COLLABORATIVE / VISIONARY / INSPIRING
CONNECT: ISEM
2011 ANNUAL REPORT

INSTITUTE FOR SUPERCONDUCTING AND ELECTRONIC MATERIALS

UNIVERSITY OF WOLLONGONG

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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.

2011 POSTGRADUATE STUDENT EXCELLENCE AWARD RECIPIENT

Seyed Aboutalebi *(photo 1)*

2011 POSTGRADUATE STUDENT MERIT AWARD RECIPIENTS

Alfred Chidembo *(photo 2)*

Jyotish Debnath *(photo 3)*

Fang Hong *(photo 4)*

Lukman Neorochim *(opp. below left)*

2011 POSTGRADUATE STUDENT BEST PAPER AWARD RECIPIENT

Priyanka Jood *(photo 5)*

2011 CHINESE GOVERNMENT SCHOLARSHIP AWARD

Chao Zhong *(photo 6)*

2011 UOW PHYSICS ENGINEERING DISCIPLINE 4th YEAR PRIZE, OVERALL BEST PERFORMANCE

Frederick Steven Wells *(opp. below right)*

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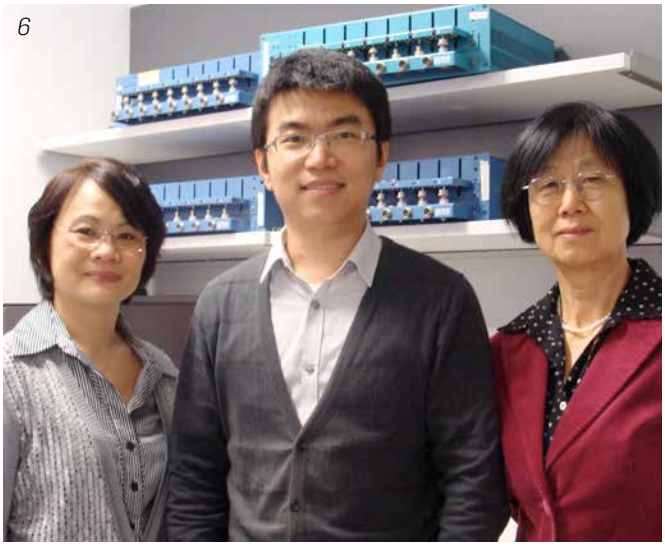
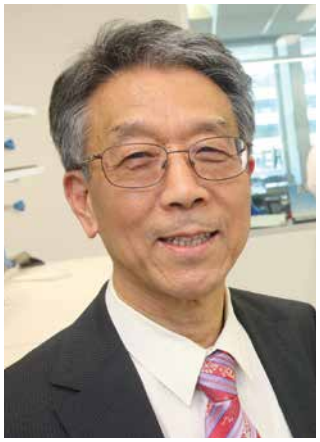


DIRECTORS REPORT



The Institute for Superconducting and Electronic Materials (ISEM) has seen another invigorating year in its history. In 2011 ISEM has grown bigger and stronger, with another significant expansion of laboratory space, new fascinating facilities, and new major research projects.

During the last year we finalised the construction and establishment of the new Australian Institute for Innovative Materials – Processing & Devices (AIIM P&D) facility. This $43.8 million Australian Government investment will open up pathways for the commercialisation and industrialisation of high quality research performed at both Institute for Superconducting and Electronic Materials and Intelligent Polymer Research Institute. Both research units are Flagship Research Strengths of the University of Wollongong, which will certainly bring many important advancements in the fields of superconductivity, energy materials, thin film technology, bionics, and chemistry.

Nearly $5 million has been invested in the purchase and installation of new facilities ranging from high end superconductor wire processing facilities, to large scale battery characterisation facilities, which have enormous potential to become one and only place to perform full range large battery performance analysis. Researchers at ISEM have been working tirelessly to establish this facility as National Centre for Battery Testing.

In addition, AIIM P&D will host a newly established clean room. This state-of-the-art laboratory will lead the way in the technological advances of thin film research, with the capability to generate even better outcomes in a variety of research fields.

ISEM has maintained its high level of productivity in terms of publications and postgraduate student enrolments. We had a stellar year in PhD completions, with a record 17 PhD graduates, who were successful in getting post-doctoral appointments in many leading laboratories around the globe. We are very proud of our graduates and I am confident that in the future many of them will initiate further collaborations with ISEM.

In terms of research funding, ISEM performed very well in the latest ARC competitive funding round, including one ARC DP project, three ARC LP grants, one Future Fellowship, one Discovery Early Career Researcher Award and one LIEF grant. In addition, the establishment of The Bao Steel Australia Joint Centre (BAJC) at four universities is a significant achievement. Bao Steel will invest $25m over five years to support research in advanced materials, energy and environment at four universities. A project on thermoelectric materials for waste heat recovery was awarded to ISEM researchers. With a part of this cash contribution an ARC LP was successful in the second round ARC funding scheme.

The most important news came from the Cooperative Research Centre (CRC) funding scheme. ISEM, as program leader for electrification, was successful in Auto CRC bid. This was the first grant of its kind in the history of ISEM, and I am extremely happy to be a part of such monumental success. The $26 million funding available through the CRC will open up new pathways in the research and development of alternative energy solutions for automotive industry. A very close proximity to industrial applications and needs will ensure that the newly established AIIM P&D facility will be used for the commercialisation and industrialisation of advanced applied research.

Our research findings are diverse and abundant. In superconductivity, for the new Fe based superconductor we found that inhomogineity in K distribution in K doped BaF_2Ac_2 resulted in the co-existance of superconductivity and antiferromagnetism at lattice scale (Phys Rev Lett 106, 247002 (2011)). Using nano-carbon coated boron and large magnesium articles as precursor materials we have achieved record high critical current density of MgB_2 wires (Adv Mater 23, 4942 (2011)). Malic acid doping into MgB_2 not only showed significant enhancement in critical current density, upper critical field but also improved the density by reducing porosity. It is also quite striking that carbon was not detected in the interior of grain and high density of stacking faults were obsrerved. Graphene doping is unique among 100 dopants that not only improve the high field critical current density but also improves the grain connectivity thanks to extremely thin layer and high electrical conductivity. A new critical current density (J_c) model for high-quality YBCO ($YBa_2Cu_3O_7$) thin films has been proposed, combining thermally activated flux creep with a vortex pinning potential for columnar defects. The model yields an adequate description of the J_c behaviour over the whole applied field range. We have also developed an innovative calorimetric AC loss measurement technique. This technique provides great simplification compared to pick-up coil and lock-in amplifier methods and is applied to a lower temperature range.

We made some significant breakthroughs in the development of advanced renewable energy materials. We reported Al-containing ZnO nanocomposites with up to a factor of 20 lower kappa(L) than non-nanostructured ZnO, while retaining bulklike alpha and sigma. We showed that enhanced phonon scattering promoted by Al-induced grain refinement and $ZnAl_2O_4$ nanoprecipitates presages ultralow kappa similar to 2 $Wm^{-1}K^{-1}$ at 1000 K (Nano Lett 11, 4337 (2011)). We also evaluated the potential of hematite as material for lithium ion storage. The electrochemical tests showed that the HHNS/CNT composite is a promising lithium storage material in terms of high capacity (similar to 700 $mAhg^{-1}$), good high-rate capability, and good

cycle life (up to 150 cycles). The materials improve both lithium ion and electron transport, which are limiting factors on the high-rate capability of lithium-ion batteries.

In electronic materials, we investigated domain wall dynamics in multifferoic $YMnO_3$ single crystals. Domain walls exhibit significantly enhanced conductance after being poled in electric fields, possibly induced by oxygen vacancy ordering at domain walls. The electronic conduction can be understood by the Schottky emission and Fowler-Nordheim tunnelling mechanisms. Our results show that the domain wall conductance can be modulated through band structure engineering by manipulating ordered oxygen vacancies in the poling fields. In the field of solar cell research, we reported a completely novel approach-three-dimensional (3D) TiO_2 nanostructures with favorable dendritic architectures through a simple hydrothermal synthesis (J Am Chem Soc 133, 19314 (2011)).

The size of the 3D TiO_2 dendrites and the morphology of the constituent nano-units, in the form of nanorods, nanoribbons, and nanowires, are controlled by adjusting the precursor hydrolysis rate and the surfactant aggregation. These novel configurations of TiO_2 nanostructures possess higher surface area and superior electrochemical properties compared to nanoparticles with smooth surfaces. Our findings provide an effective solution for the synthesis of complex TiO_2 nano-architectures, which can pave the way to further improve the energy storage and energy conversion efficiency of TiO_2-based devices.

Last but not the least, in terahertz and solid state physics we have expanded our research in optical rectification of zincblende in quasireflection geomtery. While this geometry introduces a p-polarized signal component due to mechanisms other than optical rectification, such as photocarrier acceleration by the surface depletion field, the azimuthal angle dependence of the optical rectification component yields further insight into the crystallographic orientation and surface properties of the sample.

As usual, we have hosted large number of seminars that were given by distinguished researchers and academics from national and international laboratories, universities, and companies. Many of our visitors, such as Prof. Q. L Wang (IEE, China), Dr. N. Zaluzec (Argonne National Labs, USA), A/Prof. C. Ulrich (UNSW, Australia) delivered exceptional talks ranging from application of superconductors in transportation to fundamental aspects of optical and electron microscopy for advanced function materials research. ISEM will continue to organise more seminars in years to come as this provides outstanding postgraduate student training – one of the strategic goals of ISEM.

It is important as well to recognise the efforts of our best postgraduate students, who have received annual nominations for ISEM Excellence, Merit and Best Paper awards. The hard work and dedication to the subject sets an outstanding example for other PhD students, to strive for excellence in every step of their PhD career at the University of Wollongong. I believe that maintaining high PhD training standards will only benefit ISEM, as high class specialists will be trained providing strong platform for the expansion of research at ISEM.

I see a very bright future for ISEM in the years to come, and I hope that this annual report will be a testament for this statement.

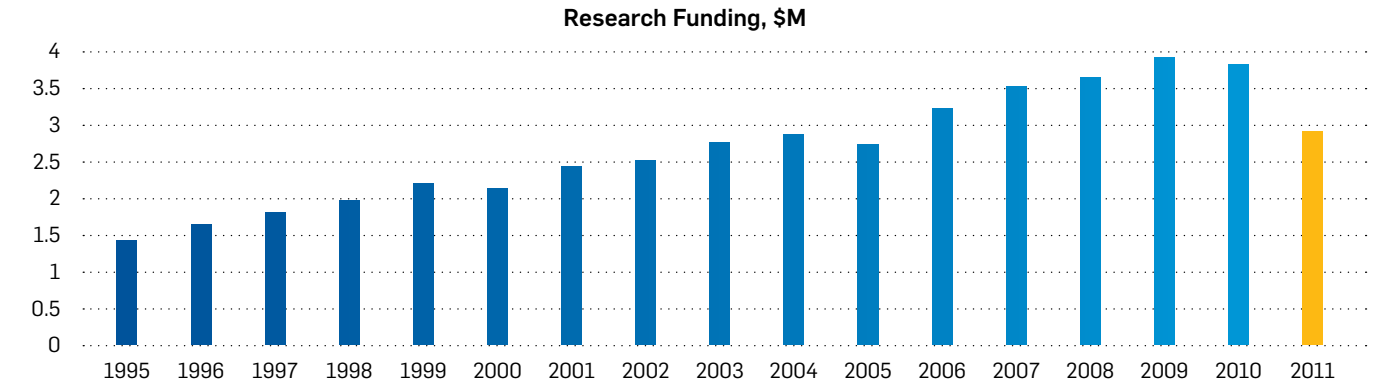
Sincerely yours,

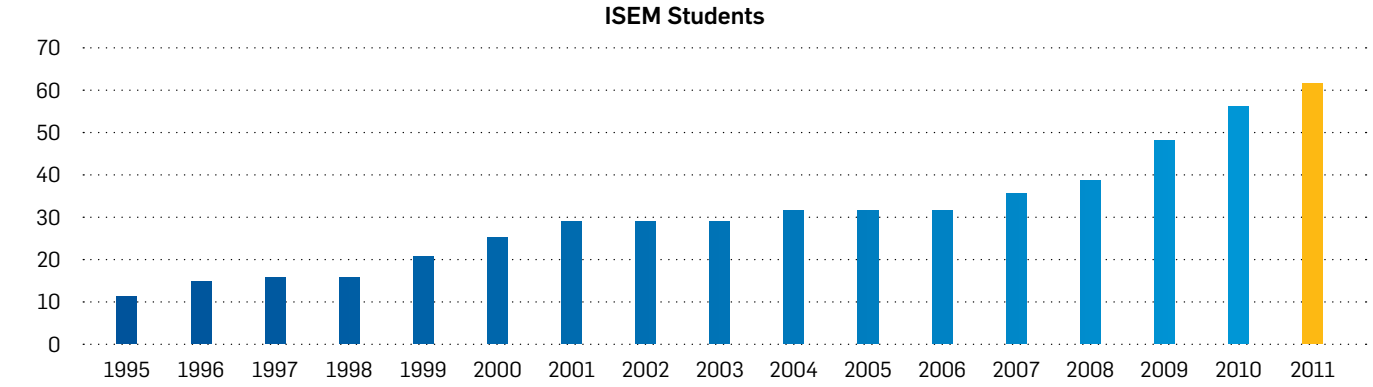
PROF. SHI XUE DOU

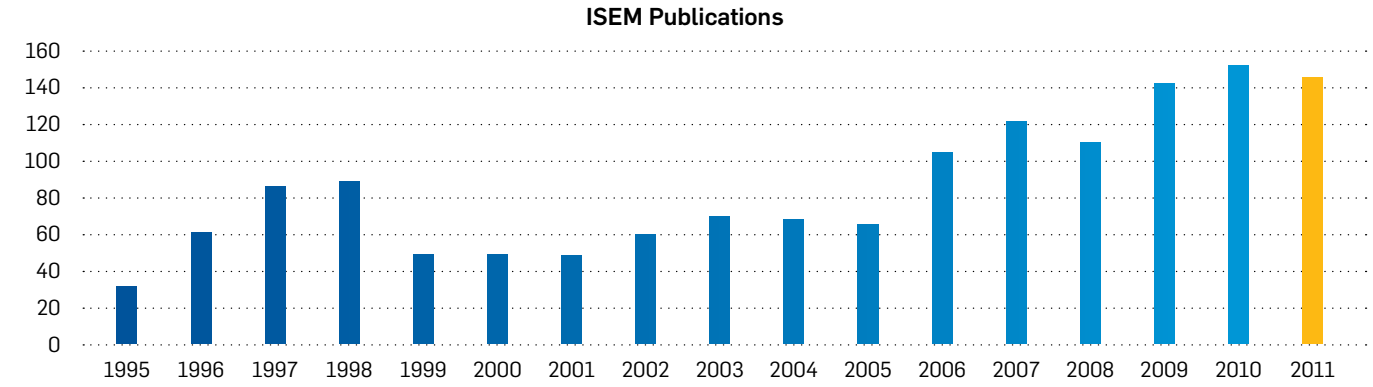
DIRECTOR, INSTITUTE FOR SUPERCONDUCTING AND ELECTRONIC MATERIALS

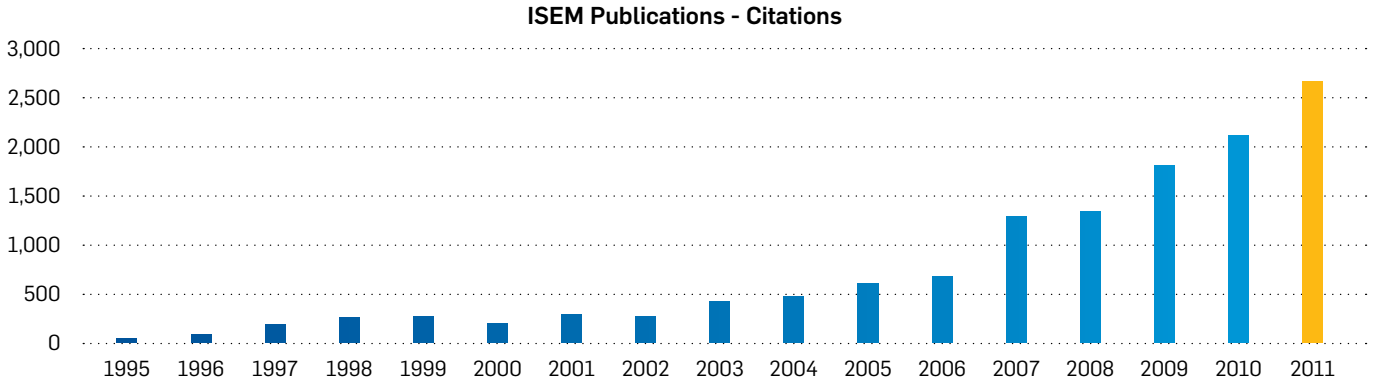
Prof. Shi Xue Dou and Prime Minister Julia Gillard, during the Prime Minister's visit to the Australian Institute for Innovative Materials.

ISEM AT A GLANCE









MANAGEMENT

MANAGEMENT COMMITTEE

Chairperson:	Prof. Judy Raper	Deputy Vice Chancellor (Research), University of Wollongong
	Prof. Shi Xue Dou	Director, ISEM
	Prof. Chris Cook	Dean, Faculty of Engineering, University of Wollongong
	Prof. Chao Zhang	Associate Director, ISEM
	Prof. Hua Kun Liu	Research Co-Coordinator, ISEM
	Dr. Germanas Peleckis	Assistant Director, ISEM

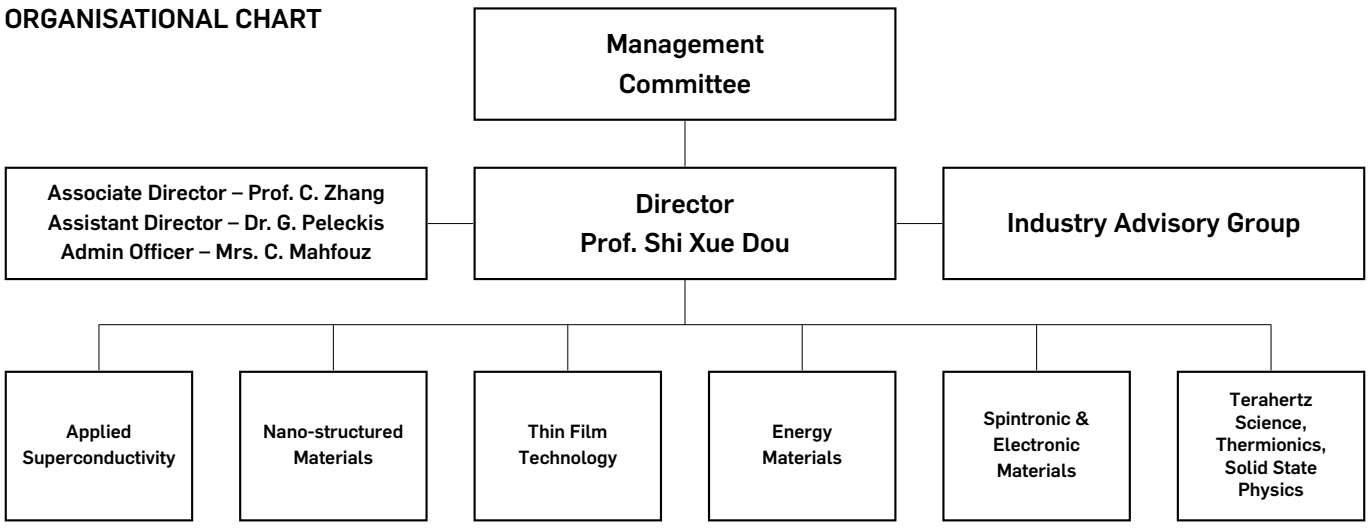
INDUSTRY ADVISORY GROUP

Dr. F. Darmann	Managing Director, Zenergy Power Ltd.
Mr. J. F. Wu	Marketing Manager, DLG Battery Co Ltd, Shenzhen, P. R. China
Mr. M. Tomsic	Managing Director, Hyper Tech Research Ltd, Ohio, USA,
Dr. X. F. Gao	General Manager, Lexel Batteries Co. Ltd, Shenzhen, P. R. China
Dr. S. Cooper	Chief Technological Officer, Mesaplexx Ltd, Brisbane, QLD, Australia
Mr. A. Kittel	Managing Director, Redarc Electronics, Adelaide, SA, Australia
Mr. R. Blade	Chief Executive Officer, Australian Electric Vehicle Co, VIC, Australia
Mr. J. Brown	Managing Director, ChargePoint Australia, NSW, Australia
Dr. Y. Sharma	Chief Technological Officer, Galaxy Resources Ltd
Mr. J. Y. Xu	Chief Executive Officer, Ningbo Jain Sen Mechanism Ltd
Mr C. Fu	Chief Executive Officer, Zhuo Yi Technology Ltd, Yingko, China

ADVISORY COMMITTEE

Prof L. Jiang	Professor and Fellow of Academy of Science Institute of Chemistry, CAS
Prof. R. Taylor	Adjunct Professor, Queensland University of Technology, Australia
Dr. O. Mukhanov	Chief Technological Officer, Hypres Ltd, USA
Prof. P. Robinson	Chair, Cast CRC Ltd

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)

ASSISTANT DIRECTOR

Dr. Germanas Peleckis (BCh, MSc, PhD)

SENIOR PROGRAM COORDINATORS

A/Prof. Josip Horvat (BSc, PhD, FAIP)

Dr. Kosta Konstantinov (BSc, MSc, PhD)

Prof. Hua Kun Liu (Dipl. for PGS, APF)

A/Prof. Alexey Pan (MSc, PhD, ARC ARF)

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, ARC Australian Professorial Fellow)

Prof. Xiaolin Wang (BSc, MSc, PhD, ARC QE-II Fellow)

A/Prof. Alexey Pan (BSC, MSc, PhD, ARC Australian Research Fellow)

A/Prof. Zaiping Guo (BSc, MSc, PhD, ARC QE-II Fellow)

Dr. Jung Ho Kim (BSc, MSc, PhD, ARC Future Fellow)

Dr. Dapeng Chen (BSc, MSc, PhD, ARC Postdoctoral Fellow)

Dr. Germanas Peleckis (BCh, MSc, PhD, ARC Postdoctoral Fellow)

A/Prof. Zhenxiang Cheng (BSc, MSc, PhD, ARC Future Fellow)

Dr. Xun Xu (BSc, MSc, PhD, ARC Postdoctoral Fellow (Industry))

Dr. Ziqi Sun (BSc, MSc, PhD, ARC Postdoctoral Fellow)

Prof. T. Johansen (ARC International Fellow)

Prof. G. Hong (ARC International Fellow)

RESEARCH STAFF

Dr. Tania Silver (BSc, PhD)

Dr. Rong Zeng (BSc, MSc, PhD)

Dr. Olga Shcherbakova (PhD)

Dr. Dongqi Shi (BSC, MSc, PhD)

Dr. Ivan Nevirkovets (NCRIS Fellow)

RESEARCH STAFF *(continued)*

Dr. Jiazhao Wang (BSc, MSc, PhD)

Dr. Sima Aminorroaya

Dr. Yun Zhang

Dr. Sihai Zhou (BSc, MSc, PhD)

Dr. Cao Wang

Dr. Shi Zhong

Dr. Md Shahriar Hossain

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)

SENIOR LECTURER

Dr. Yue Zhao (MSc, PhD)

VISITING STAFF

Dr. Weichang Hao

Dr. Yan Zhou

Dr. Mingang Zhang

Dr. Qinghua Chen

Dr. Zuyong Feng

Dr. Chongjun Zhao

Dr. Wei Du

Dr. Jian Yang

ADMINISTRATION OFFICER

Mrs. Crystal Longin Mahfouz

HONORARY FELLOWS

Dr. Scott Needham (Intven Ltd)

Prof. Edward Collings (Ohio State University)

Prof. Shane Kennedy (ANSTO)

Prof. Tom Johansen (Oslo University)

Dr. Brad Winton (Australian Public Service)

Prof. G. X. Wang (University of Technology, Sydney)

2011 was another successful year for the ISEM team.

