pan, S. V. Pysarenko, and S. X. Dou

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2nd International Symposium on Anomalous Quantum Materials (ISAQM2008) and the 7th Asia-Pacific Workshop, (15th September 2008, Tokyo, Japan)

"Latest development of two dimensional CoO_2 compounds and MgB_2 superconductors", X. L. Wang

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Electrochemical Society/PRiME 2008 Joint International Meeting (12th to 17th October 2008, Honolulu, Hawaii)

"Investigation of THz emission by p-GaAsSb", S. Hargreaves, L. J. Bignell, R. A. Lewis, D. Schoenherr, M. Sağlam, and H. L. Hartnagel

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21st International Symposium on Superconductivity (ISS2008) (27th to 29th October 2008, Tsukuba, Japan)

"Improved superconducting properties of in situ powder-in-tube processed $Mg_{1.15}B_2$/Fe wires with nano size SiC addition", W. X. Li, R. Zeng, L. Lu, Y. Zhang, S. X. Dou, Y. Li, R. H. Chen, and M. Y. Zhu

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ARC Centre of Excellence for Functional Nanomaterials (5th to 7th November 2008, Goldcoast, Queensland, Australia)

"One dimensional nanostructures for advanced batteries and chemical sensor applications" G. X. Wang (Invited)

2nd International Symposium on Anomalous Quantum Materials (ISAQM2008) (7th to 10th November 2008, Tokyo, Japan)

"Latest development of two dimensional CoO_2 compounds and MgB_2 superconductors", X. L. Wang (Invited)

Australia-China Workshop on Terahertz Science and Technology (13th to 14th November 2008, Wollongong, Australia)

Chair: C. Zhang

"Superconductivity, thin films and terahertz radiation", A. V. Pan (Invited)

"Zero-gap materials", X. L. Wang

53rd Annual Conference on Magnetism and Magnetic Materials (MMM 2008) (10th to 14th November 2008, Austin, Texas, USA)

"Coexistence of ferromagnetism and cluster glass state in superconducting ferromagnet $RuSr_2Eu_{1.5}Ce_{0.5}Cu_2O_{10}$", R. Nigam, A. V. Pan, and S. X. Dou

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Korean Battery Society Annual Meeting (27th to 28th November 2008, Busan University, Busan, Korea)

"Iron oxide nanowires and nanorods as anode materials for lithium-ion batteries", G. X. Wang (Invited)

Australian Institute of Physics National Congress (30th November to 5th December 2008, Adelaide, Australia)

"Metastability in the electroresistance of electronic oxides", J. C. Knott and R. A. Lewis

"High-field far-infrared magnetospectroscopy of cobaltite/manganites", R. A. Lewis and F. Gao

"Far-infrared spectroscopy of P ion-implanted Si", R. A. Lewis, P. Spizzirri, N. Stavrias, and S. Prawer (Invited)

Honorary Appointment in Overseas Institutes

S. X. Dou

Asia Materials, Branch of Nature Materials, Advisory Committee

Beijing University of Science and Technology, Beijing, China

Hubei University, China

Institute of Electrical Engineering, Chinese Academy of Sciences, China

Open Materials Science Journal, Editor Board Member

Rare Earth Metals, Associate Editor

Shanghai Institute of Microsystems and Information Technology, Chinese Academy of Sciences, Shanghai, China

Shanghai University, Shanghai, China

H. K. Liu

Advanced Science Letters, Associate Editor

Hubei University, China

Journal of Nanoscience and Nanotechnology, Editorial Board Member

Journal of New Materials for Electrochemical Systems, Advisory Board Member

Shanghai Institute of Microsystems and Information Technology, Chinese Academy of Sciences, Shanghai, China

Shanghai University, Shanghai, China

C. Zhang

Institute of Solid State Physics, Chinese Academy of Sciences, Hefei, China

Shanghai Institute of Microsystems and Information Technology, Chinese Academy of Sciences, Shanghai, China

Tianjin University, Tianjin, China

Xi'an Institute of Optics and Precise Mechanics, Chinese Academy of Sciences, Xi'an, China

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G. X. Wang

Jiangsu University, Guest Professor, China

Invited Presentations / Seminars at Other Institutions

S. X. Dou

"A Review of development of technical MgB_2 superconductors"
European Superconductivity Workshop, *Twente University, Netherlands*, January 2008

"Control of nanostructure to enhance materials performance property"
Shanghai Eastern Forum, Shanghai University, Shanghai, China, June 2008

"Research progress in new superconductors"
Hua Zhong University of Science and Technology, Wu Han , China, June 2008

"Flux pinning of MgB_2 and As-Fe based new superconductors"
Global Partnership Project Workshop, Jeju, Korea, June 2008