POSTGRADUATE STUDENTS

CURRENT

PhD	Thesis Title	Supervisors
Mr. Seyed Hamed Aboutalebi	Nanoceramics for supercapacitor applications	Dr. Kosta Konstantinov
Mr. Yee Sin Ang	Many-body effect in massless Dirac fermions	Prof. Chao Zhang
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, Dr. Jung Ho Kim
Mr. Colin Bleasdale	Electromagnetic properties of superconducting films and multilayers	Prof. Roger Lewis, Prof. Chao Zhang
Mr. Qinjun Chen	Electrical and optical properties of functional thermoelectrical materials	Prof. Xiaolin Wang, Prof. Chao Zhang, Prof. Roger Lewis
Mr. Evan Constable	Strong magnetic fields in the terahertz regime	Prof. Roger Lewis, A/Prof. Josip Horvat
Mr. David Cortie	Electron spin in magnetic systems	Prof. Xiaolin Wang
Mr. Alfred Chidembo	Advanced nanoceramics and composites for supercapacitors	Dr. Kosta Konstantinov, Prof. Hua Kun Liu
Mr. Krunal Radhanpura	Semicondurctor materials and structures for the efficient generation of terahertz radiation	Prof. Roger Lewis, A/Prof. Rodney Vickers
Mrs. Kaludewa Sujeewa De Silva	Improving superconducting properties of MgB_2 by chemical doping using graphene as C source	Prof. Shi Xue Dou, Dr. Xun Xu, Prof. Xiaolin 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	A/Prof. Zaiping Guo, Prof. Hua Kun Liu
Mr. Muhamad Faiz	Nanomaterials for biosensor.	Prof. Shi Xue Dou, Dr. Jianli Wang
Mr. Sergey Fedoseev	Investigation of superconducting thin films and multilayered structures for electronic applications	A/Prof. Alexey Pan, Prof. Shi Xue Dou
Ms. Liya Feng	Spintronics	Prof. Xiaolin Wang, Dr. Zhenxiang Cheng
Ms. Abby Scott	Terahertz Imaging	Prof. Roger Lewis, A/Prof. Josip Horvat
Ms. Xuanwen Gao	Development of inorganic-conducting polymer composites and ionic liquid-based electrolytes for rechargeable lithium batteries	Dr. Jiazhao Wang, Prof. Hua Kun Liu
Mr. Igor Golovchanskiy	REBCO superconducting thin films and multilayers for electronic applications	A/Prof. Alexey Pan, Prof. Shi Xue Dou
Ms. Lucia Leposide	Terahertz spectroscopy of electronic materials	Prof. Roger Lewis, A/Prof. Josip Horvat
Mr. Fang Hong	Spin manipulation by electrical field	Prof. Xiaolin Wang, Dr. Zhenxiang Cheng
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
Mr. Abolfazl Jalalian	Lead free Piezoelectric materials	Prof. Shi Xue Dou, Prof. Xiaolin Wang
Ms. Priyanka Jood	Oxide thermoelectric materials for high temperature power generation	Dr. Germanas Peleckis, Prof. Xiaolin Wang
Mr. Tomas Katkus	Thermoelectric modules for high temperature power generation	Dr. Germanas Peleckis, Prof. Xiaolin Wang
Mr. Julian Steele	Optical characterization of semiconductors	Prof. Roger Lewis, A/Prof. Josip Horvat
Mr. Jae Geun Kim	Research on superconductor thin films	Prof. Shi Xue Dou, Dr. Dongqi Shi, Dr. Jung Ho Kim
Mr. Philip Lavers	Electronic structure of perovskite and related materials	Prof. Shi Xue Dou
Mrs. Lin Lu	Electrolytes for rechargeable batteries	Dr. Jia Zhao Wang, Prof. Hua Kun Liu
Ms. Elise Pogson	The medical applications of terahertz	Prof. Roger Lewis, Dr. Peter Metcalfe

PhD	Thesis Title	Supervisors
Ms. Sha Li	Bio-compatible materials for batteries	Prof. Hua Kun Liu, A/Prof. Zaiping Guo, Prof. Gordon Wallace,
Mr. Qi Li	Research on superconducting films and buffer layers for electronic applications	Prof. Shi Xue Dou, Dr. Dongqi Shi
Ms. Li Li	Enhancement of electrochemical properties of cathdode materials for Li-ion batteries	A/Prof. Zaiping Guo, Prof. Hua Kun Liu
Ms. Dan Li	Three-dimensional porous electrode materials for lithium ion batteries	A/Prof. Zaiping Guo, Prof. Hua Kun Liu
Ms. JianJian Lin	Nanomaterials for catalyst	Dr. Jung Ho Kim, Dr. Zi Qi Sun, Prof. Shi Xue Dou
Mr. Victor Malgras	Nanostructured TiO_2 for DSSC	Dr. Jung Ho Kim, Prof. Shi Xue Dou
Mr. Nandhagopal Masilamani	Josephson junctions and other electronic devices based on graphene	A/Prof. Alexey Pan, Prof Shi Xue Dou
Mr. Jianfeng Mao	Study on hydrogen storage behaviour of $LiBH_4$	A/Prof. Zaiping Guo, Prof. Hua Kun Liu
Mr. Qing Meng	Development of battery management system for Li-ion batteries	A/Prof. Zaiping Guo, Dr. Hongtao Zhu
Mr. Ashkan Motaman	Current limiting mechanism in MgB_2	Dr. Jung Ho Kim, Prof. Shi Xue Dou, Dr. Shahriar Hossain
Mr. Mislav Mustapic	Enhancement of MgB_2 superconductor by magnetic nanoparticle doping	A/Prof. Josip Horvat, Prof. Shi Xue Dou
Mr. Lukman Noerochim	Improving the capacity and safety of lithium ion battery	Prof. Hua Kun Liu, Dr. Jia Zhao Wang
Ms. Maryam Salari	Application of nanostructural titania in supercapacitors	Prof. Hua Kun Liu, Dr. Kosta Konstantinov
Mr. Kuok Hau Seng	Advanced nanomaterials for lithium ion batteries	A/Prof. Zaiping Guo
Ms. Mahboobeh Shahbazi	Study of iron pnictides superconductors	Prof. Xiaolin Wang, Prof. Shi Xue Dou
Mr. Jonathan Knot	Electromagnetic design of MgB_2 coil for fault current limiter	Prof. Shi Xue Dou, Dr. Jeff Moscrop, A/Prof. Josip Horvat
Ms. Precious Shamba	Novel magnetocaloric materials for room temperature magnetic refrigeration	Dr. Jianli Wang, Prof. Shi Xue Dou
Mr. Babar Shabir	Design of new superconductors	Prof. Xiaolin Wang, Prof. Shi Xue Dou
Mr. Rhys Hargreaves	Ultrafast change of magnetization as terahertz source	A/Prof. Josip Horvat, Prof. Roger Lewis
Ms. Yi Shi	Graphene composite materials for lithium ion batteries	Dr. Jia Zhao Wang, Prof. Hua Kun Liu, Dr. Huijun Li
Ms. Asyd Tawfiq	Dielectric response of graphene under electromagnetic radiation.	Dr. Jia Zhao Wang, Prof. Chao Zhang
Ms. Yunxiao Wang	Nanomaterials for LIBs	Prof. Shi Xue Dou, Prof. Hua Kun Liu
Mr. Jiantie Xu	Nanomaterials For lithium ion battery	Prof. Shi Xue Dou, Prof. Hua Kun Liu, Dr. Shulei Chou
Mr. Feixiang Xiang	Energy materials	Prof. Xiaolin Wang, Prof. Shi Xue Dou
Mr. Zengji Yue	Transport properties of topological insulators Sb_2Te_3 and Bi_2Te_3 crystals and films	Prof. Xiaolin Wang, Prof. Shi Xue Dou
Mr. Zidong Zhang	Metal-ceramic composites	Prof. Xiaolin Wang
Mr. Zhijia Zhang	Development of advanced materials for rechargable lithium batteries	Dr. Shulei Chou, Dr. Jiazhao Wang, Dr. Huijun Li
Mr. Eoin Hodge	Design, build and test of FCL using MgB_2 coils	Dr. Jeff Moscrop, Prof. Shi Xue Dou, Dr. Frank Darmann
Mr. Chaofeng Zhang	Three-dimensional nano-materials for lithium-ion batteries	A/Prof. Zaiping Guo
Mr. Chengbo Zhu	Spin wave and spin density wave in magnetic materials	Prof. Xiaolin Wang, Prof. Shi Xue Dou
Mr. Chao Zhong	Graphene materials for Li-ion batteries	Prof. Hua Kun Liu, Dr. Jiazhao Wang
Mr. David Sheppard	Fe based superconductors	Prof. Xiaolin Wang, Prof. Shi Xue Dou

MASTERS

Masters	Thesis Title	Supervisors
Ms. Azrin Chowdhury	Synthesis of nanoceramics for supercapacitors	Dr. David Wexler, Dr. Kosta Konstantinov
Mr. Rhys Hargreaves	Ultrafast change of magnetization as Terahertz source	Prof. Roger Lewis, A/Prof. Josip Horvat
Mrs. Irin Sultana	Biodegradable materials for bio-battery	Prof. Hua Kun Liu, Dr. Jiazhao Wang, Prof. Gordon Wallace,
Mr. Zhenwei Yu	Thermoelectric materials	Prof. Chao Zhang, Prof. Xiaolin Wang
Ms. Hanan Baiej	Superconducting thin films	A/Prof. Alexey Pan
Mr. Matthew Sale	Large throughput analysis of crystal structures for identification of promising Li-ion battery materials.	Dr. Jiazhao Wang, Dr. Shulei Chou, Dr. Maxim Avdeev
Mr. Mutthavarapu Rao	Condensed matter physics	Prof. Roger Lewis, A/Prof. Josip Horvat
Mr. Xuchuan Wang	Study of energy materials	Prof. Xiaolin Wang
Mr. Fei Yun	Energy materials	Prof. Xiaolin Wang

COMPLETIONS

PhD Graduates

PhD Name	Thesis Title	Awarded	Position	Appointed
Y. Du	Multiferroic transition metal oxides: structural, magnetic, ferroelectric, and thermal properties	2011	Associate Research Fellow, ISEM, University of Wollongong, Australia	2011
M. F. Hassan	Nanostructured materials for lithium ion batteries	2011	Lecturer, University Malaysia Teregganu	2011
S. Hargreaves	High efficiency terahertz emitters	2011	Research Fellow, Australian National University Canberra, Australia	2011
H. Liu	Design of nano-structured materials and their applications for lithium ion batteries	2011	University of Technology, Sydney VC Fellowship, Australia	2012
M. Minoru	Densification and connectivity in polycrystalline MgB_2 materials for improvement of critical current density	2011	Associate Professor, Nihon University, Japan	2011
C. K. Poh	Metallic nanostructures, ultrathin films and optical technologies for hydrogen storage and switchable mirrors	2011		
J. Park	Nanostructured semiconducting metal oxides for use in gas sensors	2011	Research Fellow, Gyeongsang National University, South Korea	
M. M. Rahman	Advanced materials for lithium-ion batteries	2011	Postdoctoral Fellow, Deakin University, Australia	2012
A. Shcherbakov	Magnesium diboride superconductor: thermal stabilization and doping	2011		
B. Winton	Low energy metal ion implantation of Poly-di-methylsiloxane (PDMS) for increased biocompatibility for use in tissue engineering applications	2011	Australian Public Services	2011
H. Wu	New catalyst materials for hydrogen fed fuel-cells and hydrogen storage on double walled carbon nanotubes	2011	Senior Lecturer at Hubei University	2011
L. Wang	Chemical solution deposition for YBCO superconducting films and Sm_2O_3 buffer layers on single crystal and biaxially textured metallic substrates	2011	Senior Engineer at Siemens in Shanghai	2012
P. Zhang	Synthesis and characterization of nanostructured electrodes for lithium-ion batteries	2011	Research fellow at Griffith University	2012
S. L. Chou	Nanostructured / composite materials for rechargeable Li-ion battery and supercapacitor	2010	ARC Postdoctoral Fellow, ISEM, University of Wollongong	2010
W. X. Li	Carbohydrate doping effect on the superconductivities and microstructure of MgB_2 superconductor	2010	VC Fellow, ISEM, University of Wollongong	2010
S. Pysarenko	HTS multi-layers thin films fabrication	2010		
R. Nigam	Study of magnetic behaviour of Ru-based superconducting ferromagnets	2010	Research Associate, ISEM, University of Wollongong	2010
A. Ranjbar	Effect of catalysts on hydrogen storage properties of MgH_2	2010	Research Associate, ISEM, University of Wollongong	2010
Q. Yao	Study of newly discovered two dimensional cobalt based perovskite compounds doped with various rare earth elements	2009	Research Associate, ISEM, University of Wollongong	2009
Y. Zhang	Improvement of critical current density in MgB_2 by optimizing process parameters and chemical doping	2009	Research Associate, ISEM, University of Wollongong	2009
X. Xu	Effect of starting boron powder on the superconducting properties of MgB_2	2009	ARC APDI Fellow, ISEM, University of Wollongong	2010
S. Y. Chew	Advanced materials for electrodes and electrolyte in rechargeable lithium ion batteries	2009		

PhD Name	Thesis Title	Awarded	Position	Appointed
D. P. Chen	Crystal growth, magnetism, transport and superconductivity of two dimensional sodium cobalt oxide single crystals	2009	ARC APD Fellow, ISEM, University of Wollongong	2009
M. M. Farhoudi	Studies of structures, transport and magnetic properties of doped novel three dimensional perovskite compounds	2009	Research staff at Iranian Institute of Sci & Tech 2010	
Y. P. Yao	A study of electro materials for lithium-ion batteries	2008	Part Time Associate Fellow, UTS	2010
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	Research 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 Centre, Samsung Advanced Institute of Technology, South Korea	2008
M. 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	Post doctorate Fellow, Electrochemistry Laboratory, Paul Scherrer Institute, Switzerland Technical Customer Support Manager, Asia Pacific, Changzhou Timcal Graphite Corp. Ltd, Shanghai, China	2008 2009
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 UOW VC Fellow, University of Wollongong ARC DECRA Fellowship, University of Wollongong	2008 2011 2012
S. A. Needham	Development of advanced electrode materials for lithium-ion batteries	2007	Commercialization Manager, University of Wollongong Commercialization Manager, Intven Ltd.	2007 2009
G. Peleckis	Studies on diluted oxide magnetic semiconductors for spin electronic applications	2007	Research Fellow, ISEM, University of Wollongong ARC APD Fellow, ISEM, University of Wollongong	2007 2010
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 in Shenzhen	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

PhD Name	Thesis Title	Awarded	Position	Appointed
S. Keshavarzi	Investigation of vortex dynamics of (Tl,Pb)(Sr,Ba)$_2$Ca$_2$Cu$_3$O$_y$ 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
M. Lindsay	Data analysis and anode materials for lithium ion batteries	2004	Postdoctoral Research Fellow, University of New South Wales Research Staff, ANSTO	2004 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 Lecturer, University of Wollongong	2003 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 Research Fellow, ISEM, University of Wollongong APD Fellow, ISEM, University of Wollongong	2002 2004 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 APD Fellow, ISEM, University of Wollongong Research Fellow, ISEM	2003 2004 2007
R. Baker	Zeeman and piezo-spectroscopy of antimony and aluminium in germanium	2001	Professional Officer, University of Wollongong	2003
X. K. Fu	Fabrication and characterization of Bi-2223 current lead	2002	Research Fellow, Texas A&M University, USA Research Fellow, University of Waterloo, Canada	2002 2005
K. Uprety	Magnetic hysteresis and relaxation in Bi2212 single crystals doped with iron and lead	2002	Research Fellow, Argonne National Lab, USA	2002
F. Darmann	AC Loss in high temperature superconductor	2001	Chief Engineer, Zenergy Power Ltd.	2004
G. X. Wang	Investigation on electrode materials for lithium-ion batteries	2001	APD Fellow, ISEM, University of Wollongong ARC QEII Fellow, ISEM, University of Wollongong Associate Professor, ISEM, University of Wollongong	2001 2006
J. P. Chelliah	Optical spectroscopy of semiconductors	2000		
L. Sun	Amorphous and nanocrystalline hydrogen storage alloy materials for nickel-metal hydride batteries	2000	Senior Research Engineer, Saint-Gobain Northborough Research and Development Center, USA	2012

PhD Name	Thesis Title	Awarded	Position	Appointed
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 ARC APD Fellow, ISEM, University of Wollongong ARC QEII Fellow, ISEM, University of Wollongong Associate Professor Professor	2000 2002 2005 2006 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 Professor, Nankai University, China	1999 2003
T. Silver	Near band-edge optical properties of MBE GaAs and related layered structures	1999	Research Fellow, ISEM, University of Wollongong	2000
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 Electrochemist, Energizer Co, USA	1997 2000
R. J. Heron	Far-infrared studies of semiconductors in large magnetic fields	1998	Postdoctoral Fellow, SUNY, Buffalo, USA Research Fellow, Janis Research Company Inc., USA	1997 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 Senior Research Scientist, ANSTO	1997 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 ARC, APD Fellow, ISEM, University of Wollongong Professor, University of Electronic Engineering	1997 2000 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 Teacher Associate Professor	1998 1999 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 Associate Director, Ningbo Materials Institute, Chinese Academy	1997 2007
B. Zeimetz	High temperature superconducting tapes & current leads	1998	Research Fellow, Cambridge Univ., U.K.	1999
S. Zhong	Investigation on lead-calcium-tin-aluminium grid alloys for valve-regulated lead-acid batteries	1998	ARC Postdoctoral Fellow, ISEM, University of Wollongong CEO, Leadcel Dynamic Energy Ltd, P.R. China CEO, Guangzhou Delong Energy Tech Ltd.	1997 2002 2003
B. L. Luan	Investigations on Ti_2Ni hydrogen storage alloy electrode for Rechargeable nickel-metal hydride batteries	1997	Senior Research Officer, The National Research Council Canada Professor, Chemistry Department, University of Western Ontario	1997
N. Vo	Design and characterization of HTS coils	1997	Research Fellow, Los Alamos Nat. Lab, USA Research Staff, Intermagnetics General Co., USA	1999 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

PhD Name	Thesis Title	Awarded	Position	Appointed
M. Yavus	Powder processing of Bi-Pb-Sr-Ca-Cu-O superconducting materials	1997	Ass. Professor, Texas A&M University, Texas USA Ass. Research Professor, Tohoku University, Sendai, Japan Ass. Professor, University of Waterloo, Canada	2000 1997 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 Research Scientist, Argonne National Lab., USA Senior Engineer, Lucent, USA	1997 1999 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
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 ARC Postdoctoral Fellow, ISEM, University of Wollongong Senior IT Specialist, ITS, University of Wollongong	1997 1998 2002
A. Bourdillion	Microstructure, phase characterization and texture processing of HTS	1992	Senior Engineer, Hewlett Packard, Singapore Hewlett Packard, USA	1993 2000
M. Apperley	The fabrication of high T_c superconductor wire	1992	Chief Technologist, Australian Superconductors Business Development Manager, University of Sydney	1993 2004

Mahboobeh Shahbazi-Manshadi, Prof. Xiaolin Wang and Andrey Shcherbakov.

Irin Sultana, Prof. Hua Kun Liu, Md. Mokhlesur Rahman and Prof. Shi Xue Dou.

MASTERS COURSE GRADUATES

Masters Name	Thesis Title	Awarded	Position	Appointed
M. Shahbazi-Manshadi	Study of Superconducting and Magneto Transport Properties of $REFeAsO_{1-x}F_x$ (RE=La and Ce)	2011	PhD Candidate, ISEM	2011
C. Zhong	Development of New Electrode Materials for Lithium Ion Batteries	2010	PhD Candidate, ISEM	2011
L. Lu	Enhancement of connectivity and flux pinning in MgB_2 superconducting bulk and wires	2009	PhD Candidate, ISEM	2009
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		
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 Research Fellow, Argonne National Lab., USA	2000 2003
J. Z. Wang	Investigations on anode materials for rechargeable lithium-ion batteries	1999	PhD Candidate, ISEM, University of Wollongong Research Fellow, ISEM, University of Wollongong	2000 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 ARC, PDF, ISEM, University of Wollongong	1997 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
University of Western Australia
University of Western Sydney
Swinburne University of Technology

INTERNATIONAL

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

Canada
École Polytechnique de Montreal
University of Alberta

Croatia
University of Zagreb

Germany
Max-Planck-Institut fur 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 Auckland
Industrial Research Lab

Peoples Republic of China
Beijing University of Science and Technology
Harbin University
Hubei University
Institute for Microsystems and Information Technology
Institute of Electrical Technology
Institute of Non-ferrous Metals
Nankai University
Nanjing University
Northeastern University
Shanghai Jiao Tong University
Shanghai University
Tianjin University

Russia
Institute of General Physics

Singapore
National University
Nanyang University of Technology

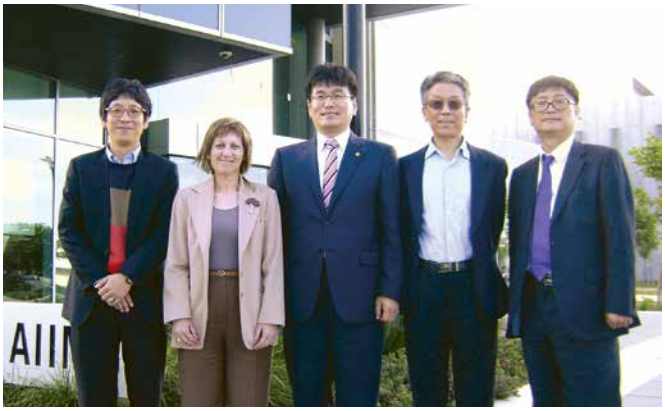
South Korea
Andong National University
Korea Advanced Institute of Science & Technology
Korea Aerospace Research Institute (KARI)
Korea Institute of Materials Science (KIMS)
Korea Electrotechnology Research Institute (KERI)
Sangji University

Switzerland
University of Geneva
Paul Scherrer Institute

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 Laboratory
Houston University
Los Alamos Laboratory
National Institute of Standard Technology
New York Polytechnic University
Ohio State University
University of Wisconsin
Rensselaer Polytechnic Institute



Collaborators from ISEM and Sangji University.

PROGRESS REPORTS FOR ARC PROJECTS

ARC CENTRE OF EXCELLENCE

PROJECT ID: CE0561616

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

Chief Investigator: H.K. Liu

Associate investigators: J. Wang, Z.P. Guo, K. Konstantinov, G.X. Wang

PhD students: M. Rahman, N. Idris, L. Noerchim, S. Li, I. Saultana

Porous conductive architecture a-$LiFeO_2$–C composite: A novel nanocrystalline porous a-$LiFeO_2$–C composite with a high surface area of around 115 m^2/g was synthesized by a simple molten salt method, followed by a carbon coating process. Electrochemical measurements showed that the a-$LiFeO_2$–C nanocomposite delivered a significantly higher reversible capacity and excellent cycle stability (230 mAh/g at 0.5 C after 100 cycles). Even at the high rate of 3 C, the electrode showed more than 50% of the capacity at low rate (0.1 C). The excellent electrochemical performance of the a-$LiFeO_2$–C nanocomposite electrode can be attributed to the porous conductive architecture among the nanoparticles, which not only has benefits in terms of decreasing the absolute volume changes and increasing the mobility of lithium ions, but also offers conductive pathways along the whole interconnected wall in the structure, which is favourable for the transport of electrons, promotes liquid electrolyte diffusion into the bulk materials, and acts as a buffer zone to absorb the volume changes.

$Li_4Ti_5O_{12}$-TiO_2 nanocomposite anode material: The microstructure and morphology of the $Li_4Ti_5O_{12}$-TiO_2-C were characterized systematically. The $Li_4Ti_5O_{12}$-TiO_2-C nanocomposite electrode yielded good electrochemical performance in terms of high capacity (166 mAh/g at a current density of 0.5 C), good cycling stability, and excellent rate capability (110 mAh/g at a current density of 10 C up to 100 cycles). The likely contributing factors to the excellent electrochemical performance of the $Li_4Ti_5O_{12}$-TiO_2-C nanocomposite could be related to the improved morphology, including the presence of high grain boundary density among the nanoparticles, carbon layering on each nanocrystal, and grain boundary interface areas embedded in a carbon matrix, where electronic transport properties were tuned by interfacial design and by varying the spacing of interfaces down to the nanoscale regime, in which the grain boundary interface embedded carbon matrix can store electrolyte and allows more channels for the Li^+ ion insertion/extraction reaction. This research suggests that carbon-coated dual phase $Li_4Ti_5O_{12}$-TiO_2 nanocomposites could be suitable for use as a high rate performance anode material.

Publications:

1. N. Idris, M. Rahman, J. Wang, Z. Chen, H.K. Liu, "Synthesis and electrochemical performance of LiV3O8/carbon nanosheet composite as cathode material for lithium-ion batteries", *Composites Science and Technology*, 2011, 71 (3), 343-349.
2. N. Idris, J. Wang, S. Chou, C. Zhong, M. Rahman, H.K. Liu, "Effects of polypyrrole on the performance of nickel oxide anode materials for rechargeable lithium-ion batteries", *J. Mater. Res*., 2011, 26(7), 860-866
3. M. Rahman, J. Wang, M.F. Hassan, Z. Chen, H.K. Liu, "Synthesis of carbon coated nanocrystalline porous α-LiFeO2 composite and its application as anode for the lithium ion battery", *Journal of Alloys and Compounds*, 2011, 509, 5408–5413
4. *M. Rahman, J. Wang, Z. Chen, H.K. Liu*, "Nanocrystalline porous α-LiFeO2–C composite—an environmentally friendly cathode for the lithium-ion battery", *Energy & environmental science*, 2011, 4(3) 952
5. I. Kottegoda, N. Idris, L. Lin, J. Wang, H.K. Liu, "Synthesis and Characterization of Graphene-Nickel Oxide Nanostructures for Fast Charge-Discharge Application", *Electrochimica Acta*, 2011, 56 5815–5822
6. T. Tao, A.M. Glushenkov, C. Zhang, H. Zhang, D. Zhou, Z. Guo, H.K. Liu, Q. Chen, H. Hu, Y. Chen, "MoO3 particles dispersed uniformly in carbon matrix: a high capacity composite anode for Li-ion batteries", *J. Mater. Chem*., 2011, 21 9350
7. V. Aravindan, J. Gnanaraj, S. Madhavi, H.K. Liu, "Lithium-Ion Conducting Electrolyte Salts for Lithium Batteries", *Chem. Eur. J.* 2011, 17, 14326 – 14346

ARC SUPER SCIENCE FELLOWSHIP PROGRESS REPORT

PROJECT ID: FS100100023

Title: Three dimensional polymer structures for bionic applications.

Chief Investigators: G.G. Wallace, S.E. Moulton, R.M.I. Kapsa, D. L. Officer, H. K. Liu

SSF Dr Eoin Murray commenced November, 2010.

SSF Dr Johnson Chung commenced September 2011.
(Dr Javad Foroughi was in the position prior to Dr Chung).

1. The design and synthesis of novel biodegradable/bio-erodible organic conducting polymer (OCP) hybrid systems

This aspect of the project is concerned with the development

of biodegradable conducting materials to be processed as polymeric scaffolds for biomedical applications, as the growth of electro-responsive cells such as nerve and muscle cells can benefit from a conducting substrate. Highly conducting graphene nanosheets were combined using a number of novel synthetic routes to form both binary mixtures and covalently linked composites with a number of biopolymers, such as polylactic acid (PLA), chitosan, polycaprolactone (PCL) and various copolymers. The resulting graphene-biopolymer materials retained the biocompatibility, biodegradability and processability from the polymer but with conductivities and mechanical properties enhanced by orders of magnitude due to the graphene filler. The composites were processed using melt extrusion, wet spinning and dip/spray coating techniques and cell growth studies showed good adhesion and proliferation of electro-responsive cell lines to these scaffolds.

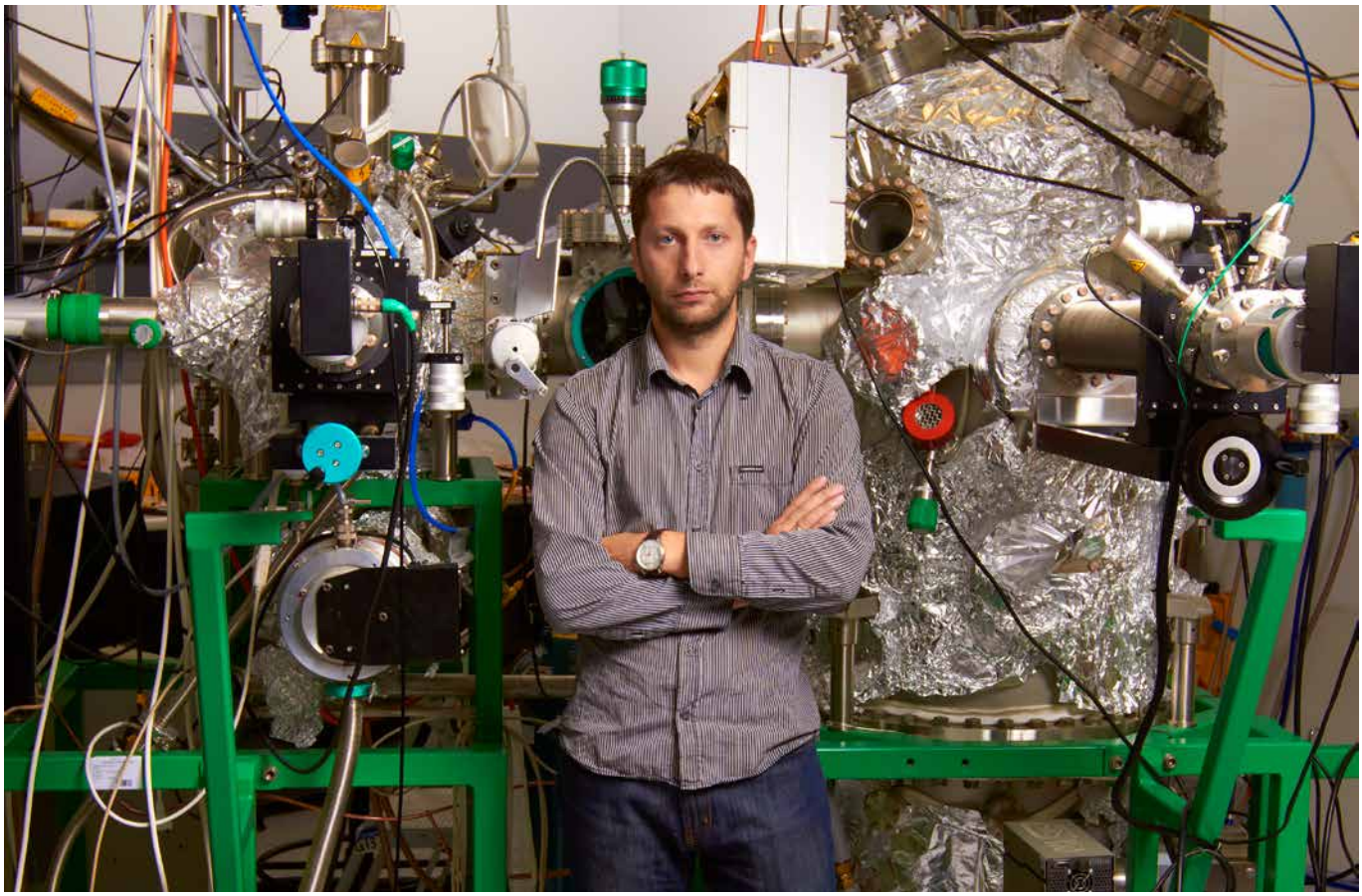
2. The development of protocols to create 3D structures for growth, proliferation and directed growth of cells.

In 2011 include the fabrication of chitosan scaffolds for the bone regeneration research being undertaken with St Vincent's Hospital Melbourne. Scaffolds were printed from a 3D extrusion printer and further studies were conducted to improve printing consistency. In addition, due to the rapid shrinkage of chitosan scaffolds immediately after printing, several post processing methods were assessed. Freezing scaffolds at -20˚C followed by drying them in petri dishes were found to be least damaging to the printed structure. Neutralisation through a series of ethanol concentrations from 100% (w/v) to 70% (w/v) was also found to most effective in removing acetate ions that would be detrimental to cells. These 3D scaffolds have been analysed in vitro at SVHM utilizing pluripotent stem cells. Most recently (November 2011) these scaffolds have been implanted into a rabbit model for osteochondral defect analysis.

Apart from viscous polymers, thermoplastic polymers such as polycaprolactone (PCL) have successfully been printed using 3D melt-extrusion printer equipped with a temperature control unit. PCL printing parameters such as: temperature, feed rate, tip size, dispensing pressure were tested and characterised by optical profilometry in order to build up a database of successful polymers that can be printing using this equipment.

3. The development of protocols to create 3D structures for energy storage (biobatteries) – that also possess controlled release capabilities.

Work addressing this objective will be undertaken once suitable materials have been developed in Sections 1 and 2 above.



DISCOVERY PROJECTS

PROJECT ID: DP0984200

Title: Better emitters, enhanced optics, superior detectors: advancing terahertz science and technology for applications in medicine, agriculture, industry and national security

Chief Investigators: R. A. Lewis, J. Horvat, W. Xu

Personnel W. Xu left the ANU to take up a Professorial appointment in China. Not eligible to be a CI, he has changed role to PI with ARC approval. In 2009 Elise Pogson began a PhD on the project, supported by the student stipend requested in the grant. Colin Bleasdale has also contributed to the research but is now on extended leave due to ongoing medical issues; he is a PhD student funded by an APA. Abby Scott commenced on the project in 2010 and Evan Constable in 2011, both as PhD students funded by APAs. Julian Steele worked on the project as an Honours student in 2011 and continues as a PhD student in 2012 UOW electrical (T. Braddock, D. Henness), electronic (P. Ihnat) and mechanical workshop (R. Marshall *et al.*) technical staff also contributed to the project.

Equipment The major equipment failure of the Coherent pump laser of the Terahertz (THz) time-domain spectroscopy (TDS) spectroscopy system has been resolved and the replacement Millennia pump laser has been working well. The time-delay stage failed and has now been repaired.

Progress Candidate THz materials, sourced from the University of Nottingham, UK, and the Technical University of Darmstadt, Germany, were studied. Much experimental data was collected, analysed and prepared for publication. Six journal papers were published in 2011 in high-impact journals, these are listed below. Numerous conference presentations were made, including at *AIP Condensed Matter Meeting, Wagga Wagga, Australia, February 2011; CLEO conference, Sydney, Australia, July 2011; PIERS Symposium, Suzhou, China, September 2011; 36th International Conference on Infra-red, Millimeter and Terahertz Waves, Houston, USA October 2011.*

Publications:

1. R. A. Lewis, "Let's talk terahertz!", *American Journal of Physics* 79, 341 (2011).
2. Cameron Lee and R. A. Lewis, "Optical rectification for terahertz generation", *Physica Status Solidi C* 8, 2761–2765 (2011).
3. K. Radhanpura, S. Hargreaves, R. A. Lewis, "Bulk and surface-field--induced optical rectification from (11N) zincblende crystals in a quasi-reflection geometry", *Physical Review B* 83, 125322 (2011).
4. A. Wang, A. Tuniz, P. Hunt, E. Pogson, R. A. Lewis, A. Bendavid, S. Fleming, B. Kuhlmey, M. Large, "Fiber metamaterials with negative magnetic permeability in the terahertz", *Optical Materials Express* 1, 115-120 (2011).
5. A. Tuniz, R. Lwin, A. Argyros, S. C. Fleming, E. M. Pogson, E. Constable, R. A. Lewis, B. T. Kuhlmey, "Stacked-and-drawn metamaterials with magnetic resonances in the terahertz range", *Optics Express* 19, 16480-16490 (2011).
6. D. L. Cortie and R. A. Lewis, "Role of vanguard counter-potential in terahertz emission due to surface currents explicated by three-dimensional ensemble Monte Carlo simulation", *Physical Review B* 84, 155328 (2011).

PROJECT ID: DP1094261

Title: New directions to miniaturised power sources: Integrated all-solid-state rechargeable batteries

Chief Investigators: Z. P. Guo, Z. X. Chen, J. Dahn, J. Chen

Novel TiO_2(B)@anatase hybrid nanowires with a bicrystalline structure consisting of TiO_2(B) core and anatase shell were synthesized and exhibited superior Li ion storage capacities, cycling stability and rate capability. Owing to the excellent electrochemical performance, TiO_2(B)@anatase hybrid nanowires could be promising anode materials for lithium ion batteries.

TiO_2(B)@SnO_2/carbon hybrid nanowires have been synthesized by two simple hydrothermal processes and subsequent heat treatment in argon. The composite has a unique architecture, as its morphology consists of particles having a TiO_2(B) nanowire core and a porous SnO_2/carbon nanoparticle shell layer. The unique core/shell structure and chemical composition will be useful for many potential applications, including the lithium ion battery.

Synchrotron X-ray diffraction data were used to determine the phase purity and re-evaluate the crystal-structure of $Li_4Ti_5O_{12-x}Br_x$ electrode materials. In situ neutron diffraction of a composite anatase TiO_2/$Li_4Ti_5O_{12}$ anode within a custom-built battery was used to determine the electrochemical function of the TiO_2 component. The $Li_4Ti_5O_{12}$ component was found to be electrochemically active at lower voltages (1.5 V) relative to TiO_2 (1.7 V). This enabled Li insertion/extraction to be tuned through the choice of voltage range in both components of this composite or in the anatase TiO_2 phase only. Porous nanowires of Co_3O_4/Carbon composite are synthesized by using relatively simple and inexpensive electropinning route. This material exhibited high rate capability and good cycling performance. The improved performance may attribute to the effects of nanoscale grains, the carbon coated character of the Co_3O_4 and 1D nanostructure. Because of the advantages shown above, Co_3O_4/C composite nanowires have a potential application in high-performance lithium ion batteries.

Publications:

1. Z. X. Yang, G.D. Du, Z. P. Guo, et al. "TiO_2(B)@Anatase Hybrid Nanowires with Highly Reversible Electrochemical Performance", *Electrochemistry Communications*, 13, 46 (2011).
2. K.H. Seng, J. Liu, Z. P. Guo, et al. "Free-Standing V_2O_5 Electrode for Flexible Lithium Ion Batteries", *Electrochemistry Communications*, 13, 383 (2011).
3. T. Tao, et al. "MoO_3 nanoparticles dispersed uniformly in carbon matrix: a high capacity composite anode for Li-ion batteries", *J. Mater. Chem*., 21, 9350 (2011).
4. Jun Liu, Zaiping Guo, et al. "Highly Porous Metal Oxide Polycrystalline Nanowire Films with Superior Performance in Gas Sensors", *J. Mater. Chem*., 21, 11412 (2011).
5. Z. X. Yang, et al. "TiO_2(B)@Carbon Composite Nanowires as Anode for Lithium Ion Batteries with Enhanced Reversible Capacity and Cyclic Performance", *J. Mater. Chem*. 21, 8591 (2011).
6. P. Zhang, Z. P. Guo, Y.D. Huang, D.Z. Jia, H.K. Liu "Synthesis of Co_3O_4/Carbon composite nanowires and their electrochemical properties", *J. Power Sources*, 196, 6987 (2011).
7. J. Liu, Z. P. Guo, et al. "Heterogeneous ZnS Hollow Urchin-like Hierarchical Nanostructures and Their Structure-enhanced Photocatalytic Properties", *Nanoscale*, 3, 1470 (2011).
8. J. Liu, et al. "Self-assembly of [1010] grown ZnO nanowhiskers with exposed reactive(0001) facets on a hollow sphere and their enhanced gas sensitivity", *CrystEngComm*, 13, 3425 (2011).
9. G. D. Du, et al. "Layered a-MnO_2 as positive electrode for lithium intercalation", *Materials Letters*, 65, 1319 (2011)
10. G. D. Du, et al. "Br-doped Li5Ti4O12 and composite TiO2 anodes for Li-ion batteries: Synchrotron X-ray diffraction and *in-situ* neutron diffraction studies", *Advanced Functional Materials*, 21, 3990 (2011)
11. N. Sharma, et al. "In-situ neutron diffraction study of the MoS2 anode using a custom-built Li-ion battery", *Solid State Ionics*, 199, 37 (2011)
12. N. Sharma, et al. "Time-dependent *in-situ* neutron diffraction investigation of a Li(Co0.16Mn1.84)O4 cathode", *The Journal of Physical Chemistry C*, 115, 21473 (2011).
13. Z. X. Yang, et al. "Encapsulation of TiO_2(B) Nanowire Cores into SnO_2/Carbon Nanoparticle Shells and Their High Performance in Lithium Storage", *Nanoscale*, 3, 4440 (2011).
14. Y. D. Huang, et al. "Preparation and characterization of core–shell structure Fe3O4/C nanoparticles with unique stability and high electrochemical performance for lithium-ion battery anode material", *Electrochimica Acta*, 56, 9233 (2011).
15. Z. X. Yang, et al. "Dispersion of SnO_2 Nanocrystals on TiO_2(B) Nanowires as Anode Material for Lithium Ion Battery Application", *RSC Advances*, 1, 1834 (2011)

PROJECT ID: DP1096546

Title: Directed assembly and photoelectric properties of coreshell nanowire network of PbSe-TiO_2 hetrostructures for high efficiency low-cost solar cells

Chief Investigators: J. H. Kim, Y. Zhao, X. Zhu, Z. Sun

The research has proceeded as planned.