"Strategic postgraduate training leads to sustainable research excellence at ISEM"
Showcase Lecture Series, University of Wollongong, Australia, September 2008

"Strategic postgraduate training leads to sustainable research excellence at ISEM"
Australia-China Forum, Gold Coast, Australia, October 2008

C. Zhang

"Thermal transport and thermionic emission in semiconductor nanostructures"
Beihang University, China, March 2008

"Electronic properties of graphene and graphene nanoribbons"
Beijing University of Science and Technology, China, March 2008

"Optical anisotropy of graphene at high frequencies"
Xian University of Technology, China, December 2008

"Terahertz conductance of graphene nanoribbons"
Xian Institute of Opticas and Precision Mechanics, Chinese Academy of Sciences, China, December 2008

"Optical spectra in Graphene and graphene nanoribbons"
Rensselaer polytechnic Institute, USA, December 2008

"Thermoelectrics and thermionics in nanomaterials"
University of Utah, USA, December 2008

G. X. Wang

"Synthesis and characterization of semiconducting gallium oxide nanostructures: nanowires, nanoribbons and nanosheets"
Shanghai Jiaotong University, Shanghai, China, January 2008

"Physical and optical properties of In_2O_3 and CdSe nanowires"
Institute of Solid State Physics, Chinese Academy of Science, Hefei, China, January 2008

"Nanosize transition metal oxides for supercapacitor application"
Jiangsu University, Zhenjiang, China, January 2008

"Improvement of electrochemical performance of $LiFePO_4$ cathode materials through ZrO_2 nanolayer coating"
Korea Electrotechnology Research Institute, Changwon, Korea, November 2008

H. K. Liu

"Nano-materials for energy storage applications"
Eastern Forum, *Shanghai University*, June 2008

"Advanced materials for energy storage applications"
Hubei University, June 2008

"Energy materials and their applications"
Australia-China Forum, Gold Coast, Australia, October 2008

Z. P. Guo

"Si-based anode materials for lithium ion batteries"
KERI, Chungwon, Korea, May 2008

"Tin based nanocomposites for lithium ion batteries"
Gyeongsang National University, Korea, June 2008

"The impact of nanocomposites on the electrochemical performance of lithium ion batteries"
ICSSM, Guangzhou, China, November 2008

Seminars by Visiting Scientists

Date	Name	Institute	Title
8/1/2008	Prof. Cheol-Jin Kim	Gyeongsang National University, Jinju, Kyungnam, South Korea	TEM analysis of MgB_2 thin film and conductor
30/1/2008	Prof. Edward Collings	Ohio State University, OH, USA	Prospectus for improving the intrinsic and extrinsic properties of magnesium diboride superconductors
1/2/2008	Prof. Yong-Mook Kang	Division of Advanced Materials Engineering, Kongju University, Korea	Ab-initio calculation-coupled elucidation on the phase transition of Si during Li insertion
8/2/2008	Prof. Yong-Mook Kang	Division of Advanced Materials Engineering, Kongju University, Korea	The comparison between morphology control and other modifications to improve the electrochemical performance of SnO_2
11/2/2008	Dr. Vitaliy V Yurchenko	Centre for Materials Science & Nanotechnology, Dept of Physics, University of Oslo, Norway	Magneto-optical and thermal imaging of superconductors
12/2/2008	Prof. Min Gu	Director – Centre for Micro-Photonics, Faculty of Engineering & Industrial Science, Swinburne University of Technology, Hawthorn, VIC, Australia	Femtosecond lasers light bio/nanophotonics
15/2/2008	Prof. Xungai Wang	Alfred Deakin Professor, Centre for Material & Fibre Innovation, Deakin University, VIC, Australia	Applied nano and fibre research
15/2/2008	Prof. Yong-Mook Kang	Division of Advanced Materials Engineering, Kongju University, Korea	New synthetic way for olivine-structured $LiFePO_4$; Microwave heating coupled with high energy ball-milling
25/2/2008	Prof. Wooyoung Lee	Dept of Materials, Science & Engineering, Yonsei University, Korea	On-film formation of Bi nanowires with extraordinary electron mobility
22/5/2008	Dr. Bernd Fischer	The Adelaide T-ray Group, School of Electrical & Electronic Engineering, University of Adelaide, SA, Australia	Broadband terahertz time-domain spectroscopy of biomolecules
2/6/2008	Dr. Soo-Kien Chen	Dept of Materials Science & Metallurgy, University of Cambridge, UK	Nominal Mg non-stoichiometry in Mg_xB_2: Evidence for structural and superconducting property variations
5/6/2008	Dr. Young-Kuk Kim	Korea Institute of Materials Science, Korea	Metal-organic deposition of HTSC films
25/6/2008	Prof. David Jiles	Wolfson Centre for Magnetics, Cardiff University, UK	Non linear modeling of magnetic materials