Controlling the agglomeration and particle size of TiO_2 electrode by zeta-potential analysis: Controlling the particle size and agglomeration of titanium dioxide (TiO_2) in dye-sensitized solar cells is crucial for obtaining superior efficiency. In this study, different colloidal conditions, i.e., potential of hydrogen (pH), hydrolysis rate, and viscosity, were adopted to obtain the well-dispersed nano-sized TiO_2. In particular, degree of agglomeration and particle size were predicted by zeta-potential analysis. Under the zeta-potential of ±20 mV (1-3 pH), TiO_2 particles were quite well-dispersed and tend to be smaller. Solar cell efficiency of 4% was obtained by using the well-dispersed TiO_2 with 20 nm in size.

High efficiency of PbSe quantum-dot sensitized TiO_2: We have demonstrated an approach to sensitized-type solar cells, based on TiO_2 and the use of PbSe quantum dot (QDs) as sensitizers. PbSe QDs were grown in site on TiO_2 electrode, utilizing a chemical bath deposition method. All of the photovoltaic performances will be tested.

Roll-to-roll production of large size grapheme film for transparent electrode: We report the roll-to-roll production and wet-chemical doping of predominantly monolayer large size films grown by chemical vapour deposition onto flexible PET. This film can apply to electrodes for solar cells.

ZnO nanowire growing on the FTO glass: ZnO nanowire was directly prepared from a chemical solution on a spin-coated ZnO seed film on fluorine-doped SnO_2 (FTO) on glass, which are used as a substrate for dye-sensitized or quantum-dot sensitized solar cell. From cell testing, efficiency of 1-2% was obtained.

Rational design of "fur-ball-like" TiO_2 through hydrothermal process: Controlling the morphology and size of TiO_2 is crucial for obtaining superior photovoltaic properties. Here, we report a completely new approach- "fur-ball-like" TiO_2 – to

achieve high efficiency by using hydrothermal method. We show that abundant sharp arms on the "fur-ball-like" TiO_2 surface increases the surface area by controlling surfactant amount and hydrolysis rate. Our finding provides nanostructure insights, which could pave the way to further improve energy conversion efficiency of TiO_2 based devices.

Publications:

1. Ziqi Sun, Jung Ho Kim* et al, *Journal of the American Chemical Society*, vol. 133 (2011) pp. 19314
2. Ziqi Sun, Jung Ho Kim* et al, *CrystEngComm*, in press (2012)

PROJECT ID: DP0987805

Title: Development of inorganic-conducting polymer composites and ionic liquid-based electrolytes for rechargeable lithium batteries

Chief Investigators: J. Z. Wang

(1) Nano-Sn/PPy composite

Nano-Sn/PPy composite was prepared by chemically reducing and coating Sn nanoparticles onto the PPy surface. The electrochemical results show that both the capacity retention and the rate capability are in the same order of nano-Sn/PPy-CMC > nano-Sn/PPy-PVDF > nano-Sn-CMC > nano-Sn-PVDF. The present results indicate that the nano-Sn/PPy composite could be suitable for the next generation of anode materials with relatively good capacity retention and rate capability.

(2) Fe_3O_4–graphene composites

Fe_3O_4–graphene composites with three-dimensional laminated structures has be synthesised by a simple in situ hydrothermal method. Results show that the Fe_3O_4-graphene nanocomposite exhibits a stable capacity of about 650 mAh g^{-1} with no noticeable fading up to 100 cycles. The superior performance of Fe_3O_4-graphene is clearly established by comparison of the results with those from bare Fe_3O_4. The graphene nanosheets in the composite material could act not only as lithium storage active materials, but also as an electronically conductive matrix to improve the electrochemical performance of Fe_3O_4.

(3) Flexible, free-standing, paper-like V_2O_5-polypyrrole (PPy) films

Highly flexible, paper like, free-standing V_2O_5 and V_2O_5-polypyrrole (PPy) films were prepared via vacuum filtration method. The films are soft, lightweight, and mechanically robust. The electrochemical performance of the free-standing pure V_2O_5 electrode was improved by incorporating the conducting polypyrrole. A novel designed bendable cell was fabricated with free-standing V_2O_5-PPy cathode, gel electrolyte, and lithium foil, and it was tested under repeated bending condition for the first time.The results show that the battery performance of bent cell was similar to the conventional cell in the initial bending test.

(4) SnO_2-coated multiwall carbon nanotube (SnO_2/MWCNT) nanocomposites

SnO_2/MWCNT nanocomposites were synthesized by a facile hydrothermal method. The SnO_2/MWCNT composites show excellent cyclic retention, with the high specific capacity of 473 mAh g^{-1} beyond 100 cycles, much greater than that of the bare SnO_2 which was also prepared by the hydrothermal method in the absence of MWCNTs.

(5) Ionic liquid electrolytes

Two types of ionic liquid electrolytes of 1 M LiTFSI in 1-ethyl-3-methyl-imidazolium bis(fluorosulfonlyl)imide (EMI-FSI) and 1 M LiTFSI in 1-methyl-1-propylpyrrolidinium bis(fluorosulfonyl) imide (Py13-FSI) have been tested with transition metal oxide/carbon composites (Fe_2O_3/C, NiO/C and CuO/Cu_2O/C). The electrochemical measurements show that the composite electrodes using Py13-FSI as electrolyte show much better electrochemical performance than those using EMI-FSI as electrolyte in terms of reversibility. The Fe_2O_3/C composite shows the highest specific capacity and the best capacity retention (420 mAh g-1) under a current density (50 mA g-1) up to 20 cycles, compared with NiO/C and CuO/Cu_2O/C compsoites. The present research demonstrates Py13-FSI could be used as an electrolyte for transition metal oxides in lithium-ionbattery.

Publications:

1. J. Z. Wang, C. Zhong, N. H. Idris, D. Wexler, Z. X. Wang, L. Q. Chen, H. K. Liu, "Graphene Encapsulated Fe_3O_4 Nanoparticles with 3D Laminated Structure as Superior Anode in Lithium Ion Batteries", *Chem-EUR J,* 17(2011) 661 – 667.
2. Lin Lu**,** Jia-Zhao Wang, Xue-Bin Zhu**,** Xuan-Wen Gao**,** Hua-Kun Liu **"**High capacity and high rate capability of nanostructured CuFeO2 anode materials for lithium-ion batteries", *J. Power Sources*, 196 (2011) 7025-7029.
3. Shu-Lei Chou, Xuan-Wen Gao, Jia-Zhao Wang, David Wexler, Zhao-Xiang Wang, Li-Quan Chen, Hua-Kun Liu," Tin/Polypyrrole Composite Anode Using Sodium Carboxymethyl Cellulose Binder for Lithium-Ion Batteries", *Dalton Trans.*, 40 (2011) 1–7.
4. Lukman Noerochima, Jia-Zhao Wang, Shu-Lei Chou§, Hui-Jun Li, Hua-Kun Liu, "SnO_2-coated multiwall carbon nanotube composite anode materials forrechargeable lithium-ion batteries" *Electrochim. Acta* 56 (2010) 314–320.
5. Shu-Lei Chou , Lin Lu, Jia-Zhao Wang, M. M. Rahman, Chao Zhong, and Hua-Kun Liu, "The compatibility of transition

metal oxide/carbon composite anode and ionic liquid electrolyte for the lithium-ion battery" *J. Appl. Electrochem.* 41 (2011) 1261-1267.

PROJECT ID: DP110103909

Title: A novel hybrid electrochemical energy system for both high energy and high power.

Chief Investigators: J. Z. Wang, S. L. Chou, H. J. Li, Y. P. Wu, K. Ozawa

(1) $Li_4Ti_5O_{12}$ microspheres anode materials

$Li_4Ti_5O_{12}$ microspheres composed of nanoflakes were synthesized within 1 h by a combination of a microwave-assisted hydrothermal method and a microwave postannealing process. The electrode using CMC as binder showed much lower charge transfer resistance, lower apparent activation energy, and lower apparent diffusion activation energy than for the electrode using PVDF as the binder. Apparent activation energies of $Li_4Ti_5O_{12}$ microsphere electrodes using CMC and PVDF as binder were calculated to be 26.8 and 33.6 kJ mol $^{-1}$, respectively.

(2) Hollow-structured α-Fe2O3/carbon (HIOC) composite anode materials

Hollow-structured α-Fe_2O_3/carbon (HIOC) composites were synthesized by spray pyrolysis method using iron (II) lactate solution and sucrose as the precursors. Electrochemical tests showed that the HIOC composite electrode with 14.7% carbon using sodium carboxymethyl cellulose (CMC) as a binder had the best electrochemical performance due to its high capacity (1000 mAh g-1 at 0.1 C), good rate capability (700 mAh g-1 at 2 C), and good cycle stability (720 mAh g-1 at 2 C up to 220 cycles).

(3) $LiCoPO_4$ cathode materials

Cathode materials including $LiCoPO_4$ were synthesized, and their electrochemical performance was also investigated. A series of $LiCoPO_4$ (x = 0.90~1.05) compounds have been successfully prepared by the sol-gel method. Electrochemical results show that Li$x$$CoPO_4$ (x = 0.95) presents the highest discharge capacity in the series at 0.05 C in the voltage range of 3.5–5.0 V over 25 cycles.

(4) $Li_2FeP_2O_7$/carbon composite cathode materials

Nanoporous $Li_2FeP_2O_7$/carbon composite was synthesized by a sol-gel method. The electrochemical tests showed that the porous $Li_2FeP_2O_7$/carbon composite electrode had better high-rate capability than the one prepared by solid-state reaction. This work has been finished, and a manuscript is under preparation.

(5) $LiFePO_4$/graphene composite cathode materials

$LiFePO_4$/graphene composites were synthesised using a microwave autoclave. $LiFePO_4$ composites with different percentages of graphene (4%, 8%, 15%) were synthesized, and their electrochemical performance was also compared. The specific capacity and charge–discharge efficiency of $LiFePO_4$ increase dramatically from 125 mAh g^{-1} ($LiFePO_4$) to 165 mAh g^{-1} ($LiFePO_4$/graphene (8%)). A possible reason is that graphene nanosheets act as conducting routes between the $LiFePO_4$ nanoparticles, so that the contact resistance is reduced. A highly stable reversible capacity of 80 mAh g^{-1} has been obtained at the highest current density of 10 C, while the corresponding value is only 50 mAh g^{-1} for $LiFePO_4$. After 40 cycles under various conditions, the $LiFePO_4$/graphene (15%) cell deliver about 99% of the initial capacity. The values of charge transfer resistance (R_{ct}) for the $LiFePO_4$ and $LiFePO_4$/graphene (15%) electrodes were calculated to be 513 Ω and 201 Ω, respectively. Obviously, the R_{ct} of the $LiFePO_4$/graphene (15%) electrode is much smaller than that of the $LiFePO_4$ electrode, indicating the enhanced ionic conductivity of the $LiFePO_4$/graphene (15%) composite.

Publications:

1. Shu-Lei Chou, Jia-Zhao Wang, Hua-Kun Liu, and Shi-Xue Dou, "Rapid Synthesis of Li4Ti5O12 Microspheres as Anode Materials and Its Binder Effect for Lithium-Ion Battery", J. *Phys. Chem. C*, 115 (2011) 16220–16227.
2. S. L. Chou, J. Z. Wang, Z. X. Chen, H. K. Liu and S. X. Dou, "Hollow hematite nanosphere/carbon nanotube composite: mass production and its high-rate lithium storage properties", *Nanotechnology*, 22 (2011) 265401.

PROJECT ID: DP1093952

Title: Advanced Nanostructured Ceramic Composites for Ultracapacitors.

Chief Investigators: K. Konstantinov, H. K. Liu, A. Calka, D. Wexler

The research project is progressing very well. The achievements and outcomes are summarised as follows:

We have achieved a breakthrough in mass production of novel type globular metal Oxide/Graphene Oxide composite structures through non-conventional spray pyrolysis technology. These special "lettuce like" structures provide superior supercapacitance performance (up to 685F/g) and excellent cycle life. The results are included in a Provisional Patent and part of them have been published in a most prestigious energy related journal (Energy and Environmental Science) with IF 9.45 [1]. The paper was evaluated from the journal as a "hot communication" and listed on the EES blog. The article is top 2nd accessed online according to the journal:

http://blogs.rsc.org/ee/2012/01/27/top-ten-most-read-ees-articles-in-december/ Novel nanoceramic composites for solid-state supercapacitors such as $BaLa_2Ti_4O_{12}$ and $CaCu_3Ti_4O_{12}$ have been obtained through Electric Discharge Assisted Mechanical Milling Method [2]. The materials have a very high dielectric constant around 3.5x105 at 50Hz and will be explored in new type all-solid-state supercapacitors.

Further study of the phase evolution and effect of oxygen stoichiometry on Titania based supercapacitors [3]. It was observed that the transformation of anatase to rutile in all samples began at 500 C and was completed at 800 C, regardless of annealing atmosphere. However, the transformation rate of anatase to rutile was accelerated by annealing the powders under argon atmosphere due to the decreased oxygen partial pressure of the annealing atmosphere, which favors the formation of oxygen vacancies in the nanocrystalline TiO_2 particles.

A number of other high quality papers have been published as well reflecting our earlier research achievements on the project [4-6].

Publications:

1. Alfred Chidembo, Seyed Hamed Aboutalebi, Konstantin Konstantinov*, Maryam Salari, Brad Winton, Sima Aminorroaya Yamini, Ivan P. Nevirkovetsa and Hua Kun Liu, Globular reduced graphene oxide-metal oxide structures for energy storage Applications, *Energy Environ. Sci. 5* (2012) 5236-5240.
2. A. Calka, A. A. Chowdhury, and K. Konstantinov, Rapid Synthesis of Functional Oxides by Electric Discharge Assisted Mechanical Milling Method, *J. Alloys Compounds*, in press.
3. M. Salari, M. Rezaee*, A. T. Chidembo, K. Konstantinov, and H. K. Liu, Rietveld Analysis of the Effect of Annealing Atmosphere on Phase Evolution of Nanocrystalline TiO2 Powders, *J. Nanosci. Nanotechnol*., in press.
4. Maryam Salari*, Seyed Hamed Aboutalebi, Konstantin Konstantinov and Hua Kun Liu, A highly ordered titania nanotube array as a supercapacitor electrode, *Phys. Chem. Chem. Phys*. 13 (2011) 5038-5041.
5. Maryam Salari*, Konstantin Konstantinov and Hua Kun Liu, Enhancement of the capacitance in TiO2 Nanotubes through controlled introduction of oxygen vacancies, *J. Mater. Chem. 21* (2011) 5128-5133.
6. Seyed Hamed Aboutalebi, Alfred T. Chidembo, Maryam Salary, Konstantin Konstantinov,* David Wexler, Hua Kun Liu and Shi Xue Dou, Comparison of GO, GO/MWCNTs composite and MWCNTs as potential electrode materials for supercapacitors, *Energy & Environmental Science 4* (2011) 1855-1865.

PROJECT ID: DP0879933

Title: Tailoring superconducting hybrid multilayered film systems for electric and electronic applications

Chief Investigators: A. V. Pan, C. Foley, T. H. Johansen, H. Hilgenkamp

The main aim of the project is to develop new superconducting systems and junctions, exhibiting novel properties and phenomena for various applications, ranging from quantum electronics to effective charge transport.

We have managed to fabricate and characterize double-barrier multi-terminal superconducting transistor-like hybrid devices with the $S_1IS_2FIS_3$ structure, where S, I and F refer to superconducting, insulating, and ferromagnetic layers, respectively. A thin ferromagnetic Ni layer screens the superconductivity of the middle Nb layer on the injector-barrier side, so that the Nb/Ni bilayer manifests itself as a superconductor in the current-voltage characteristic (*I-V* curve) of the acceptor S_1IS_2 junction, but as a normal metal in the *I-V* curve of the injector S_2FIS_3 junction. It is shown that this property allows for considerable improvement of the input-output isolation of the quasiparticle-injection devices as compared with that for the formerly reported quiteron.

Comprehensive magnetic phase diagrams of a $RuSr_2Eu_{1.5}Ce_{0.5}Cu_2O_{10-\delta}$ (Ru-1222) superconducting ferromagnet have been derived from extensive measurements of static and dynamic magnetic responses. These measurements have been done by temperature and field dependences of dc magnetization and nonlinear ac susceptibility in both low and high magnetic fields. Comparison of magnetic phase diagrams of phase pure and impure samples singles out the intrinsic and extrinsic magnetic features, naturally proposing a unified model of Ru-1222 magnetic behaviour. The results considered within the proposed interpretation indicate full agreement between static and dynamic properties which, if measured in combination, effectively complement each other, uncovering existing ambiguities. This sophisticated work has been selected to feature a New Article by Institute of Physics Science.

The dependence of properties in $YBa_2Cu_3O_7$ (YBCO) superconducting films grown by pulsed laser deposition (PLD) at different distances from the target to a substrate has been systematically studied. The target to substrate distance D_{TS} is shown to enable simple means for tunability of the critical current density and microstructure of the YBCO films. The variation of structural and electromagnetic properties in the films as a function of D_{TS} has been explained in terms of laser plume propagation model and thin film formation mechanism.

A new critical current density (J_c) model for high-quality YBCO thin films has been proposed combining thermally activated flux creep with vortex pinning potential for columnar defects. Pinning for thermally activated vortices has been described

by strong pinning on chains of individual edge dislocations that form low-angle domain boundaries in high quality YBCO thin films. The model shows an adequate description of the J_c behaviour in the whole applied field range as verified by direct measurements of J_c in YBCO thin films grown by PLD. It also indicates that the effective pinning landscape changes under the influence of external conditions. The pinning potential obtained from the model is consistent with the values obtained for columnar defects, which confirm the validity of the overall approach.

Publications:

1. A. V. Pan, S. Pysarenko, and S. X. Dou, "Origin of surface morphology variation during pulsed laser deposition of $YBa_2Cu_3O_7$ superconducting films", *IEEE Trans. Appl. Supercond.* 21, 3179-3183 (2011).
2. I. A. Golovchanskiy, A. V. Pan, O. V. Shcherbakova, S. A. Fedoseev, and S. X. Dou, "An all-field-range description of the critical current density in superconducting YBCO films", *Supercond. Sci. Technol*. 24, 105020 (2011).
3. R. Nigam, A. V. Pan and S. X. Dou, "Magnetic phase diagrams based on static and dynamic magnetic behaviour in Ru-based superconducting ferromagnets", *J. Phys.: Condens. Matter* 23, 435702 (2011).
4. News Article (01/12/2011): *The magnetic versus the superconducting state* (http://iopscience.iop.org/0953-8984/labtalk-article/48013).
5. I. P. Nevirkovets, O. Chernyashevskyy, J. B. Ketterson, and A. V. Pan, "Multi-terminal superconducting nonequilibrium device with a ferromagnetic screen", *IEEE Trans. Appl. Supercond.* 21, 721-723 (2011).

PROJECT ID: DP110100398

Title: New approach to control grain boundary behaviour in superconducting thin films

Chief Investigators: A. V. Pan, O. V. Shcherbakova, S. Zhou, I. Nevirkovets, K. H. Muller, T. H. Johansen, H. Hilgenkamp

The main aim of the project is to a new approach to overcome the cornerstone problem of high temperature superconducting films through new design, magnetic interactions, and real-time magnetic flux visualisation at the quantum level. The expected ultimate achievement would be to develop new technologies, delivering the best performance of the films.

The project has formally commenced at the end of July 2011. Nevertheless, a substantial progress has been achieved during the remaining 5 months period as a result of the extensive preliminary research work carried out since the announcement that this project has been awarded by the ARC in late 2010.

In order to enhance the performance of high temperature superconducting (HTS) Josephson junctions (representing artificial grain boundaries which can be used as a model system), we have introduced multilayered approach to YBCO-based step-edge Josephson junction manufacture. Thin $YBa_2Cu_3O_7$ (YBCO) and multilayered YBCO/NdBCO/YBCO films of a similar thickness (~210 nm) were grown by a pulsed-laser deposition technique on MgO (100) substrates with artificially created step edge. Large discrepancies of *Ic* and *Rn* values were found between these two types of junction. Results of their structural and electrical properties have been published.

In addition, we have investigated superconducting YBCO, insulator $SrTiO_3$ (STO), and ferromagnetic $La_{2/3}Ca_{1/3}MnO_3$ (LCMO) multilayered heterostructures grown by pulsed-laser deposition (PLD) on <100> YSZ substrates. These systems have demonstrated strong superconducting properties with minimum influence by the ferromagnetic layer. We also report the unusual transport properties and negative differential resistance above T_c, as well as electro- and magnetoresistance effects in YBCO micro-bridge with top LCMO layer which may be the consequence of magnetic phase separation induced by electric current.

Publications:

1. O. V. Shcherbakova, S. K. H. Lam, A. V. Pan, S. Fedoseev, S. X. Dou, J. Du, and C. P. Foley, "Step-edge Josephson junctions on multilayered high temperature superconducting thin film", *IEEE Trans. Appl. Supercond.* 21, 156-159 (2011).

PROJECT ID: DP0770205

Title: Current limiting mechanisms in magnesium diboride superconductors.

Chief Investigators: S. X. Dou, J. Driscoll, R. L. Flukiger, H. Kumakura, M. D. Sumption

The aim of this project is the understanding of mechanisms responsible for the significant enhancement in J_c, H_{irr} and H_{c2} The research in 2011 proceeded as planned. We have further investigated superconducting properties of MgB_2 samples.

Tailored Materials for High-Performance MgB_2 Wire: Carbon-encapsulated crystalline boron nanopowder and coarse magnesium powder are used as inexpensive tailored starting materials for the fabrication of high-performance MgB_2 superconducting wire. A low sintering temperature leads to a high critical current density, as a result of nanometer-sized boron powder, surface oxidation preclusion by carbon encapsulation, and grain alignment by elongated magnesium coarse powder. [1]

Graphene micro-substrate-induced pi gap expansion in MgB_2: The lattice effect induced by tensile strain on the

superconductivity of graphene-MgB_2 composites was studied systematically to deduce the electron-phonon coupling (EPC) and the multiple superconducting gap behavior. Compared with nano-carbon doped MgB_2, graphene-MgB_2 composites show larger lattice parameters and higher critical superconducting transition temperatures (T_c). The EPC strength of MgB_2 with similar to 2 wt.% graphene addition is even higher than that of the pure reference sample, as estimated from the Sommerfeld constant. The π gap was found to be expanded by graphene addition through the analysis of heat capacity data, and it is responsible for both the enhanced EPC strength and the weak dependence of T_c on the graphene content. [2]

Flux pinning mechanisms in graphene-doped MgB_2 superconductors: The effects of graphene doping on the superconducting properties of MgB_2 were studied. We found that small addition of graphene significantly improves the superconducting properties of MgB_2, with only a small reduction in T_c. Low resistivity, high critical fields and enhanced flux-flow activation energy were observed for the optimally doped bulk sample. The spatial fluctuation in the transition temperature (delta T_c pinning) is the flux pinning mechanism in graphene-doped MgB_2. [3]

Effect of thermal strain on J_c and T_c in high density nano-SiC doped MgB_2: The influences of lattice strain on the superconducting critical current density J_c and critical transition temperature T_c in pure MgB_2 and a SiC-MgB_2 composite made by the diffusion process are explored, based on the thermal expansion coefficients and the low temperature effects on Raman scattering. The strong thermal strain provides a strong flux pinning force for the supercurrents at the interfaces between SiC and MgB_2. The high T_c of SiC-MgB_2 is also discussed according to the expanded lattice and Raman characteristics. [4]

Evaluation of carbon incorporation and strain of doped MgB_2 superconductor by Raman spectroscopy: Raman spectroscopy is employed to study both the strain and the carbon substitution level in SiC-doped MgB_2 bulk samples. Raman spectroscopy was demonstrated to be a better method to distinguish the individual influences of strain and carbon than standard X-ray diffraction. It is found that the lattice parameter correlation method for C content determination is invalid for highly strained samples. Our result also provides an alternative explanation for lattice variation in non-carbon-doped MgB_2, which is basically due to lattice strain. [5]

Publications:

1. J. H. Kim, S. Oh, H. Kumakura, A. Matsumoto, Y.-U. Heo, K.-S. Song, Y.-M. Kang, M. Maeda, M. Rindfleisch, M. Tomsic, S. Choi, and S. X. Dou, "Tailored Materials for High-Performance MgB2 Wire," *Adv. Mater.,* vol. 23, pp. 4942-4946, Nov 9 2011.
2. W. X. Li, X. Xu, Q. H. Chen, Y. Zhang, S. H. Zhou, R. Zeng, and S. X. Dou, "Graphene micro-substrate-induced pi gap expansion in MgB2," *Acta Mater.,* vol. 59, pp. 7268-7276, Nov 2011.
3. K. S. B. De Silva, X. Xu, S. Gambhir, X. L. Wang, W. X. Li, G. G. Wallace, and S. X. Dou, "Flux pinning mechanisms in graphene-doped MgB2 superconductors," *Scr. Mater.,* vol. 65, pp. 634-637, Oct 2011.
4. W. X. Li, R. Zeng, L. Lu, and S. X. Dou, "Effect of thermal strain on J(c) and T-c in high density nano-SiC doped MgB2," *J. Appl. Phys.,* vol. 109, Apr 1 2011.
5. W. K. Yeoh, R. K. Zheng, S. P. Ringer, W. X. Li, X. Xu, S. X. Dou, S. K. Chen, and J. L. MacManus-Driscoll, "Evaluation of carbon incorporation and strain of doped MgB2 superconductor by Raman spectroscopy," *Scr. Mater.,* vol. 64, pp. 323-326, Feb 2011.

PROJECT ID: DP0879070

Title: Giant magnetocaloric materials and room temperature refrigeration.

Chief Investigators: S. X. Dou, J. H. Kim, T. H. Johansen, E. Bruck

In 2011, we have applied a wide range of experimental techniques together with related analytical and theoretical modelling in the study of selected magnetocaloric materials. The main outcomes of our studies are as follows:

- The magnetic entropy values associated with the first-order magnetic transitions from antiferromagnetism to ferromagnetism are obtained: $-\Delta S^M max$ =12.3 J kg^{-1} K^{-1} around 36 K (ΔB=0–2 T) in $NdMn_2Ge_{0.4}Si_{1.6}$ and – ΔSM_{max}=8.2 J kg-1 K-1 around 25 K (ΔB=0–1.5 T) in $PrMn_{1.4}Fe_{0.6}Ge_2$, respectively.
- By substitution of Mn with Ti, Fe and Nb in MnCoGe, we successfully control the structural and magnetic transitions in MnCoGe to be close or coincide around room temperature, which leads to the large magnetic entropy change near room temperature in $Mn_{1-x}T_xCoGe$ with T=Ti, Fe and Nb) being detected. A giant magnetocaloric effect 14.8 J/kgK under a magnetic field of 5T had been observed in the $Mn_{0.94}Ti_{0.06}$ CoGe alloy, making it a promising candidate for magnetic refrigeration near room temperature.
- Magnetocaloric effect (MCE) in low-cost iron-based $Ho_2Fe_{17-x}Mn_x$ alloys has been investigated. With a magnetic field change of 0–5 T, the magnetic entropy change around T_C has been found to be 3.2 J kg^{-1} K^{-1} and 2.7 J kg^{-1} K^{-1} for Ho_2Fe_{17} (T_C=336 K) and $Ho_2Fe_{15}Mn_2$ (T_C=302 K), respectively. These alloys are suitable as room temperature MCE materials.
- Neutron diffraction, Mössbauer spectroscopy, critical

magnetization behaviour and magnetocaloric studies of novel compounds RNi_2Mn (R= Tb, Dy, Ho and Er) have been performed. With second order transition at TC being confirmed, a moderate Magnetocaloric effect has been detected with $-\Delta S^M_{max} = 7.4$ J kg^{-1} K^{-1} around 30 K for $HoNi_2Mn$ with ΔB =0-5 T.

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2. J.L. Wang, S.J. Campbell, S.J. Kennedy, R. Zeng, S.X. Dou and G.H. Wu, *J. Phys.: Conden. Matter 23* (2011) 216002
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8. J. C. Debnath, R. Zeng, J. H. Kim, and S. X. Dou, *J. Magn. Mater*. 323 (2011) 139.
9. J. C. Debnath, R. Zeng, J. H. Kim, and S. X. Dou, *J. Alloy. Comp.*, 509 (2011) 3699
10. R. Zeng, J. Liu, G.D. Du, W.X. Li, J.L. Wang, J. Horvat, S. X. Dou, *J. Appl. Phys. 111* (2012) 07E142
11. J.L. Wang, A. Studer, S.J. Kennedy, R. Zeng S.X. Dou and S. Campbell, *J. Appl. Phys. 111* (2012) 07A911
12. J.L. Wang, S.J. Campbell, M. Hofmann, M. Hoelzel, R. Zeng, S.X. Dou and S.J. Kennedy, *J. Appl. Phys. 111* (2012) 07E334
13. J.L. Wang, S.J. Campbell, S.J. Kennedy, S.X. Dou and G.H. Wu, *Hyperfine Interactions*, 208 (2012) 43
14. J. C. Debnath, R. Zeng, J. H. Kim,; P. Shamba and S.X. Dou, *Applied Physics A-Materials Science & Processing 106* (2012) 245
15. J. C. Debnath, R. Zeng, J. H. Kim, D.P. Chen, S.X. Dou, *Materials Science And Engineering B-Advanced Functional Solid-State Materials 177* (2012) 48-53
16. R. Zeng, S. Wang, G. Du, J.L. Wang, J. Debnath, P. Shamba, S. X. Dou, *J. Appl. Phys. 111* (2012)07E144
17. J. C. Debnath, R. Zeng, J. H. Kim, P. Shamba, D.P. Chen, S.X. Dou, *J. Alloy. Comp*., 510 (2012) 125

PROGRESS REPORT: DP0987190

Title: Frustrated magnets: a new platform for multiferroic materials

Chief Investigators: X.L. Wang, Z. X. Cheng and D. P. Chen, PIs: T. Kimura, F. Klose,

The project has preceded as planned. The following results were obtained or published in 2011:

1) We reported for the first time the transport properties of domain walls in oxygen deficient multiferroic $YMnO_3$ single crystals have been probed using conductive atomic force microscopy and piezoresponse force microscopy. Domain walls exhibit significantly enhanced conductance after being poled in electric fields, possibly induced by oxygen vacancy ordering at domain walls. The electronic conduction can be understood by the Schottky emission and Fowler-Nordheim tunnelling mechanisms. Our results show that the domain wall conductance can be modulated through band structure engineering by manipulating ordered oxygen vacancies in the poling fields. *This work has been published in Applied Physics Letters, 2011 [1]*

2) We reported for the first time the coupling effect between a half metal and a ferroelectric materials. We observed a for the first time a sharp drop in resistance and a magnetization anomaly in $La_{2/3}Ca_{1/3}MnO_3$ film in zero magnetic field at the $BaTiO_3$ substrate structural phase transition temperature, due to the substrate clamping/strain effect, which is confirmed by Raman scattering. However, the anomalies for both resistance and magnetization were eliminated by a strong external magnetic field. These phenomena indicate that strain can cause colossal resistance and a change in magnetization which resembles the magnetic field effect. The interplay of the external forces (strain and magnetic field) is a good demonstration of the strong coupling between spin and lattice in colossal magnetoresistance materials. *This work has been published in Appplied Physics Letters, 2011 [2]*

3) Multiferroic Bi_2NiMnO_6 nanoparticles were synthesized by a simple electrospray method. Bi_2NiMnO_6 nanoparticles crystallize in the monoclinic structure with space group C121. The particles show a uniform spherical shape with a diameter of 100 nm to 300 nm. The ferromagnetic transition of Bi_2NiMnO_6 is confirmed at 122 K. The room temperature ferroelectricity of the Bi_2NiMnO_6 nanoparticles is verified by Kelvin probe force microscopy. *This work has been published in Journal of Applied Physics [3]*

4) We have investigated the structural, magnetic and ferroelectric properties of magnetically frustrated multiferroic $YMnO_3$ single crystals. The ferroelectric domain structures of $YMnO_3$ samples were studied by piezoresponse force microscopy. Instead of domain vortex structure in 13 stoichiometric crystals, $YMnO_3$ exhibits a random domain configuration with straight domain walls. In magnetic measurements, the $YMnO_3$ crystal shows typical antiferromagnetic behavior with higher Ne´el temperature and lower magnetization compared to the stoichiometric sample. This work has been accepted for publication in Journal of Applied Physics [4]

5) Single phase $ErMe_xMn_{1-x}O_3$ samples were synthesized by the solid state reaction method. The differences between the doping effects on the Raman spectra and on the structural, magnetic and thermal properties of the two systems have been systematically investigated. In the $ErCu_xMn_{1-x}O_3$ system, lattice parameter *a* increases with doping, while lattice parameter c decreases. It is more complicated in the $ErFe_xMn_{1-x}O_3$ system, where lattice parameter a decreases with doping, while lattice parameter c is enhanced after an initial slight decrease. Raman spectra show that the phonon peaks of $ErFe_xMn_{1-x}O_3$ slightly shift to higher frequencies with doping, while those of $ErCu_xMn_{1-x}O_3$ apparently shift toward lower frequencies. Heat capacity data indicates that the Ne´el temperature of $ErMnO_3$ is reduced to 61 K for $ErCu_{0.1}Mn_{0.9}O_3$ by Cu doping, whereas it is slightly enhanced to 79 K for $ErFe_{0.1}Mn_{0.9}O_3$ through Fe doping. *This work has been published in Journal of Applied Physics [5]*

6) In order to find high-performance multiferroic materials, which are good candidates for lead-free piezoelectric/ferroelectric films,a new type of heterostructural thin film of $YMnO_3/SnTiO_{3+x}$ (YST) was designed and produced. $SnTiO_3$ is a metastable but promising lead-free ferroelectric material. Our expectation was that it could be stabilized by alternating $YMnO_3$ layers. Here we report the fabrication and ferroelectric, piezoelectric and magnetic properties of YST films. Antiferromagnetic and ferroelectric properties were observed to coexist on the YST film with four layers, fabricated using the pulsed laser deposition method on (1 1 0) Nb:$SrTiO_3$ substrates.

   Although some basic ferroelectric properties of the $SnTiO_3$ films have previously been reported, further study is needed to obtain high-performance $SnTiO_3$ films. *This work was published in Scripta Materialia.*

Publications:

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2. Z. X. Cheng, X. L. Wang, S. X. Dou, M. Osada, and H. Kimura, *Applied Physics Letters*, 99 (2011)092103;
3. Y. Du, et al, *Journal of Applied Physics* 109, 07B507 (2011); P. Liu, X.L. Wang, Z.X. Cheng, Yi Du, H. Kimura, *Physical Review B*, 83, 144404 (2011)
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PROJECT ID: DP1094073

Title: Materials science and superconductivity in the new Fe-based high temperature superconductors

Chief Investigators: X. L. Wang, D. Chen, G. Peleckis, H. Hosono, X. H. Chen, A. Studer, K. Muller, E. Muromachi

This project was officially started in Sep. 2010 due to the delay of the agreement from partner investigators' Institutions. The following results were obtained or published in 2011:

1) We reported Giant magnetic flux jumps we observed in magnetic hysteresis loops of $Ba_{0.6}K_{0.4}Fe_2As_2$ single crystals. The size of the flux jumps, which appear only at low temperatures (T<4K), is so large that it can transform the whole superconducting state into the normal state. The recovery rate to the superconducting state is rather slow, although the superconducting state is almost fully recovered. We show that theoretical predictions based on the adiabatic approach with nonlocal electrodynamics give a good explanation of the flux jumps observed in the single crystals of $Ba_{0.6}K_{0.4}Fe_2As_2$. *This work has been published in Applied Physics Letters [1].*

2) Local fluctuations in the distribution of dopant atoms are thought to cause the nanoscale electronic disorder or phase separation in pnictide superconductors. Atom probe tomography has enabled the first direct observations of dopant species clustering in a K-doped 122-phase pnictide. First-principles calculations suggest the coexistence of static magnetism and superconductivity on a lattice parameter length scale over a wide range of dopant concentrations. Our results provide evidence for a mixed scenario of phase coexistence and phase separation,

depending on local dopant atom distributions. *This work was published in Physical Review Letters [2].*

3) The magneto-resistance, critical current density, Jc, upper critical field, H_{c2}, and flux pinning properties of $LaFeAsO_{1-x}F_x$ superconductors were investigated systematically by magnetic and magneto-transport measurements in the fields up to 13 T over a temperature range of 5–35 K. It was found that the H_{c2} increased with increasing fluorine concentration up to x=0.15, while with higher fluorine doping, H_{c2} decreased. A peak effect in the J_c as a function of field was observed at T<15 K for both the 5% and 15% fluorine doped samples. The broadening of the superconducting transition in magnetic field can be well understood by the thermally activated flux flow model. The pinning potential, Uo, scales as Uo/kB ! B_n with n¼0.13 for B<1 T and n¼_0.68 for B>1 T for $LaFeAsO_{0.85}F_{0.15}$. This work was published in Journal of Applied Physics [3]and was selected for the April, 2011 issue of Virtual Journal of Applications of Superconductivity. The Virtual Journal, which is published by the American Institute of Physics and the American Physical Society in cooperation with numerous other societies and publishers, is an edited compilation of links to articles from participating publishers, covering a focused area of frontier research.

4) The critical current density, J_c, flux pinning behavior and magneto- resistance results of $BaFe_{2-x}Ni_xAs_2$ single crystal have been investigated in fields up to 13 T over a temperature range of 2 to 20 K. The magnetoresistance below the superconducting transition temperature (T_c) shows Arrhenius thermally activated behavior: q¼qoexp(-Uo(T,H)/kBT), where Uo is the thermally activated energy. $BaFe_{2-x}Ni_xAs_2$ exhibits high thermally activated flux flow energy with a very weak field dependence. J_c is as high as 105 A/cm^2 for zero magnetic field at 2 K. Jc was found to decrease for B<1 T, but showed a very weak field dependence and remained nearly constant with increasing magnetic field for B>1 T at T¼2, 5, and 10 K. Flux jumping was also observed in magnetization loops at very low temperature for large sample, which is related to the high J_c in the single crystal. A peak effect was observed at 10 K. This work was published in Journal of Applied Physics [4] and was selected for the April 2011 issue of Virtual Journal of Applications of Superconductivity.

5) Superconductivity has been found in newly discovered iron-based compounds. This paper studies the motion of magnetic vortices in $BaFe_{1.9}Ni_{0.1}As_2$ single crystal by means of the magneto-optical imaging technique. A series of magneto-optical images reflecting magnetic flux distribution at the crystal surface were taken when the crystal was zero-field cooled to 10 K. The behavior of the vortices, including penetration into and expulsion from the single crystal with increasing and decreasing external fields, respectively, is discussed. The motion behavior is similar to that observed in high-T_c superconducting cuprates with strong vortex pinning; however, the flux-front is irregular due to randomly distributed defects in the crystal. This work has been published in Journal of Applied Physics [5]

Publications:

1. W.K. Choi, et al., G.S. Jeon, X. F. Wang, X. H. Chen, X. L. Wang, M.H.Jung, S.I. Lee, G.S. Park, *Appl. Phys. Lett. 98*, 182505 (2011)
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5. Z. W. Lin et al, *J Appl Phys 109*, 07E142 (2011)

FUTURE FELLOWSHIP

PROJECT ID: FT0990391

Title: Manipulation of spin by electric field.

Chief Investigators: Z. X. Cheng

The following results were obtained in 2011:

The structure and magnetic properties of perovskite $DyMn_{1-x}Fe_xO_3$ samples have been studied. Static orbital orderings are expected to exist in samples with x=0.2 due to strong Jahn-Teller distortion, which become less stable as x increases and probably disappears in samples with x>0.5. The antiferromagnetic transition temperature increases as x increases. At the composition x>0.5, spin reorientation starts to appear. Meanwhile, the spin reorientation temperature and the antiferromagnetic Neel temperature gradually separate and widen the temperature range of the magnetic metastable state between these two transitions. The magnetic competition is discussed based on exchange interaction and Dzyaloshinsky-Moriya interaction.[1]

Structural and magnetic properties have been studied in perovskite $Nd_{1-x}Er_xMnO_3$ ($0<x<0.5$). Er^{3+} doping enhances the Jahn-Teller distortion, strongly affects the Nd^{3+}-Mn^{3+} interaction, destroys the intermediate state below the antiferromagnetic transition temperature in $NdMnO_3$, and breaks the antiparallel arrangement between Nd^{3+} and Mn^{3+} spin ordering. The decreasing ferromagnetic component in magnetic hysteresis loops at 30K indicates that the canted angles vary with x. These results offer strong evidence for the interaction between rare earth ions and transition metal ions and competition among rare earth ions as well.[2]

A multiferroic $BiFeO_3$ and $YMnO_3$ multilayer film was deposited on an $SrTiO_3$:Nb substrate using the pulsed laser deposition method. A large perpendicular exchange bias was observed, arising from the cycloid spin structure of the $BiFeO_3$. In addition, at room temperature the film displays a larger magnetic moment than $BiFeO_3$ and $YMnO_3$, as well as ferroelectricity with good retention capability. Large exchange biasing, controlled by the magnetic field cooling history, will introduce one more parameter into the magnetoelectric control of multiferroic multilayers.[3]

We investigate the photo-induced carrier dynamics and spin-lattice interaction in hexagonal $YMnO_3$ film by the temperature-dependent femtosecond pump-probe spectroscopy. The spin-lattice interaction is identified from the slow component of the transient transmittance change with the excitation energies tuned to 1.7 eV and 2.0 eV, which are close to Mn^{3+} ions $d_{(xy),(yz)}$-d_z^2 and $d_{(x^2-y^2)',(xy)}$-d_z^2 transition, respectively. Temperature dependences of the spin-lattice relaxation parameters demonstrate that the spin-lattice interaction is strongly connected with the d-d transition within Mn3þ ions and enhanced by spin ordering.[4]

$YFeO_3$ single crystal displays two relaxor-like dielectric relaxations, one at low temperature (170_300 K) and one at high temperature (370-520 K), which are attributed to the activation of electrons and oxygen vacancies, respectively. Above the temperature at which electrons are activated, the sample displays a large magnetocapacitance effect. Comparison of the impedance Cole-Cole plots measured with and without applied magnetic field reveals that the occurrence of magnetocapacitance effect is accompanied with an increasing in DC conductivity under magnetic field after the activation of electrons, which is explained by the enhancement of electron jumping in Fe^{2+}-O-Fe^{3+} chains by magnetic field. Thus the magnetocapacitance effect in $YFeO_3$ single crystal can be explained by the combination of the Maxwell-Wagner space charge effect and/or magnetoresistance effect, depending on the frequency range.[5]

Publications:

1. Fang Hong, Zhenxiang Cheng, Hongyang Zhao, Hideo Kimura, Xiaolin Wang, "Continuously tunable magnetic phase transitions in the $DyMn_{1-x}Fe_xO_3$ system", *Applied Physics Letters*, 99 (2011)092502;
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4. Zuanming Jin, Hong Ma, Gaofang Li, Yue Xu, Guohong Ma, and Zhenxiang Cheng, "Ultrafast dynamics of the Mn^{3+} d-d transition and spin-lattice interaction in $YMnO_3$ film", *Applied Physics Letters*, 100 (2012) 021106;
5. Z. X. Cheng,H. Shen, J. Y. Xu, P. Liu, S. J. Zhang, J. L. Wang, X. L. Wang, and S. X. Dou, "Magnetocapacitance effect in nonmultiferroic $YFeO_3$ single crystal", *Journal of Applied Physics Letters*, 111 (2012) 034103.

LINKAGE PROJECTS

PROJECT ID: LP0991012

Title: Development of advanced lithium ion battery and battery management system for electric vehicle/hybrid electric vehicle applications.

Chief Investigators: Z. P. Guo, H. K. Liu, C. Cook, D. Wexler, H. T. Zhu, X. J. Zhu

The potential of using coconut shell, which is very cheap and readily available, for the production of graphitic nanocarbon three-dimensional networks is investigated. The three-dimensional carbon has been produced via the wet-impregnation of coconut shell powder with a transition metal catalyst. The novel process employed offers low costs and environmental advantages, with biological waste used in place of carbonaceous precursor as the feedstock. Nanocarbon/tin oxide composites were prepared via wet-impregnation and the solvothermal method, using tin chloride solution with the activated nanocarbon. One composite made by using the solvothermal method shows stable cyclic retention up to 100 cycles and delivers a high reversible capacity of about 405 mAh g^{-1}.