Date	Name	Institute	Title
3/7/2008	Prof. Qiuliang Wang	Head – Superconducting Magnet Science & Technology, Key Laboratory of Applied Superconductivity, CAS, Institute of Electrical Engineering, Chinese Academy of Sciences, China	Development of high magnetic field superconducting magnet technology and applications
5/8/2008	Prof. Xiaoxing Xi	Department of Physics and Department of Materials Science and Engineering, Penn State University, USA	MgB_2 thin films for high field electronic and RF applications
5/8/2008	Dr. Sonja Schlachter	Superconductors and Structure Materials Institute for Technical Physics, Forschungszentrum Karlsruhe, Germany	MgB_2 conductor development at the Institute for Technical Physics at Forschungszentrum Karlsruhe
13/8/2008	Prof. Feng Liu	Department of Materials Science and Engineering, University of Utah, USA	A unified design rule for nanomagnetism in graphene
26/9/2008	Dr. Keith McIntosh	Centre for Sustainable Energy Systems, The Australian National University, ACT, Australia	Photovoltaic research at the ANU
21/10/2008	Prof. Wei Lu	Director, State Key Laboratories for Infrared Technology, Shanghai Institute of Technical Physics, Chinese Academy of Sciences, Shanghai, China	Infrared detector technology for space remote sensing
20/11/2008	Prof. H. L. Hartnagel	Technical University Darmstadt Institut für Hochfrequenztechnik Darmstadt, Germany	Terahertz source developments
15/12/2008	Dr. Willem V. Hassenzahl	President, Advanced Energy Analysis, Piedmont, CA, USA	Energy storage and application of superconductors

Equipment and Facilities

In 2008 ISEM expanded its laboratory space from approx. 420 m^2 and 9 labs in main campus to approx. 900m^2 and 21 labs in the new AIIM facility at the Innovation Campus. This expansion allowed us to dedicate space to research specific areas and diversify our research teams. The laboratories are ranging from general sample processing for various kinds of materials to sophisticated single crystal growth lab, low temperature laboratory, energy and hydrogen testing laboratories, etc.

The majority of these facilities were founded through 7 ARC RIEF programs and the Metal Manufactures Ltd Consortium program over the past ten years, as well as additional funds were allocated from the relocation budget considering great increase in the laboratory space. Through relocation funds ISEM purchased Mettler Toledo TGA/DTA for materials characterization, powerful solid state laser (Quanta Ray) for deposition of thin films and optical table, four mirror floating zone single crystal growth facility (CSC Corporation) for growth of large high quality single crystals, new GBC MMA XRD machine with most up-to-date PDF2 database, and other minor equipment.

The following institutions and Chief Investigators have been involved with the ARC RIEF proposals in the past:

Australian Nuclear Science & Technology Organisation	Dr. M. Ionescu, Dr. S. Kennedy
James Cook University	Prof. J. Mazierska
Macquarie University	A/Prof. E. Goldys
Monash University	Dr. Y. B. Cheng Dr. R. Krishanmurthy
University of Melbourne	A/Prof. D. N. Jamieson
University of NSW	Prof. M. Skyllas-Kazacos Dr. S. Li Dr. R. Ramer Prof. S. Campbell
University of Queensland	Prof. M. G. Lu, Dr. L Wang Prof. D. R. Mackinnon
University of Sydney	Prof. S. Ringer, Prof L.Z. Zhang, Dr. R.K. Zheng, Dr. X.Z. Liao,
University of Technology, Sydney	Prof. J. G. Zhu, Dr. J. Lin Prof. J. Smith
Curtin University	A/Prof. J. Low
University of West Sydney	Prof. M. Wilson

Materials Processing Facilities

- Freeze Drier, Lyph-Loch 4.5, 4.5l/24h
- Spray Drier, GA-32, ~100g/h
- Spray Drier OPD8 3l/hour
- Attrition Mill, 01-HD, 0-660rpm
- Planetary Mill, pulverisette 5, 0-300rpm agate
- Drawing Bench, 8m, fixed die, 11.5kW
- High energy ring mill
- Ultrasonic spray unit
- Bull Block, 22cm diameter
- Rolling mill, 2 x 60mm flat & square rollers, 5cm/s
- Rolling mill, 2 x 55mm supported rollers, 5cm/s
- Swagging machine, 15-1mm diameter
- Hydraulic press, 10t-100t
- More than 30 various furnaces
- Four mirror floating zone single crystal growth
- Controlled atmosphere glove boxes

Thin Film Deposition and Structuring Facilities

- Excimer laser, ComPex301, 9W, 10Hz, 248nm
- Solid state laser, Quanta-Ray, Nd:YAG laser, 200-400 mJ, 266-532 nm, 10Hz
- Thin Films Pulsed-Laser Deposition (PLD) Chamber, 18" With high vacuum system
- Ultra High Vacuum (UHV) PLD chamber equipped with ISD and IBAD.
- UHV chamber (10^{-12} mBar) with multi-target rf magnetron sputtering and multi-pocket electron beam evaporation EBE techniques with direct HV connection to UHV analysis chamber.
- Electron Beam Lithography (EBL) system on the base of SEM (LaB6).
- Optical lithography.

Materials Characterisation

- DTA/TG, Setaram, 18-92, 1750°C
- Mettler Toledo DTA/TGA system, 1600 ºC
- TEM, J2000FX1, with EDS
- Gas absorption analyser Nova 1000 for BET and pore size analyses
- XRD, M18XHFCu with HT 2000°C camera
- XRD, GBC MMA with solid detector for fast and accurate reading of reflections.
- XPS, AES, ISS, UVPS in UHV analysis chamber connected to UHV thin film deposition chamber.
- SEM (LaB6 filament) JEOL, equipped with EDS
- SEM, Stereoscan 440, with EDS and EBSP
- AFM, Nanoscope IIIa
- Particle Size Analyser, Mastersizer S, 0.05-900μm
- XRD, PW1050, 3kW;
- DSC, TA300,-170°C+600°C

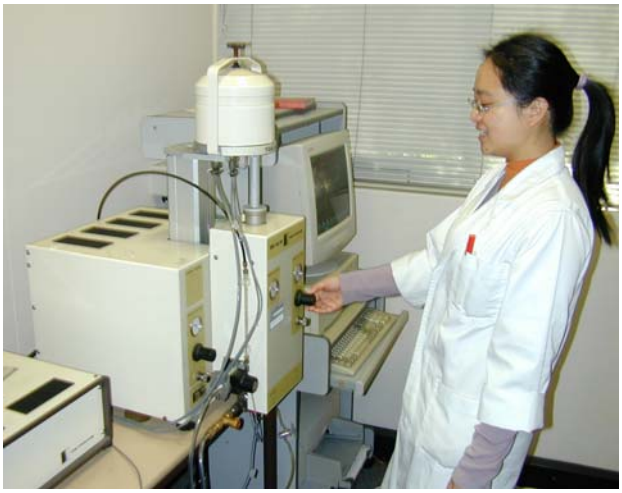
Physical Property Characterisation

- MPMS, 1.5-400K, 0-5T DC field
- PPMS, 4-400K, 0-9T DC field
- PPMS, 4-1000K (VSM), 0-14T DC field (multiple options such as thermal transport, heat capacity, AC transport are available)
- Horizontal field superconducting Magnet, 0-8T, 5-300K
- 15T VTI magnet, 200A DC current leads for critical current measurements
- Lock-in Amplifier, SR510; Lock-in Amplifier, SR830DSP, 2 x PAR 5209 Lock-in Amplifier, PAR 124 Lock-in Amplifier
- Magneto Optical Imaging, 2K-300K, up to 0.2 T DC field
- Five power supplies (HP and Keithley) 0-900A
- Cryogenic Temperature Controller, ITC4, 0-500K
- SR560 low-noise preamplifier
- Pacific Power 3120 AMXoc current source, 12 kVA
- Spectrometers, Bomem DA3 - fast scan interferometer, Polytec FIR 25 (modified) - slow scan interferometer, Beckman FS 720 - slow scan interferometer, SPEX 1402 double grating 1 m instrument, SPEX 1704 single grating 1 m instrument, 2xSPEX 1870 single grating 0.5 m instruments
- Ballantine 1620 transconductance amplifier (up to 100A)
- Magnets, Oxford Instruments superconducting (0-7T), 2x4 inch iron-cored, Rawson-Lush gaussmeter
- Cantilever (torque force) magnetometer
- Various multimeters, HP and Keithley, including a nano-voltmeter
- VSM, Maglab, 2-400K, 0-12T DC field CTI 8001/8300 cryocooler
- Function Generator, DSC340; Digital Oscilloscope, TDS320
- Digital Teslameter, DTM-132, with Hall Probe; Fluxmeter, 916
- 2 x He Recovery System, 2 He liquefiers from CryoMech – 20 LHe/day each
- Eddy current generator
- Electromagnet, 3473-70, 2T, 150mm pole diameter, Rawson-Lush Gaussmeter
- Lasers, Spectra Physics Model 2040 25 W Ar^+, Spectra Physics Model 165 6 W Ar^+, Spectra Physics Model 3900 Titanium-sapphire, Spectra Physics Model 380 Dye, Spectra Physics 15 mW HeNe
- Detectors, 4xInfrared Laboratories bolometers, Infrared Laboratories Ga-doped Ge photoconductor, N. Coast Scient. Corp Ge photoconductor, Photomultiplier with GaAs photo-cathode
- Cryostats, A number of L He with optical access, L N cryostats, 60 L He storage, 30 L He storage, 60 L N storage, 50 L N storage, 2x30 L N storage, 25 L N storage
- Leak detector Vacuum system