Nanosized C-LiFePO_4 particles are synthesized by a microwave-assisted solid-state method. A novel conductive agent, Ag/C nanocables, is adopted for the first time to modify C-Li$FePO_4$ so as to improve the electronic conductivity. The electrochemical measurement results indicate that the rate capacity of the Ag/C nanocables-modified C-Li$FePO_4$ is improved due to the nanosized particle distribution and enhanced electronic conductivity.

A simple molten salt method has been employed to prepare nanosize alpha-Fe_2O_3. The as-prepared alpha- Fe_2O_3 is a rhombohedral phase of hematite with crystal size in the range of 20-40 nm. The nanosized alpha- Fe_2O_3 shows excellent cycling performance and rate capability. It also exhibits the feature of capacity increase upon cycling. The outstanding electrochemical performance of the alpha- Fe_2O_3 can be related to several factors, namely, the short Li^+ diffusion length along the porous rhombohedral structures and the nanosized nature of the materials, which decreases the traverse time for electrons and Li^+ ions, and reduces the volume expansion to some extent during charge/discharge reactions.

V_2O_5•nH_2O-graphene composites with different amount of graphene were prepared by mixing and filtration of hydrothermal technique obtained V_2O_5•nH_2O xerogel and graphene. In the composites, the V_2O_5•nH_2O ribbons fell apart into nanoparticles when heated at 200 oC and the graphene formed disorder carbon uniformly coating on the V_2O_5 nanoparticles with a thickness of 3 – 5 nm. Graphene content in the composites played an important role in structure, morphology and electrochemical performance. The composite with 39.6% graphene exhibited outstanding performance for lithium ion batteries. The nature of easy formation of thin film or paper makes the composites have potential application in miniature cells or flexible devices.

Publications:

1. Mohd Faiz Hassan, Zaiping Guo, et al., "α–Fe2O3 as an anode material with capacity rise and high rate capability for lithium-ion batteries", *Materials Research Bulletin*, 46, 858 (2011)
2. Z.F. Dong, Y.D. Huang, D.Z. Jia, Z.P. Guo, "Preparation and performance comparison of LiMn2O3.95Br0.05 and LiMn2O3.95Br0.05/SiO2 cathode materials for lithium ion battery", *J. Solid State Electrochem. 15*, 725 (2011). (IF=2.234)
3. G.D. Du, B. Wan, Z.P. Guo, et al., "Effect of Annealing on Electrochemical Performance of Anodized TiO2 Nanotubes for Lithium Ion Batteries", *Advanced Science Letter*, 4, 469 (2011).
4. Y.D. Huang, R.R. Jia, D.Z. Jia, Z.P. Guo, "Preparation, microstructure and electrochemical performance of nanoparticles LiMn2O3.9Br0.1", *Materials Letters*, 65, 3486 (2011).
5. S.Q. Wang, et al. "Solvothermal synthesis of Mn2P2O7 and its application in lithium-ion battery", *Materials Letters*, 65, 3265 (2011).
6. G.D. Du, K.H. Seng, Z.P. Guo, et al., "Graphene-V2O5•nH2O xerogel composite cathodes for lithium ion batteries", *RSC Advances*, 1, 690 (2011).
7. Y.D. Huang, D. Li, D.Z. Jia, Z.P. Guo, et al. "Preparation and characterization of Ag/C nanocables modified nanosized C-LiFePO4", *J. Nanopart. Res*., 13, 4815 (2011) (IF=3.25)
8. C.F. Zhang, M. Quince, Z.X. Chen, Z.P. Guo, et al, "3-Dimensional Nanocarbon and the Electrochemistry of Nanocarbon/Tin Oxide for Lithium Ion Batteries", *J. Solid-State Electrochemistry*, 15, 2645-2652 (2011). (IF=2.234)

PROJECT ID: LP100100802

Title: Room Temperature Rechargeable Sulphur Batteries.

Chief Investigators: J. Z. Wang, H. K. Liu, K. Konstantinov, Z. X. Wang

(1) NiS cathode materials

Nanocrystalline α-NiS-β-NiS powder has been successfully synthesized in a simple microwave autoclave within a short period of time. The results indicate that hexagonal NiAs-type α-NiS phase can be partially converted to a β–NiS millerite like

secondary phase with increasing heat-treatment temperature. In a sample prepared at 160°C, a duplex crystallite size (α-NiS ~ 47 nm and high surface area β-NiS ~ 35 nm) is observed. Electrochemical testing demonstrates that the sample synthesized at 160°C has a high reversible capacity with good rate capability. This finding strongly suggests that the synthesis process is very simple and convenient, and also requires only a low-treatment temperature and a very short period of time as well. The motivation for using this method is to decrease the reaction time as compared to the conventional hydrothermal method. Therefore, the electrical energy consumption for materials synthesis is significantly reduced.

(2) Ball-milled sulfur cathode

Small particle size sulfur with porous structure was produced by simple ball milling of elemental sulfur. The porous structure sulfur significantly enhanced the specific particle surface area that results in increasing the interface area between electroactive species S and electrolyte, as well as effectively preventing polysulfide solubilization in the rechargeable lithium-sulfur cell. The cell shows a significantly improvement of capacity and cycle life compared to the commercial S electrode.

(3) S-CNT-PPy composite

S-CNT-PPy composite was synthesized using two steps methods. Firstly, sulfur particles was synthesized by an acid catalyzed precipitation of sodium thiosulphate in MCNTs suspension solutions. The sulfur coated on MCNTs to form S-MCNTs composite. Comparing with physical vapour coating, the advantage of using the chemical reaction to load S on the MCNTs is that the S-MCNTs composite has a high loading (94%) of active material (S). Secondly, PPy was coated on the S-MCNTs composite using chemical polymerization method. The physical and electrochemical characterization has been conducted. The electrochemical results show that the composite significantly improved the electrical conductivity, the capacity, and the cycle stability in a lithium cell compared with the bare sulfur electrode.

(4) PPy-S-PPy composite

The sandwich-like PPy-S PPy composites have been synthesized. The physical and electrochemical characterizations are under testing.

Publications:

1. J. Z. Wang, L. Lu, M. Choucair, J. A Stride, X. Xu, H. K. Liu, "Sulfur-graphene composite for rechargeable lithium batteries", *J. Power Sources*, 196 (2011) 7030–7034.
2. Nurul Hayati Idris, Md Mokhlesur Rahman, Shu-Lei Chou, Jia-Zhao Wang, David Wexler, Hua-Kun Liu, "Rapid synthesis of binary α-NiS–β-NiS by microwave autoclave for rechargeable lithium batteries", *Electrochimica Acta,* 58 (2011) 456– 462.
3. Bo Zhang, Xuan-Wen Gao, Jia-Zhao Wang, Shu-Lei Chou, Konstantin Konstantinov, Hua-Kun Liu, "CuS Nanoflakes, Microspheres, Microflowers, and Nanowires: Synthesis and Lithium Storage Properties", *Journal of Nanoscience and Nanotechnology*. (Accepted)

PROGRESS REPORT: LP100100440

Title: Design, build and test a fault current limiter employing magnesium diboride (MgB_2) superconducting coils

Chief Investigators: S. X. Dou, J. Horvat, X.Xu, J. W. Moscrop

Progress: The primary simulations of electromagnetic, thermal and structural design of MgB_2 coil with COMSOL and Solid Works are finished. Negotiations with Hyper tech resulted in availability of their high performance multi-filaments MgB_2 wire for our prototype MgB_2 coil. The construction order is being prepared. The decision has been made to implement a single-stage, conduction-cooled MgB_2 coil. The thermal design of cryostat is in review stage, and the production order will be send before 2/2012. The Solid State Quench Protection method was designed, and some testing will be done when the HTS Lab in the AIIM P&D building is ready. Knowing accurate value of critical current (I_c) of the wire to be used in the MgB_2 coil is very important for the design. However the measurements of I_c suffer from many inaccuracies. We developed a method for accurate determination of Ic in MgB_2 wires, which will allow for more accurate design of MgB_2 coil. Combination of FEM simulations of the heat flux at the contact between the MgB_2 and current leads and I_c measurements using conventional DC method resulted in a procedure that can give a reliable value of I_c.

Personnel: X. Xu continues his fellowship under the project. K. W. See is supported by UPA scholarship and his contribution is in measuring AC loss and transport properties of the MgB_2 wire that is used in superconducting coil. J. Knott is working on the simulation of thermal properties of the superconducting coil and associated cooling system.

Equipment: System for measuring the AC Loss properties of MgB_2 wires between 20 and 30K was set-up. This system is being retro-fitted with closed circle liquid helium cooling, to save the liquid He consumption. All the supporting equipment that will be needed to run, quench-protect and test the MgB_2 magnet have been ordered: 2x AL325 cry cooler heads, 1x vacuum pump, 1x 600A DC power supply, 1x 200A DC power supply, multiple temperature/magnetic field sensors and PCI eXtensions for Instrumentation.

Publications:

1. See, K., Xu, X., Horvat, J., Cook, C. David. & Dou, S. Xue. (2011). "Transport critical current of MgB_2 wires: pulsed

current of varying rate compared pulsed current of varying rate compared to direct current method". *Superconductor Science & Technology*, (24), 105009 1-105009 8.

PROGRESS REPORT: LP0989352

Title: Development of MgB_2 superconductor magnets for applications.

Chief Investigators: S. X. Dou, X. L. Wang, C. Cook, X. Xu, E. W. Collings, K. C. Chung

The Effects of Graphene Doping on the In-Field J_c of MgB_2 Wires:

The field and temperature dependence of the critical current density Jct were measured for both un-doped and graphene doped MgB_2/Fe wires manufactured by 99.999% Crystalline Boron and 10% excess Magnesium (99%, 325 mesh). At 4.2 K and 10 T, Jct was estimated to be for the wire sintered at 800ºC for 30 minutes, the doped sample is almost improved as one order, compared with the best un-doped sample. At the same time, the temperature dependence of the upper critical field (Hc2) and the irreversibility field (H*irr*)for the samples will also be included from the resistance (R)–temperature (T). A significant increase in the upper critical field is the main cause of the enhancement of the critical current density, Jct, in the high field region. The calculated active crosssectional area fraction (AF represents the connectivity factor between adjacent grains. This value is decreased with wire samples, which is why the improvement of transport Jct is lower than the improvement of magnetic Jcm in diffusion bulk sample.

Graphene micro-substrate-induced p gap expansion in MgB_2:

The lattice effect induced by tensile strain on the superconductivity of graphene–MgB_2 composites was studied systematically to deduce the electron–phonon coupling (EPC) and the multiple superconducting gap behavior. Compared with nano-carbon doped MgB_2, graphene–MgB_2 composites show larger lattice parameters and higher critical superconducting transition temperatures (Tc). The EPC strength of MgB_2 with~ 2 wt.% graphene addition is even higher than that of the pure reference sample, as estimated from the Sommerfeld constant. The π gap was found to be expanded by graphene addition through the analysis of heat capacity data, and it is responsible for both the enhanced EPC strength and the weak dependence of Tc on the graphene content.

Flux pinning mechanisms in graphene-doped MgB2 superconductors:

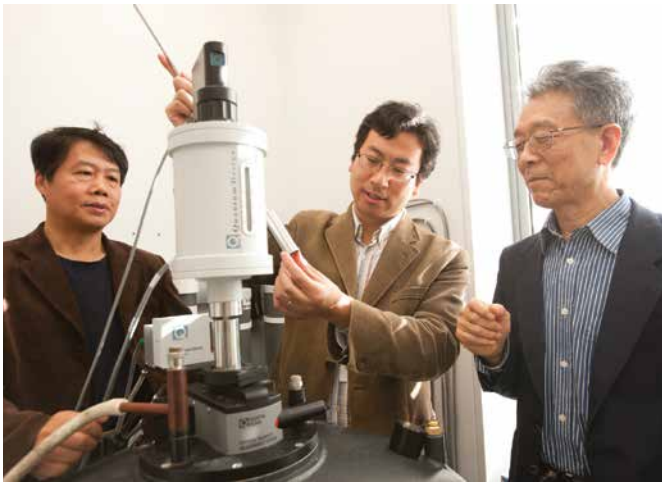
The effects of graphene doping on the superconducting properties of MgB_2 were studied. We found that small addition of graphene significantly improves the superconducting properties of MgB_2, with only a small reduction in Tc. Low resistivity, high critical fields and enhanced flux-flow activation energy were observed for the optimally doped bulk sample. The spatial fluctuation in the transition temperature (δTc pinning) is the flux pinning mechanism in graphene-doped MgB_2.

Evaluation of carbon incorporation and strain of doped MgB2 superconductor by Raman spectroscopy:

Raman spectroscopy is employed to study both the strain and the carbon substitution level in SiC-doped MgB_2 bulk samples. Raman spectroscopy was demonstrated to be a better method to distinguish the individual influences of strain and carbon than standard X-ray diffraction. It is found that the lattice parameter correlation method for C content determination is invalid for highly strained samples. Our result also provides an alternative explanation for lattice variation in non-carbon-doped MgB_2, which is basically due to lattice strain.

Publications:

1. X. Xu et al., Journal of Nanoscience & Nanotechnology *in press* (2012). (ARC ERA Ranking: A)
2. Li.W et al., *Acta Materialia*, 59 (19), 7268 (2011). (ARC ERA Ranking: A)
3. K.S.B. De Silva et al. *Scripta Materialia*, 65(7), 634 (2011). (ARC ERA Ranking: A)
4. W.K. Yeoh et al., *Scripta Materialia* 64, 323 (2011). (ARC ERA Ranking: A*)



CURRENT AND ONGOING RESEARCH PROJECTS

ARC CENTRE OF EXCELLENCE

NANO-MATERIALS FOR ENERGY STORAGE

Years funded:	2010	2011	2012	2013
Amount funded:	$90,000	$90,000	$90,000	$90,000
Project ID:	CE0561616			
Chief Investigator:	H. K. Liu			
Research Fellow:	J. Z. Wang			
Postgraduate Students:	S. L. Chou, MD. M. Rahman, N. Idris, C. Zhong, L. Neorochim, S. Li, I. Sultana			

ARC SUPER SCIENCE FELLOWSHIP

THREE DIMENSIONAL POLYMER STRUCTURES FOR BIONIC APPLICATIONS

Years funded:	2010	2011	2012	2013
Amount funded:	$93,000	$186,000	$186,000	$93,000
Project ID:	FS100100023			
Chief Investigators:	G. G. Wallace, S. E. Moulton, R. M. I. Kapsa, D. L. Officer, H. K. Liu			

ARC DISCOVERY PROJECTS

CURRENT LIMITING MECHANISMS IN MAGNESIUM DIBORIDE SUPERCONDUCTORS

Year Funded:	2007	2008	2009	2010	2011
Amount funded:	$320,000	$330,000	$390,000	$180,000	$210,000
Total Funding:	$1,430,000				
Project ID:	DP0770205				
Chief Investigator:	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.

GIANT MAGNETOCALORIC MATERIALS AND ROOM TEMPERATURE REFRIGERATION

Years Funded:	2008	2009	2010	2011
Amount funded:	$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.

TAILORING SUPERCONDUCTING HYBRID MULTILAYERED FILM SYSTEMS FOR ELECTRIC AND ELECTRONIC APPLICATIONS

Years Funded:	2008	2009	2010	2011	2012
Amount funded:	$165,000	$164,000	$159,000	$120,000	$105,000
Total Funding:	$713,000				
Project ID:	DP0879933				
Chief Investigator:	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 revolutionising 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.

FRUSTRATED MAGNETS: A NEW PLATFORM FOR MULTIFERROIC MATERIALS

Years Funded:	2009	2010	2011
Amount funded:	$160,000	$115,000	$115,000
Total Funding:	$390,000		
Project ID:	DP0987190		
Chief Investigators:	X. L. Wang, Z. X. Cheng, D. P. Chen		
Partner Investigators:	T. Kimura, F. Klose		

Project Summary: Ferroelectric materials with simultaneous ferroelectricity and ferromagnetism are one of the most important new emerging fields in the materials science and condensed matter physics communities. Novel magneto-electronic devices based on new multiferroic materials will open up a huge market for these devices, which are expected to have a huge impact on modern science and daily life. The purpose of this project is to make Australia one of the leading countries in this field and to work with colleagues in Australia and around the world to move this field forward for mutual benefit.

BETTER EMITTERS, ENHANCED OPTICS, SUPERIOR DETECTORS: ADVANCING TERAHERTZ SCIENCE AND TECHNOLOGY FOR APPLICATIONS IN MEDICINE, AGRICULTURE, INDUSTRY AND NATIONAL SECURITY

Years Funded:	2009	2010	2011
Amount funded:	$120,000	$90,000	$90,000
Total Funding:	$300,000		
Project ID:	DP0984200		
Chief Investigators:	R. A. Lewis, J. Horvat		
Partner Investigator:	W. Xu		

Project Summary: We will start with a new fundamental study of the interaction of light and matter to explicate the phenomena of the emission, transmission and detection of terahertz electromagnetic radiation. Using our increased understanding of terahertz science, we will the engineer better terahertz sources, optics, and sensors. Getter terahertz technology will open up new applications in medical diagnosis, especially dermatology; industrial productivity, such as quality control; and the detection of contraband, including illicit drugs and explosives. In maintaining good health, transforming industries and safeguarding Australia, advanced terahertz systems will bring the nation health, economic and security benefits.

DEVELOPMENT OF INORGANIC-CONDUCTING POLYMER COMPOSITES AND IONIC LIQUID BASED ELECTROLYTES FOR RECHARGEABLE LITHIUM BATTERIES

Years Funded:	2009	2010	2011
Amount funded:	$110,000	$110,000	$110,000
Total Funding:	$330,000		
Project ID:	DP0987805		
Chief Investigator:	J. Z. Wang		

Project Summary: The project will lead to development of safe lithium batteries for electric vehicles and hybrid electric vehicles to contribute to the national priority goal of reducing and capturing emissions in transport to improve our environment. Small, flexible batteries for new implantable medical devices will also be developed to treat millions of people suffering from different diseases. The development of new scientific knowledge related to this project will place Australia at the forefront of an emerging domain of research. The projects will take the incentive in establishing a leading national position in development of new energy storage technology.

NEW DIRECTIONS TO MINIATURISED POWER SOURCES: INTEGRATED ALL-SOLID-STATE RECHARGEABLE BATTERIES

Years Funded:	2010	2011	2012	2013	2014
Amount funded:	$135,000	$145,000	$140,000	$160,000	$120,000
Total Funding:	$700,000				
Project ID:	DP1094261				
Chief Investigators:	Z. P. Guo, Z. Chen				
Partner Investigators:	J .Dahn, J. Chen				

Project Summary: This project will lead to the development of safe integrated all-solid-state miniaturised lithium ion batteries for small autonomous devices, such as implantable medical devices, hearing aids, small autonomous devices with sensing and actuation, and for communications and rapid chemical/biological analysis. This will make a significant contribution to the nation in the areas of science, technology, health, and the economy. The development of new scientific knowledge related to this project will place Australia at the forefront of an emerging domain of research. The project will also provide excellent training for postgraduate students and young researchers to develop their skills in chemistry, materials science and battery technology.

DIRECTED ASSEMBLY AND PHOTOELECTRIC PROPERTIES OF CORE-SHELL NANOWIRE NETWORKS OF PBSE-TIO_2 HETEROSTRUCTURES FOR HIGH EFFICIENCY LOW-COST SOLAR CELLS

Years Funded:	2010	2011	2012
Amount funded:	$100,000	$95,000	$105,000
Total Funding:	$300,000		
Project ID:	DP1096546		
Chief Investigators:	J. H. Kim, Y. Zhao, X. Zhu, Z Sun		
Partner Investigators:	Y. Kang, G. Ramanath		

Project Summary: The proposed program is aimed at studying numerous fundamental properties and phenomena of photo-electrochemical cells that have an important impact on environmentally friendly solutions to energy problems. Specifically, solar cells have a significant role in energy markets and in lessening CO_2 emissions and other environmental impacts. Solar cell technology, coupled with renewable energy sources, has the potential to provide a long-term solution to the energy crisis and the global warming threat. In addition, the strong team to be assembled will reach a leading position in this area of cutting edge technology. The outcomes will benefit Australian industries.

ADVANCED NANOSTRUCTURED CERAMIC COMPOSITES FOR ULTRACAPACITORS

Years Funded:	2010	2011	2012
Amount funded:	$90,000	$90,000	$90,000
Total Funding:	$270,000		
Project ID:	DP1093952		
Chief Investigators:	K. K. Konstantinov, H. K. Liu, A .Calka, D. Wexler		

Project Summary: The global climate changes and the related disastrous events such as heat flows, bushfires, and flooding will endanger Australian population and our natural environment. The implementation of effective devices and technologies to reduce our carbon footprint is a priority task. The project addresses the issue by development of new ultracapacitor materials for next generation green energy storage devices through engineering and implementation of advanced nanoceramics and nanocomposites created by innovative nanotechnologies. The project will also contribute to other national research priorities such as materials and frontier technologies, reduction of atmospheric pollution, and decrease in the energy dependence of our country on oil.

MATERIALS SCIENCE AND SUPERCONDUCTIVITY IN THE NEW FE-BASED HIGH TEMPERATURES SUPERCONDUCTORS

Years Funded:	2010	2011	2012	2013
Amount funded:	$155,000	$150,000	$150,000	$100,000
Total Funding:	$555,000			
Project ID:	DP1094073			
Chief Investigators:	X. L. Wang, G. Peleckis, D. Chen			
Partner Investigators:	H. Hosono, X. Chen, K. H. Muller, E. Muromachi, A. J. Studer			

Project Summary: Novel superconducting materials with high superconducting transition temperature and upper critical field are one of the most important research fields in the community of materials science and condensed matter physics. Any significant breakthrough in Fe-based superconductors will result in exotic physics and possible novel superconducting electronic devices, and will have the potential for ground-breaking research. The purpose of this project is to bring Australia to the forefront of this field and to work with world leading researchers within Australia and worldwide to make advancements in this field.