Electro-Chemical Property Characterisation

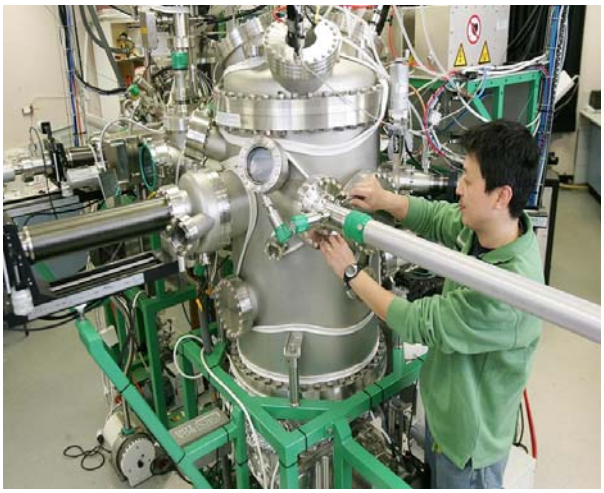
- Cyclic Voltammograph, BAS CV-27
- Impedance Analyser, M6310
- 4 Channels Data Collection System, MacLab/4e
- ICP-OES, 167-785nm range 0.009nm resolution 200nm
- Scanning Potentiostat, M326; Potentiostat, M363
- Power Supply, DCS 20-50, 0-20V, 0-50A 8 Channels Data Collection System, MacLab/8
- Amplifiers, PAR 124A Lock-in, 2xPAR 5209 Lock-in, Stanford Research SR510
- CHI 660B Electrochemical Workstation
- Arbin MSTAT8000 Electrochemical Workstation
- Automatic PCT Measuring System

ICP-OES, Vista Simultaneous
Axial Spectrometer



Setaram high-temperature DTA/TGA instrument

Magnetic Property Measurement System
4K-300K, 0-5T



Electron Beam Evaporation Facility

High-resolution JEOL SEM/EBL system

Glove box for controller atmosphere environment

Refereed Publications

Books

1. **W. K. Yeoh, J. Horvat, J. Kim, and S. X. Dou,** "Improvement of vortex pinning in MgB_2", US, UK, Canada, Germany, France: Nova Science Publishers, (2008).

Refereed Journal Articles

2. **D. J. D. Beaven, J. A. Fulcher, C. H. Yang, Z. Zeng, W. Xu, and C. Zhang,** "Photo absorption in spintronic multilayer systems", *Physica E* **40** (6), 2138 (2008). (IF:1.230)

3. **Z. X. Cheng, X. L. Wang, S. X. Dou, H. Kimura, and K. Ozawa,** "Enhancement of ferroelectricity and ferromagnetism in rare earth element doped $BiFeO_3$", *Journal of Applied Physics* **104**, 116109 (2008). (IF: 2.201)

4. ***Z. X. Cheng, X. L. Wang, H. Kimura, K. Ozawa, and S. X. Dou,** "Nb and La co-doped multiferroic $BiFeO_3$ thin films on oxide bottom electrodes by pulsed laser ablation", *Applied Physics Letters* **92**, 092902 (2008). (IF: 3.726)

5. ***Z. X. Cheng and X. L. Wang,** "Optical property and electronic band structure of a piezoelectric compound Ga_3PO_7 studies by the first-principles calculation", *Applied Physics Letters* **92**, 261915 (2008). (IF: 3.726)

6. **Z. X. Cheng, X. L. Wang, H. Kimura, K. Ozawa, and S. X. Dou,** "Significant improvement in the ferroelectric properties through La and Nb co-doping into $BiFeO_3$ thin films", *Physical Review B* **77**, 092101 (2008). (IF: 3.322)

7. **S. Y. Chew, J. Z. Sun, J. Z. Wang, H. K. Liu, M. Forsyth, and D. MacFarlane,** "Lithium-polymer battery based on an ionic liquid-polymer electrolyte composite for room temperature applications", *Electrochimica Acta* **53**, 6460 (2008). (IF: 3.078)

8. **S. L. Chou, J. Z. Wang, H. K. Liu, and S. X. Dou,** "Electrochemical deposition of porous $Co(OH)_2$ nanoflake films on stainless steel mesh for flexible supercapacitors", *Journal of the Electrochemical Society* **155** (12), A926 (2008). (IF: 2.437)

9. **S. L. Chou, J. Z. Wang, H. K. Liu, and S. X. Dou,** "Electrochemical deposition of porous Co_3O_4 nanostructured thin film for lithium-ion battery", *Journal of Power Sources* **182**, 359 (2008). (IF: 3.477)