NEW APPROACH TO CONTROL GRAIN BOUNDARY BEHAVIOUR IN SUPERCONDUCTING THIN FILMS

Years Funded:	2011	2012	2013
Amount funded:	$70,000	$70,000	$70,000
Total Funding:	$210,000		
Project ID:	DP110100398		
Chief Investigators:	A. V. Pan, O. V. Shcherbakova, S. H. Zhou, I. P. Nevirkovets		
Partner Investigators:	K. H. Muller, T. H. Johansen, H. Hilgenkamp		

Project Summary: This project aims at finding a new approach to overcome the cornerstone problem of high temperature superconducting films through new design, magnetic interactions, and real-time magnetic flux visualisation at the quantum level. The expected ultimate achievement would be to develop new technologies, delivering the best performance of the films.

A NOVEL HYBRID ELECTROCHEMICAL ENERGY SYSTEM FOR BOTH HIGH ENERGY AND HIGH POWER

Years Funded:	2011	2012	2013
Amount funded:	$90,000	$90,000	$90,000
Total Funding:	$270,000		
Project ID:	DP110103909		
Chief Investigators:	J. Z. Wang, S. L. Chou, H. J. Li		
Partner Investigators:	Y. P. Wu, K. Ozawa		

Project Summary: This project will lead to the development of a new energy-storage system by integrating the advantages of the lithium battery and the supercapacitor. The development of new scientific knowledge during this project will significantly enhance the international competitiveness of Australia in the area of energy storage.

FUTURE FELLOWSHIP

MANIPULATION OF SPIN BY ELECTRIC FIELD

Years Funded:	2009	2010	2011	2012	2013
Amount funded:	$86,000	$172,000	$172,000	$172,000	$86,000
Total Funding:	$688,000				
Project ID:	FT0990391				
Chief Investigator:	Z. X. Cheng				

Project Summary: Spin manipulation is one of the most challenging topics in the new emerging spintronics technology. This project will develop a novel solution for the problem of spin manipulation and falls into the National Research Priority: Frontier Technologies for Building and Transforming Australian Industries. This project will provide training for postgraduate students and develop patentable science and technologies. The successful accomplishment of this project will consolidate the knowledge and technology background that is needed for Australia to develop the next generation of spin-base electronics. In the long term, spin-based electronics with high efficiency and very low energy consumption will benefit the Australian manufacturing industry.

ARC LINKAGE PROJECTS

DEVELOPMENT OF ADVANCED LITHIUM ION BATTERY AND BATTERY MANAGEMENT SYSTEM FOR ELECTRIC/HYBRID ELECTRIC VEHICLE APPLICATIONS

Year Funded:	2009	2010	2011	2012
Amount funded:	$40,000	$80,000	$80,000	$40,000
Total Funding:	$240,000			
Project ID:	LP0991012			
Chief Investigators:	Z. P. Guo, H. K. Liu, C. D. Cook, D. Wexler			
Partner Investigators:	H. Zhu, X. J. Zhu			
Industry Partners:	Redarc Electronics, DLG Battery Co. Ltd.			

Project Summary: This project represents a significant scientific and economic development for advanced, high performing energy storage devices with a focus on safety that will provide enormous benefits for the environment. An added advantage will be the establishment of local and national expertise in the area of electrochemical energy storage systems that will place Australia at the forefront of lithium ion battery research and development. Flow-on benefits will also be created for Australian organisations involved in the manufacturing of electric vehicles and portable devices.

MAGNESIUM DIBORIDE SUPERCONDUCTOR MAGNETS FOR APPLICATIONS

Year Funded:	2009	2010	2011
Amount funded:	$100,000	$100,000	$100,000
Total Funding:	$300,000		
Project ID:	LP0989352		
Chief Investigators:	S. X. Dou, X. L. Wang, C. D. Cook, X. Xu		
Partner Investigator:	E. W. Collings		
Industry Partners:	HyperTech Research Inc., R&D Centre Zenergy Ltd.		

Project Summary: The proposed development of magnesium diboride magnets is one of the core technologies that underlie applications in magnetic resonance imaging, magnetic separators, and other devices. The proposed international research consortium is in a leading position to explore the potential of these superconductor magnets for various applications. A breakthrough in the current proposal will lead to widespread commercial activities in a number of industry sectors: mineral separation, health, electric power, transportation, water purification, drug delivery, and space/aviation. Application of the proposal's outcomes will lead enormous energy savings and environmental benefits.

DESIGN, BUILD AND TEST A FAULT CURRENT LIMITER EMPLOYING MAGNESIUM DIBORIDE (MGB_2) SUPERCONDUCTING COILS

Year Funded:	2010	2011	2012
Amount funded:	$195,000	$190,000	$195,000
Total Funding:	$580,000		
Project ID:	LP100100440		
Chief Investigators:	S. X. Dou, J. Horvat, X. Xu, J. W. Moscrop		
Industry Partner:	Zenergy Power Pty Ltd.		

Project Summary: Recent occurrences of blackouts around the world caused immeasurable damage to electrical network hardware in the range of $10 million; however, the losses from an unavailable network are much more. The CIs and Zenergy Power Pty Ltd (formerly Australian Superconductors) have been developing saturated core fault current limiters (FCL) since 1999. The first saturated core fault current limiter employing the Australian entity's technology was installed in California. The aim of this proposal is to extend this technology to demonstrate next generation FCL using newly developed superconductor magnesium diboride (MgB_2) wire which is cheaper and easier to manufacture than high temperature superconductors and the CI's group hold strong IP on nano-scale chemically doped MgB_2 wires.

ROOM TEMPERATURE RECHARGEABLE SULPHUR BATTERIES

Years Funded:	2010	2011	2012
Amount funded:	$70,000	$58,000	$100,000
Total Funding:	$228,000		
Project ID:	LP100100802		
Chief Investigators:	J. Z. Wang, H. K. Liu, K. K. Konstantinov		
Partner Investigator:	Z. X. Wang		
Industry Partners:	DLG Battery Co Ltd, Nipress Tbk Pt		

Project Summary: The project will lead to the development of low cost sulphur rechargeable batteries for electric vehicles and hybrid electric vehicles and will contribute to the national priority goal of reducing and capturing emissions in transport to improve our environment. The project will take the incentive in establishing a leading national position in the development of low cost energy storage technology. The partner organisation, Nipress, has close connection to Australia. The company has imported raw materials (metal lead, 8000 tons) from Australia every year. The success of sulphur batteries technology will increase the opportunity of Nipress using more Australian raw materials.

URC SMALL GRANTS & ARC NEAR-MISS GRANTS 2011

COST-EFFICIENT SURFACE ENGINEERING ON LIGHT METALS/ALLOYS

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

DEVELOPMENT OF HIGH-T_c SUPERCONDUCTING SINGLE PHOTON DETECTORS

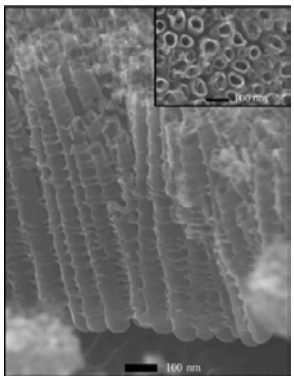
Total Funding:	$9,000
Chief Investigators:	O. V. Shcherbakova

REVEAL THE FLUX PINNING MECHANISMS OF GRAPHENE DOPED MGB_2 SINGLE CRYSTALS BY VAPOUR TRANSPORT METHOD WITH OPTICAL FLOATING ZONE SYSTEMS

Total Funding:	$7,000
Chief Investigators:	X. Xu

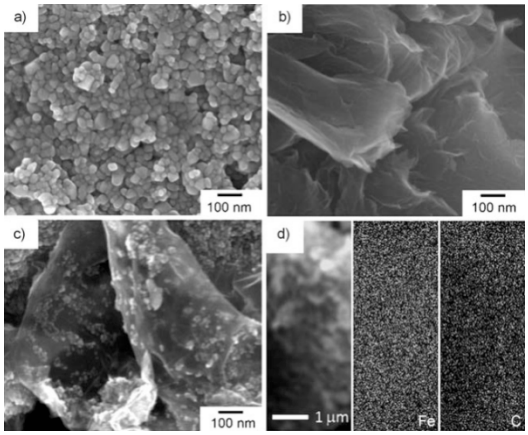
SELECTED ABSTRACTS

ENHANCEMENT OF THE CAPACITANCE IN TIO_2 NANOTUBES THROUGH CONTROLLEDINTRODUCTION OF OXYGEN VACANCIES



The many applications of high energy storage devices have forged an increasing interest in research areas related to electrochemical capacitors. Here, in this work, we present a facile method for the fabrication of self-organized titania nanotubes grown by anodic oxidation of titanium foil with different subsequent heat-treatment regimes for use as binder-free working electrodes in supercapacitor applications. The capacitance of these highly ordered titania nanotubes, when exposed to a reductive atmosphere during annealing, was determined to be well above 900 μFcm-2, confirming that the capacitance contribution was pseudocapacitive in nature. The behaviour of oxygen depleted titania in the anatase to rutile (A/R) phase transformation and also in electrochemical charge storage has been studied in detail. It was found that upon the reduction of Ti4+ to Ti3+, with oxygen depletion of the structure, the A/ R phase transformation was promoted. In addition, the fabricated electrodes showed highly reversible charge–discharge stability. (M. Salari et al., *Journal of Materials Chemistry* 21, 5128 (2011))

GRAPHENE-ENCAPSULATED FE_3O_4 NANOPARTICLES WITH 3D LAMINATED STRUCTURE AS SUPERIOR ANODE IN LITHIUM ION BATTERIES

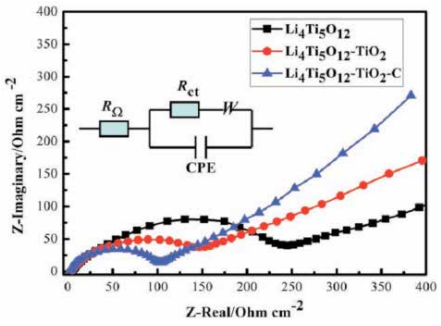


Fe_3O_4-graphene composites with three-dimensional laminated structures have been synthesised by a simple in situ hydrothermal method. From field-emission and transmission electron microscopy results, the Fe_3O_4 nanoparticles, around 3-15 nm in size, are highly encapsulated in a graphene nanosheet matrix. The reversible Li-cycling properties of Fe_3O_4-graphene have been evaluated by galvanostatic discharge-charge cycling, cyclic voltammetry and impedance spectroscopy. Results show that the Fe_3O_4-graphene nanocomposite with a graphene content of 38.0 wt% exhibits a stable capacity of about 650 mAhg-1 with no noticeable fading for up to 100 cycles in the voltage range of 0.0-3.0 V. The superior performance of Fe_3O_4-graphene is clearly established by comparison of the results with those from bare Fe_3O_4. The graphene nanosheets in the composite materials could act not only as lithium storage active materials, but also as an electronically conductive matrix to improve the electrochemical performance of Fe3O4. (J. Z. Wang et al., *Chemistry – A European Journal* 17, 661 (2011))

SNSB/GRAPHENE COMPOSITE AS ANODE MATERIALS FOR LITHIUM ION BATTERIES

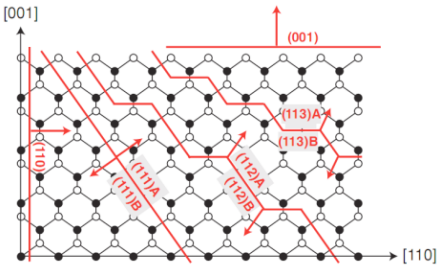
SnSb/graphene porous three dimensional (3-D) composite with dual buffering capability was prepared by an in situ chemical reduction of $SnCl_2$, $SbCl_3$, and graphene oxide prepared using a modified Hummers' method. Field emission scanning electron microscope and transmission electron microscope images shows that the SnSb nanoparticles were distributed homogenously across the surface of the graphene sheets, and some were also found trapped in the corrugated graphene structure. The electrochemical performances of the SnSb/graphene composite was investigated by cyclic voltammetry and galvanostatic charge/discharge testing. The SnSb/graphene composite delivered 688 mAh/g at the 2nd cycle (compared to a calculated theoretical value of 768 mAh/g) and shows good capacity retention of 420 mAh/g after 100 cycles. A reaction model to explain the dual buffering effects of SnSb/graphene composite as anode material for lithium insertion and extraction has been proposed. (K. H. Seng et al., *Advanced Science Letters* 4, 18 (2011))

AMORPHOUS CARBON COATED HIGH GRAIN BOUNDARY DENSITY DUAL PHASE $LI_4TI_5O_{12}$-TIO_2: A NANOCOMPOSITE ANODE MATERIAL FOR LI-ION BATTERIES



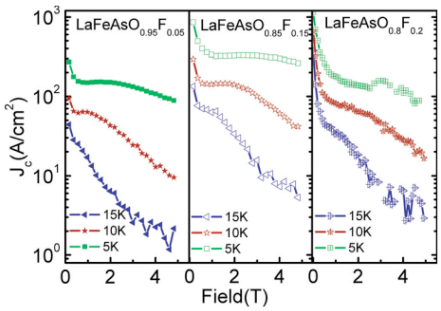
This work introduces an effective, inexpensive, and large-scale production approach to the synthesis of a carbon coated, high grain boundary density, dual phase $Li_4Ti_5O_{12}$-TiO_2 nanocomposite anode material for use in rechargeable lithium-ion batteries. The microstructure and morphology of the $Li_4Ti_5O_{12}$-TiO_2-C product were characterized systematically. The Li4Ti5O12-TiO2-C nanocomposite electrode yielded good electrochemical performance in terms of high capacity (166 mAh g-1 at a current density of 0.5 C), good cycling stability, and excellent rate capability (110 mAh g-1 at a current density of 10 C up to 100 cycles). The likely contributing factors to the excellent electrochemical performance of the $Li_4Ti_5O_{12}$-TiO_2-C nanocomposite could be related to the improved morphology, including the presence of high grain boundary density among the nanoparticles, carbon layering on each nanocrystal, and grain boundary interface areas embedded in a carbon matrix, where electronic transport properties were tuned by interfacial design and by varying the spacing of interfaces down to the nanoscale regime, in which the grain boundary interface embedded carbon matrix can store electrolyte and allows more channels for the Li+ ion insertion/extraction reaction. This research suggests that carbon-coated dual phase $Li_4Ti_5O_{12}$-TiO_2 nanocomposites could be suitable for use as a high rate performance anode material for lithium-ion batteries. (M. M. Rahman et al., *Advanced Energy Materials* 1, 212 (2011))

BULK AND SURFACE FIELD-INDUCED OPTICAL RECTIFICATION FROM (11N) ZINCBLENDE CRYSTALS IN A QUASIREFLECTION GEOMETRY



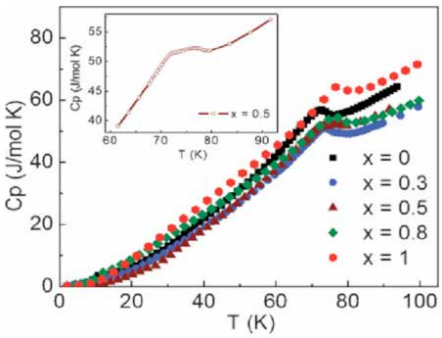
In a previous article, we presented a generalized expression for second-order bulk and third-order surface-field-induced optical rectification for zincblende (4) over bar 3m crystal faces with arbitrary Miller indices (hkl) along with experimental data for (11N)A and (11N)B GaAs in transmission geometry. We now expand the results to quasireflection geometry, with angles of incidence and detection of 45 degrees. While this geometry introduces a p-polarized signal component due to mechanisms other than optical rectification, such as photocarrier acceleration by the surface depletion field, the azimuthal angle dependence of the optical rectification component yields further insight into the crystallographic orientation and surface properties of the sample. K. Radhanpura et al., *Physical Review B* 83, 125322 (2011))

UPPER CRITICAL FIELD AND THERMALLY ACTIVATED FLUX FLOW IN $LAFEASO_{1-X}F_X$



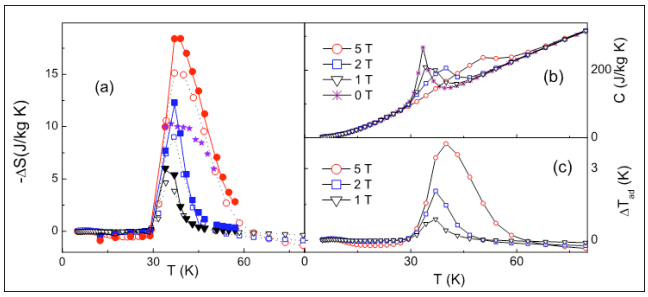
The magneto-resistance, critical current density, Jc, upper critical field, H_{c2}, and flux pinning properties of $LaFeAsO_{1-x}F_x$ superconductors were investigated systematically by magnetic and magneto-transport measurements in the fields up to 13 T over a temperature range of 5-35 K. It was found that the H_{c2} increased with increasing fluorine concentration up to x <= 0.15, while with higher fluorine doping, H_{c2} decreased. A peak effect in the J(c) as a function of field was observed at T < 15 K for both the 5% and 15% fluorine doped samples. The broadening of the superconducting transition in magnetic field can be well understood by the thermally activated flux flow model. The pinning potential, U-o, scales as U-o/k(B) proportional to B-n with n = 0.13 for B < 1 T and n = -0.68 for B > 1 T for $LaFeAsO_{0.85}F_{0.15}$. (M. Shahbazi et al., *Journal of Applied Physics* 109, 07E162 (2011))

STRUCTURAL, DIELECTRIC, ANTIFERROMAGNETIC, AND THERMAL PROPERTIES OF THE FRUSTRATED HEXAGONAL $HO_{1-X}ER_XMNO_3$ MANGANITES



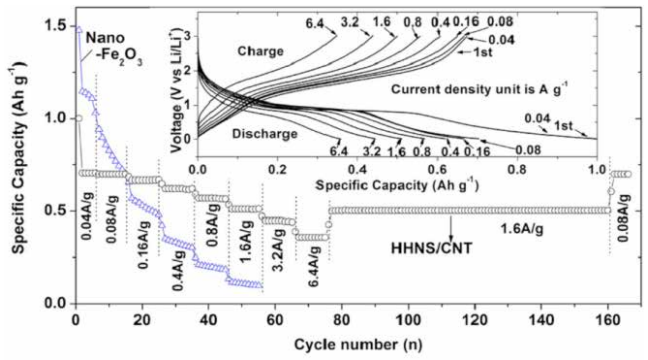
The Er doping effects on the structural, dielectric, ferroelectric, magnetic, and thermal properties of the hexagonal $Ho_{1-x}Er_xMnO_3$ (0 <= x <= 1) compounds synthesized by the solid-state reaction method have been investigated by Rietveld refinement and by measurements of dielectric constant, ferroelectric hysteresis loops, magnetic susceptibility, and specific heat. The a lattice parameter decreases as the Er content increases, whereas the c lattice parameter nearly keeps constant with pretty minor fluctuations. Dielectric data and ferroelectric hysteresis loops show all the samples are not only ferroelectric materials with leaky nature, but also with dielectric relaxation related to oxygen vacancies. The magnetizations of these compounds gradually decrease with increasing Er content. The Mn^{3+} ions in each sample remain stable in the high-spin state in the MnO_5 trigonal bipyramidal crystal field. Specific heat measurements show that the antiferromagnetic transition temperature continuously rises from 72 K for $HoMnO_3$ to 76 K for $ErMnO_3$. The Debye temperatures are 381 K for $ErMnO_3$ and 422 K for $HoMnO_3$. (P. Liu et al., *Physical Review B* 83, 144404 (2011))

MAGNETOCALORIC EFFECT IN LAYERED $NDMN_2GE_{0.4}SI_{1.6}$



A giant magnetocaloric effect has been observed in $NdMn_2Ge_{0.4}Si_{1.6}$ associated with the first-order magnetic phase transition from antiferromagnetism to ferromagnetism around Tc=36 K. The magnetic entropy change -Delta S-M and adiabatic temperature change Delta T-ad have been determined from magnetization and specific heat measurements (B=0-5 T) with -Delta S-M calculated by the Maxwell relation and Clausius-Clapeyron method. The values -Delta S-M(max) = 12.3 J kg-1K-1 and refrigerant capacity similar to 95 J/kg for Delta B=0-2 T as derived from the Maxwell relation, together with the small hysteresis (thermal < 0.5 K; magnetic field < 0.1 T), indicate the potential of $NdMn_2Ge_{0.4}Si_{1.6}$ for refrigeration applications. (J. L. Wang et al., *Applied Physics Letters* 98, 232509 (2011))

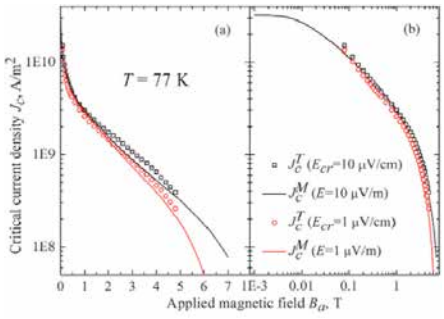
HOLLOW HEMATITE NANOSPHERE/CARBON NANOTUBE COMPOSITE: MASS PRODUCTION AND ITS HIGH-RATE LITHIUM STORAGE PROPERTIES