10. **S. L. Chou, J. Z. Wang, S. Y. Chew, H. K. Liu, and S. X. Dou,** "Electrodeposition of MnO_2 nanowires on carbon nanotube paper as free-standing, flexible electrode for supercapacitors", *Electrochemistry Communications* **10** (11), 1724 (2008). (IF: 4.194)

11. ***S. L. Chou, J. Z. Wang, J. Sun, D. Wexler, M. Forsyth, H. K. Liu, D. MacFarlane, and S. X. Dou,** "High capacity, safety, and enhanced cyclability of lithium metal battery using a V_2O_5 nanomaterial cathode and room temperature ionic liquid electrolyte", *Chemistry of Materials* **20** (22), 7044 (2008). (IF: 5.046)

12. **C. Q. Feng, S. Y. Wang, R. Zeng, Z. P. Guo, K. K. Konstantinov, and H. K. Liu,** "Synthesis of spherical porous vanadium pentoxide and its electrochemical properties", *Journal of Power Sources* **184**, 485 (2008). (IF: 3.477)

13. **F. Gao, G. X. Wang, and C. Zhang,** "Strong photon-mixing of terahertz waves in semiconductor quantum wells induced by Rashba spin-orbit coupling", *Nanotechnology* **19**, 465401 (2008). (IF: 3.446)

14. **F. Gao, J. Chen, S. X. Dou, and X. C. Zhang,** "Terahertz spectroscopy in pulsed laser deposited $LaCa_{0.7}Mn_{0.3}O_3$/MgO thin films", *Progress in Biomedical Optics and Imaging* **6840** (68401I) I8401 (2008).

15. **F. Gao, and R. Mendis,** "THz time-domain spectroscopy of cesium iodide", *Progress in Biomedical Optics and Imaging* **6840** (64801H-1), H8401 (2008).

16. **S. R. Ghorbani, X. L. Wang, S. X. Dou, Lee Sung-IK, and M. S. A. Hossain,** "Flux-pinning mechanism in silicone-oil-doped MgB_2: Evidence for charge-carrier mean free path fluctuation pinning", *Physical Review B (Condensed Matter and Materials Physics)* **78**, 184502 (2008). (IF: 3.322)

17. ***A. M. Glushenkov, V. I. Stukachev, M. F. Hassan, G. G. Kuvshinov, H. K. Liu, and Y. Chen,** "A novel approach for real mass transformation from V_2O_5 particles to nanorods", *Crystal Growth and Design* **8** (10), 3661 (2008). (IF: 4.215)

18. ***X. L. Gou, G. X. Wang, X. Y. Kong, D. Wexler, J. Horvat, J. Yang, and J. S. Park,** "Flutelike porous hematite nanorods and branched nanostructures: synthesis, characterisation and application for gas-sensing", *Chemistry - A European Journal* **14**, 5996 (2008). (IF: 5.454)

19. **X. L. Gou, G. X. Wang, J. Yang, J. S. Park, and D. Wexler,** "Chemical synthesis, characterisation and gas sensing performance of copper oxide nanoribbons", *Journal of Materials Chemistry* **18** (9), 965 (2008). (IF: 4.646)

20. **X. L. Gou, G. X. Wang, J. S. Park, H. K. Liu, and J. Yang,** "Monodisperse hematite porous nanospheres: synthesis, characterization, and applications for gas sensors", *Nanotechnology* **19**, 125606 (2008). (IF: 3.446)

21. **Z. P. Guo, D. M. Han, D. Wexler, R. Zeng, and H. K. Liu,** "Polyoxometallate-stabilized platinum catalysts on multi-walled carbon nanotubes for fuel cell applications", *Electrochimica Acta* **53** (22), 6410 (2008). (IF: 3.078)

22. **L. Hao, G. X. Wang, J. Z. Wang, and D. Wexler,** "Magnetite/carbon core-shell nanorods as

anode materials for lithium-ion batteries", *Electrochemistry Communications* **10** (12), 1879 (2008). (IF: 4.194)

23. ***S. Hargreaves and R. A. Lewis,** "Single-cycle azimuthal angle dependence of terahertz radiation from (100) n-type InP", *Applied Physics Letters* **93**, 242101-1 (2008). (IF: 3.726)

24. **S. Hargreaves, L. Bignell, R. A. Lewis, D. Schoenherr, M. Saglam, and H. L. Hartnagel,** "Investigation of p-GaAsSb as a THz Emitter", *Journal of The Electrochemical Society* **155** (10), H734 (2008). (IF: 2.437)

25. **J. Horvat, W. K. Yeoh, J. H. Kim, and S. X. Dou,** "Transport and magnetic critical current in superconducting MgB_2 wires", *Superconductor Science and Technology* **21**, 065003 (2008). (IF: 1.847)

26. **M. Ionescu, Y. Zhao, R. Siegele, D. D. Cohen, E. Stelcer, and M. Prior,** "Heavy ion ToF analysis of oxygen incorporation in MgB_2 thin films", *Nuclear Instruments & Methods in Physics Research, Section B: Beam Interactions with Materials and Atoms* **266** (8), 1701 (2008). (IF: 0.999)

27. **C. H. Jiang, X. Xu, and S. X. Dou,** "Properties of pure and carbon sphere doped MgB_2 prepared from low grade boron powders", *Superconductor Science and Technology* **21** (6), 065006 (2008). (IF: 1.847)

28. **C. H. Jiang, S. X. Dou, Z. X. Cheng, and X. L. Wang,** "Light carbon doping by oxygen-free paraffin wax to enhance the current density of MgB_2 in the entire field regime", *Superconductor Science and Technology* **21**, 065017 (2008). (IF: 1.847)

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117. **R. A. Lewis and F. Gao,** "High-field far-infrared magnetospectroscopy of cobaltite/manganites", *Proceedings of the Australian Institute of Physics 18th National Congress* (Adelaide, Australia) 93, ISBN 1-876346-57-4 (2008).

118. **R. A. Lewis, P. Spizzirri, N. Stavrias, and S. Prawer,** "Far-infrared spectroscopy of P ion-implanted Si", *Proceedings of the Australian Institute of Physics 18th National Congress* (Adelaide, Australia) 96, ISBN 1-876346-57-4 (2008).

119. **D. Pond and R. A. Lewis,** "Electroresistance of Perovskite Manganites", *Proceedings of the 32nd Annual Condensed Matter and Materials Meeting* (Wagga Wagga, Australia) 20-01, ISBN 978-0-646-49085-4 (2008).

120. **M. L. Smith, R. Mendis, R. E. M. Vickers, and R. A. Lewis,** "Terahertz emission from Mercury Cadmium Telluride", *Proceedings of the 32nd Annual Condensed Matter and Materials Meeting* (Wagga Wagga, Australia) 26-01, ISBN 978-0-646-49085-4 (2008).

121. **Y. Zhang, S. Soltanian, Y. Zhao, S. Zhou, and S. X. Dou,** "Effect of addition of TiO_2/SiO_2 nanoparticles on H_{c2} and H_{irr} in MgB_2 bulks", *Proceedings of the 2008 International Conference on Nanoscience and Nanotechnology (ICONN2008)* (Melbourne, Australia) ISBN 1-4244-1504-7 (2008).

17 x A* Publications according to ARC Ranking Schedule

70 (63.6%) articles published in journals with IF > 2.

18 (16.4%) articles published in journals with IF > 4.

Funding 2008

Australian Research Council Grants

ARC Centre of Excellence Grants

Chief Investigators	Title	2008 Funding
H. K. Liu	Nano-materials for energy storage	$230,000
	Total	**$230,000**

ARC Discovery Scheme Grants

Chief Investigators	Title	2008 Funding
Z. P. Guo	Charge transfer mechanism in 3-dimensional pore-solid nanoarchitectures for electrochemical systems	$100,000
S. X. Dou	Current limiting mechanisms in magnesium diboride superconductors	$330,000
D. Q. Shi	Development of conductive buffer layers for RABiTS-based coated conductors	$60,000
X. L. Wang, Z.X. Cheng	Development of novel ferroelectric magnetic materials for multi-functional applications	$100,000
G. Peleckis	Development of novel high efficiency thermoelectric oxides for high temperature power generation	$35,000
X. L. Wang	Exploration for new materials for spintronics	$120,000
S. H. Zhou	Fabrication of high quality MgB_2 superconductor	$40,000
G. X. Wang, C. Zhang, K. Konstantinov, J. Z. Wang	First principles for development of novel hybrid electrochemical energy storage and conversion systems	$210,000
S. X. Dou, J. H. Kim, T.H. Johansen, E. Bruck	Giant magnetocaloric materials and room temperature refrigeration	$197,000
R. A. Lewis	High efficiency terahertz emitters	$112,000
X.B. Yu	Improvement and synthesis of advanced hydrogen storage materials for fuel cell application	$96,148
Z. P. Guo, H. K. Liu	New concepts with multidisciplinary approach: novel functionalised nanostructures for hydrogen storage	$100,000
C. Zhang, D. Li, F. Liku, R.B. Kraner, Y. Jiang	Novel graphene nanostructures: modelling, synthesis, fabrication and characterisation	$150,000
Y. Zhao, M. Ionescu, J. Du	Superconducting MgB_2 thin films and structures for electronic devices and telecommunication applications	$100,000
A. V. Pan, C.P. Foley, T.H. Johansen, H. Hilgenkamp	Tailoring superconducting hybrid multilayered film systems for electric and electronic applications	$165,000
	Total	**$1,915,148**

ARC Linkage Projects

Chief Investigators	Title	2008 Funding
A.V Pan, S.X Dou, O. Mukhanov	Development of superconducting leads with ultra-low thermal conductivity for cryoelectronic applications	$151,000
C. Zhang, X. Wang, G. Wang, T. Toyoda	Novel methods for enhancing room temperature figure of merit of thermoelectric/thermionic materials for refrigeration applications	$81,000
S. X. Dou, D. Q. Shi, A. V. Pan, R. Taylor, J. Barry, T. Yamashita	Development of high performance second generation superconductors	$193,000
G. X. Wang, H. K. Liu, K. Konstantinov, J. Z. Wang, D. Wexler	Exploration of new catalyst materials for hydrogen/air fed proton exchange membrane fuel cells	$100,000
Z. P. Guo, H. K. Liu, J. Z. Wang, K. Konstantinov, M. Forsyth	Miniature lithium ion battery for implantable medical device applications	$100,000
S. X. Dou, A. V. Pan	Novel electric field induced coupling technique for liquid-phase heteroepitaxial growth of carbon thin films with diamond-like structure	$12,000
	Total	**$637,000**

ARC Linkage Infrastructure, Equipment and Facilities Proposals (LIEF)

Chief Investigators	Title	2008 Funding
S. X. Dou, L. Wang, S.J. Campbell, R. Zheng, X. Wang, J. Zou, X. Liao, S.S. Li, Z. Cheng, J. Horvat, G. Peleckis, A. V. Pan, Y. Zhao, K.K. Konstantinov, R. A. Lewis, J. Wang, D. Shi, Z. P. Guo, E. Pereloma, D. Wexler, S. Zhou, D. Li, R.J. Dippenaar	High field magnet for materials processing and characterisation	$ 340,000
	Total	**$ 340,000**

ARC Linkage International Awards

Chief Investigators	Title	2008 Funding
R. A. Lewis, R. Mendis, R. E. M. Vickers	Advanced materials and structures for terahertz science and technology	$10,000
S.X Dou, Y. Zhao, X. Xi, G. Ramanath, Q.J. Li, G. Peleckis	Approved development of nano-structured thermoelectric materials for power generation from heat	$18,200
X. L. Wang, S. Lee	Mechanism and enhancement of supercurrent carrying ability in magnesium diboride superconductor	$12,900
	Total	**$41,100**

2008 Australian Research Council Grants Total: $3,163,248

CSIRO Flaghip Grant

National Hydrogen Materials Alliance:

Chief Investigators	Title	2008 Funding
H. K. Liu	Carbon-based and Mg based Hydrogen Materials	$50,000
	Total	**$50,000**

Linkage International Fellowships

Chief Investigators	Title	2008 Funding
C. Zhang, F. Liu	Design and creation of nanomechanical architectures from folding of ultrathin Bi-layer films	$117,972
	Total	**$117,972**

URC Small Grants & ARC Near-Miss Grants

Chief Investigators	Title	2008 Funding
J. Z. Wang, K. Konstantinov	Development of room temperature sodium/sulfur batteries for electric vehicles	$11,500
Z. P. Guo	Exploration of novel highly effective electrocatalysts for proton exchange membrane fuel cells	$14,000
J. Horvat	Synthesis of $ZnCr_2Se_4$ nanoparticles	$14,000
J. H. Kim, Y. Zhao	The evolution of solar energy in photoelectrochemical cells using nano-materials	$12,000
J. H. Kim	$YB_2Cu_3O_7$-x thin film prepared by sol-gel method for electronic device applications	$9,000
	Total	**$60,500**

Research Infrastructure Block Grants

Coordinators	Title	2008 Funding
C. Zhang, R. Lewis, A.V Pan, X.F. Huang, S. X. Dou, X. L. Wang, J. Horvat, Y. Zhao, Z.X. Cheng, R. Vickers	Z-2 Portable Terahertz Time-Domain Spectrometer	$70,000
	Total	**$70,000**

AINSE Awards

Coordinators	Title	2008 Funding
Y. Zhao, H. K. Liu	Time of flight detection on superconducting MgB_2 films prepared by HPCVD and RF sputtering methods	$15,500
	Total	**$15,500**

Major Research Facility Program

Coordinators	Title	2008 Funding
Z. X. Cheng, X. L. Wang	Magnetic structure and the magnetoelectrical coupling mechanism in La doped multiferroic $BiFeO_3$	$9,100
	Total	**$9,100**

University of Wollongong Support

ISEM Performance	$95,035
ISEM Management	$150,000
PGS Maintenance	$43,750
Total	**$288,785**

2008 Grand Total Funding: $3,775,105

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