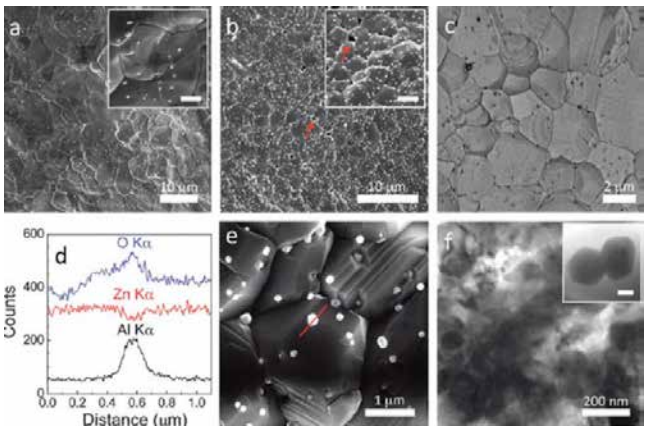
Spray pyrolysis was used to produce hollow hematite (alpha-Fe_2O_3) nanosphere (HHNS)/carbon nanotube (CNT) composite on a large scale. The method offers simplicity, high productivity, versatility, low cost, and suitability for industry. The structure is composed of hollow nanospheres in a network of CNTs. The possible formation mechanism of hollow alpha-Fe_2O_3 nanospheres is due to the rapid evaporation of water and the super-hydrophobicity of the CNT surface. The electrochemical tests show that the HHNS/CNT composite is a promising lithium storage material in terms of high capacity (similar to 700 mAhg-1), good high-rate capability, and good cycle life (up to 150 cycles). The materials improve both lithium ion and electron transport, which are limiting factors on the high-rate capability of lithium-ion batteries. The production method can be easily adapted to produce a wide range of hollow metal oxide nanosphere/CNT composites. (S. L. Chou et al., *Nanotechnology* 22, 265401 (2011))

AN ALL-FIELD-RANGE DESCRIPTION OF THE CRITICAL CURRENT DENSITY IN SUPERCONDUCTING YBCO FILMS

A new critical current density (J(c)) model for high-quality YBCO ($YBa_2Cu_3O_7$) thin films has been proposed, combining thermally activated flux creep with a vortex pinning potential for columnar defects. The pinning for thermally activated vortices has been described as strong pinning on chains of individual edge dislocations that form low-angle domain boundaries in high-quality YBCO thin films. The model yields an adequate description of the J(c) behaviour over the whole applied field range, as verified by direct measurements of J(c) in YBCO thin films grown by pulsed-laser deposition. It also indicates that the effective pinning landscape changes under the influence of the external conditions. Remarkably, the pinning potential obtained from the model is consistent with the values obtained for columnar defects, which confirms the validity of the overall approach. (I. A. Golovchanskiy et al., *Superconductor Science & Technology* 24, 105020 (2011))

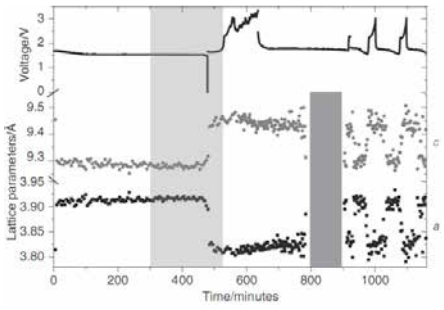


AL-DOPED ZINC OXIDE NANOCOMPOSITES WITH ENHANCED THERMOELECTRIC PROPERTIES



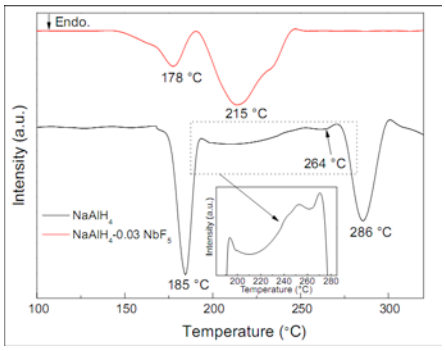
ZnO is a promising high figure-of-merit (ZT) thermoelectric material for power harvesting from heat due to its high melting point, high electrical conductivity sigma, and Seebeck coefficient alpha, but its practical use is limited by a high lattice thermal conductivity kappa(L). Here, we report Al-containing ZnO nanocomposites with up to a factor of 20 lower kappa(L) than non-nanostructured ZnO, while retaining bulklike alpha and sigma. We show that enhanced phonon scattering promoted by Al-induced grain refinement and $ZnAl_2O_4$ nanoprecipitates presages ultralow kappa similar to 2 Wm-1K-1 at 1000 K The high a alpha similar to -300 muVK-1 and high alpha similar to 1-104 Omega-1m-1 result from an offsetting of the nanostructuring-induced mobility decrease by high, and nondegenerate, carrier concentrations obtained via excitation from shallow Al donor states. The resultant ZT similar to 0.44 at 1000 K is 50% higher than that for the best non-nanostructured counterpart material at the same temperature and holds promise for engineering advanced oxide-based high-ZT thermoelectrics for applications. (P. Jood et al., *Nano Letters* 11, 4337 (2011))

BR-DOPED $LI_4TI_5O_{12}$ AND COMPOSITE TIO_2 ANODES FOR LI-ION BATTERIES: SYNCHROTRON X-RAY AND IN SITU NEUTRON DIFFRACTION STUDIES



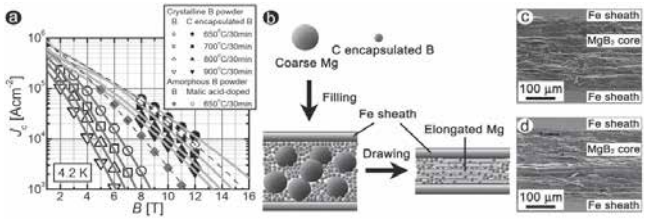
Synchrotron X-ray diffraction data were used to determine the phase purity and re-evaluate the crystal-structure of $Li_4Ti_5O_{12}$-xBrx electrode materials (where the synthetic chemical inputs are x = 0.05, 0.10 0.20, 0.30). A maximum of x' = 0.12 Br, where x' is the Rietveld-refined value, can be substituted into the crystal structure with at least 2% rutile TiO_2 forming as a second phase. Higher Br concentrations induced the formation of a third, presumably Br-rich, phase. These materials function as composite anodes that contain mixtures of TiO2, $Li_4Ti_5O_{12}$-xBrx, and a Br-rich third, unknown, phase. The minor quantities of the secondary phases in combination with $Li_4Ti_5O_{12}$-xBrx where x' similar to 0.1 were found to correspond to the optimum in electrochemical properties, while larger quantities of the secondary phases contributed to the degradation of the performance. In situ neutron diffraction of a composite anatase TiO_2/$Li_4Ti_5O_{12}$ anode within a custom-built battery was used to determine the electrochemical function of the TiO_2 component. The $Li_4Ti_5O_{12}$ component was found to be electrochemically active at lower voltages (1.5 V) relative to TiO_2 (1.7 V). This enabled Li insertion/extraction to be tuned through the choice of voltage range in both components of this composite or in the anatase TiO_2 phase only. The use of composite materials may facilitate the development of multi-component electrodes where different active materials can be cycled in order to tune power output. (G. D. Du et al., *Advanced Functional Materials* 21, 3990 (2011))

IMPROVED HYDROGEN SORPTION PERFORMANCE OF NBF_5-CATALYSED $NAALH_4$



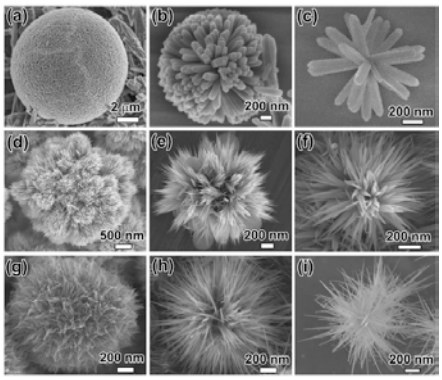
The effect of NbF_5 on the hydrogen sorption performance of $NaAlH_4$ has been investigated. It was found that the dehydrogenation/hydrogenation properties of $NaAlH_4$ were significantly enhanced by mechanically milling with 3 mol% NbF_5. Differential scanning calorimetry results indicate that the ball-milled $NaAlH_4$-0.03NbF_5 sample lowered the completion temperature for the first two steps dehydrogenation by 71 degrees C compared to the pristine $NaAlH_4$ sample. Isothermal hydrogen sorption measurements also revealed a significant enhancement in terms of the sorption rate and capacity, in particular, at reduced operation temperatures. The apparent activation energy for the first-step and the second-step dehydrogenation of the $NaAlH_4$-0.03NbF_5 sample is estimated to be 88.2 kJ/mol and 102.9 kJ/mol, respectively, by using Kissinger's approach, which is much lower than for pristine $NaAlH_4$, indicating the reduced kinetic barrier. The rehydrogenation kinetics of $NaAlH_4$ was also improved with 3 mol% NbF_5 doping, absorbing similar to 1.7 wt% hydrogen at 150 degrees C for 2 h under similar to 5.5 MPa hydrogen pressure. In contrast, no hydrogen was absorbed by the pristine $NaAlH_4$ sample under the same conditions. The formation of Na_3AlH_6 was detected by X-ray diffraction on the rehydrogenated $NaAlH_4$-0.03NbF_5 sample. Furthermore, the structural changes in the NbF_5-doped $NaAlH_4$ sample after ball milling and the hydrogen sorption were carefully examined, and the active species and mechanism of catalysis in NbF_5-doped $NaAlH_4$ are discussed. (J. F. Mao, *International Journal of Hydrogen Energy* 36, 14503 (2011))

TAILORED MATERIALS FOR HIGH-PERFORMANCE MGB_2 WIRE



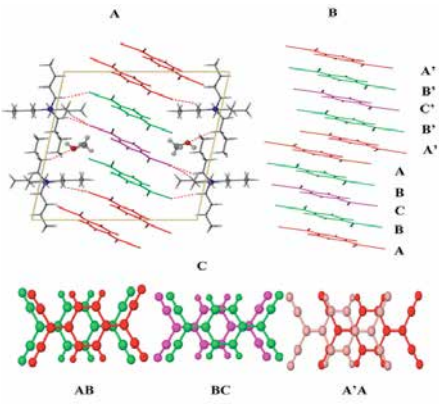
Carbon-encapsulated crystalline boron nanopowder and coarse magnesium powder are used as inexpensive tailored starting materials for the fabrication of high-performance MgB_2 superconducting wire. A low sintering temperature leads to a high critical current density, as a result of nanometer-sized boron powder, surface oxidation preclusion by carbon encapsulation, and grain alignment by elongated magnesium coarse powder. (J. H. Kim et al., *Advanced Materials* 23, 4942 (2011))

RATIONAL DESIGN OF 3D DENDRITIC TIO_2 NANOSTRUCTURES WITH FAVORABLE ARCHITECTURES



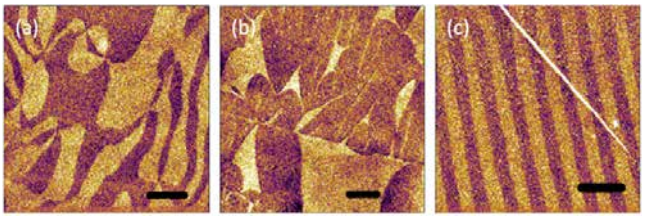
Controlling the morphology and size of titanium dioxide (TiO_2) nanostructures is crucial to obtain superior photocatalytic, photovoltaic, and electrochemical properties. However, the synthetic techniques for preparing such structures, especially those with complex configurations, still remain a challenge because of the rapid hydrolysis of Ti-containing polymer precursors in aqueous solution. Herein, we report a completely novel approach-three-dimensional (3D) TiO_2 nanostructures with favorable dendritic architectures through a simple hydrothermal synthesis. The size of the 3D TiO_2 dendrites and the morphology of the constituent nano-units, in the form of nanorods, nanoribbons, and nanowires, are controlled by adjusting the precursor hydrolysis rate and the surfactant aggregation. These novel configurations of TiO_2 nanostructures possess higher surface area and superior electrochemical properties compared to nanoparticles with smooth surfaces. Our findings provide an effective solution for the synthesis of complex TiO_2 nano-architectures, which can pave the way to further improve the energy storage and energy conversion efficiency of TiO_2-based devices. (Z. Q. Sun et al., *Journal of the American Chemical Society* 133, 19314 (2011))

SYNTHESIS AND STRUCTURAL CHARACTERIZATION OF A TCNQ BASED ORGANIC SEMI-CONDUCTING MATERIAL WITH A 2:5 STOICHIOMETRY



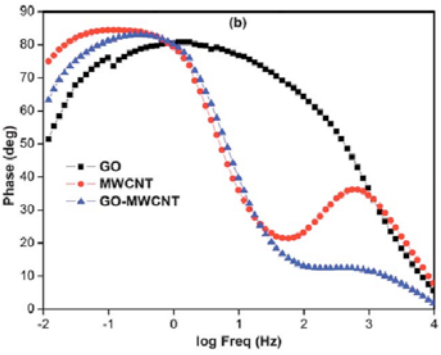
The tetrabutylammonium complex with a 2:5 stoichiometry, (n-Bu_4N)2(TCNQ)5, has been prepared and structurally characterized by X-ray crystallography. Diagnostic bands in the Raman spectrum and signature features in the electrochemistry confirm that the TCNQ moieties are partially charged in the solid state. EPR, magnetic susceptibility, and electrical conductivity measurements are all consistent with (n-Bu_4N)2(TCNQ)5 behaving as a quasi-one-dimensional organic semiconductor. (J. Z. Lu et al., *Journal of Organic Chemistry* 76, 10078 (2011))

DOMAIN WALL CONDUCTIVITY IN OXYGEN DEFICIENT MULTIFERROIC $YMNO_3$ SINGLE CRYSTALS



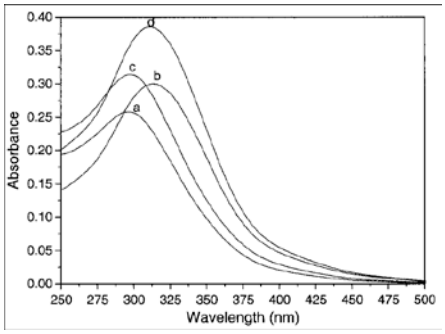
The transport properties of domain walls in oxygen deficient multiferroic $YMnO_3$ single crystals have been probed using conductive atomic force microscopy and piezoresponse force microscopy. Domain walls exhibit significantly enhanced conductance after being poled in electric fields, possibly induced by oxygen vacancy ordering at domain walls. The electronic conduction can be understood by the Schottky emission and Fowler-Nordheim tunnelling mechanisms. Our results show that the domain wall conductance can be modulated through band structure engineering by manipulating ordered oxygen vacancies in the poling fields. (Y. Du et al., *Applied Physics Letters* 99, 252107 (2011))

COMPARISON OF GO, GO/MWCNTS COMPOSITE AND MWCNTS AS POTENTIAL ELECTRODE MATERIALS FOR SUPERCAPACITORS



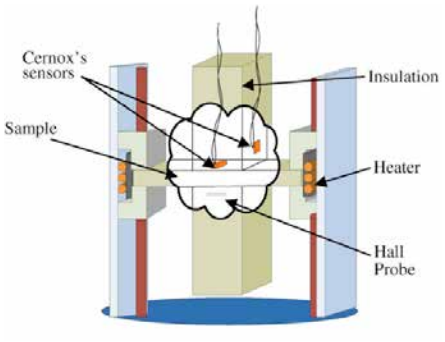
We report the synthesis of graphene oxide/multi-walled carbon nanotube (MWCNT) composites employing an alternative and novel approach for possible application as supercapacitor materials in energy storage devices. Integrating these nanostructures resulted in a strong synergistic effect between the two materials consequently leading to a robust and superior hybrid material with higher capacitance compared to either graphene oxide or MWCNTs. Specific capacitances of 251, 85 and 60 F g-1 were obtained for graphene oxide-multi-walled carbon nanotubes, MWCNTs and graphene oxide, respectively, in a potential range from -0.1 to 0.5 V. Most importantly, a 120% increase in capacitance was observed with increasing cycle number at 20 mV s-1. The ease of synthesis and the exceptional electrochemical properties make the use of this nanostructure an attractive, alternative way of designing future supercapacitors in both conventional fields and new emerging areas. (S. H. Aboutalebi et al., *Energy & Environmental Science* 4, 1855 (2011))

SYNTHESIS AND CHARACTERIZATION OF FE DOPED CeO_2 NANOPARTICLES FOR PIGMENTED ULTRAVIOLET FILTER APPLICATIONS



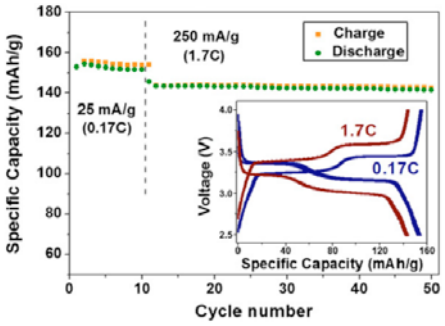
Iron doped CeO_2 nanoparticles with doping concentrations between 0 and 30 mol% were synthesized by the co-precipitation method for potential application as a pigmented ultraviolet filtration material. Each sample was calcined in air and in argon. The iron solubility limit in the CeO_2 lattice was found to be between 10 and 20 mol%. Raman spectroscopy results revealed that both iron doping and argon calcination increase the concentration of oxygen vacancies in the CeO_2 lattice. iron doping causes a blue-shift of the absorbance spectrum, which can be linked to the decreased crystallite size, as obtained by XRD peak broadening using the Scherrer formula. The undoped samples showed weak ferromagnetic behaviour whereas the doped samples were all paramagnetic. (L. Truffault et al., *Journal of Nanoscience & Nanotechnology* 11, 4019 (2011))

INNOVATIVE CALORIMETRIC AC LOSS MEASUREMENT OF HTSC FOR POWER APPLICATIONS



The applications of high-temperature superconductors (HTS) in electric power components have been widely reported and various studies have been made to define their alternating current (AC) losses-a key design parameter for many practical high power electrical engineering applications. However, very few studies over the range 25 to 45 K have been conducted even though this is one of the favored temperature ranges for cost-effective applications of HTS. Methods and techniques used to characterize and measure these losses have been so far grouped into 'electrical' and 'calorimetric' approaches with external conditions set to resemble the application conditions. In this paper, we present an approach using the calorimetric method to accurately determine losses in the superimposed AC and DC fields likely to be experienced in practical devices such as Fault Current Limiters. This technique provides great simplification compared to pick-up coil and lock-in amplifier methods and is applied to a lower temperature range. The preliminary loss data at 40 K will be presented in applied AC magnetic fields with DC fields up to 1T. The data of losses obtained on this sample will allow the estimation and minimization of losses in practical high power HTS coils and will be used in the verification of numerical coil models. (K. W. See et al., *IEEE Transactions on Applied Superconductivity* 21, 3261 (2011))

FREE-STANDING V_2O_5 ELECTRODE FOR FLEXIBLE LITHIUM ION BATTERIES



Free-standing and flexible V_2O_5 films have been prepared by the filtration of ultra-long nanowires synthesized through the hydrothermal technique. In order to improve the conductivity of the films, multiwalled carbon nanotubes (MWCNTs) were added to the V_2O_5 nanowires to form an integrated web-like structure. The structure of the V_2O_5 nanowires was investigated with X-ray diffraction and transmission electron microscopy. The possible use of these films as a cathode for lithium ion batteries was also investigated. The free-standing and flexible film electrodes exhibited good rate capability and excellent cycling performance, with a capacity of 140 mAh/g, even after 50 cycles at 1.7 degrees C in a voltage range of 2.5-4.0 V. The superior reversible lithium storage capability can be attributed to the fully reversible phase transitions of alpha- V_2O_5 through to delta-Li V_2O_5, good lithium diffusion in V_2O_5, and increased electronic conductivity and electrolyte diffusion from the incorporated MWCNT web. (K. H. Seng et al., *Electrochemistry Communications* 13, 383 (2011))

CONFERENCES

THE 2ND INTERNATIONAL FORUM ON GREEN ENERGY AND ELECTRONIC MATERIALS (28TH - 29TH MARCH 2011, ISEM WOLLONGONG, AUSTRALIA)

THE 1ST INTERNATIONAL CONGRESS ON ADVANCED MATERIALS (13TH - 16TH MAY 2011, JINAN, CHINA)

"Chemical doping and strain engineering for materials design and formulation", H. K. Liu (Keynote Speaker)

"Multiferroic Bismuth Ferrite, improvement in both ferroelectric and magnetic properties, exchange bias and multiple resistance states for memory devices" Z. X. Cheng (Invited Speaker)

"Latest progress on the development of new materials for spintronics and multiferroics", X. L. Wang (Keynote talk)

"Transport critical current of MgB_2 measured by pulsed current method with varying the pulse length", X. Xu (Invited Speaker)

THE 4TH INTERNATIONAL SYMPOSIUM ON PHOTOELECTRONIC DETECTION AND IMAGING (24TH - 26TH MAY 2011, BEIJING, CHINA)

"Terahertz Photonic in Graphene and Graphene Nanoribbons", C. Zhang (Invite Speaker)

THE 35TH WORKSHOP ON COMPOUND SEMICONDUCTOR DEVICES AND INTEGRATED CIRCUITS (29TH MAY - 1ST JUNE 2011, CATANIA, ITALY)

"Terahertz generation in compound semiconductors", R. A. Lewis (Invited Speaker)

NANOTECHNOLOGY & ENERGY WORKSHOP (6TH JUNE 2011, DEAKIN UNIVERSITY, AUSTRALIA)

"Nanomaterials for next generation of lithium ion batteries", H. K. Liu (Invited Speaker)

SYMPOSIUM N9, ICMAT (25TH JUNE - 2ND JULY 2011, SINGAPORE)

"TiO_2-based anode materials for lithium ion batteries", Z. P. Guo (Chairman)

THE 9TH INTERNATIONAL MEETING OF PACIFIC RIM CERAMIC SOCIETIES (PACRIM9) (10TH - 14TH JULY 2011, CAIRNS, AUSTRALIA)

"Improvement of Sinterability and Electrochemical Performance of Barium Zirconate for Intermediate Temperature Solid Oxide Fuel Cells Application", Z. Q. Sun (Invited Speaker)

"Symposium 4: The World Wide Increasing Demand in Energy", Z. Q. Sun (Symposium Co-organiser)

THE INTERNATIONAL WORKSHOP ON PIEZOELECTRIC MATERIALS AND APPLICATIONS (IWPMA), 6TH ANNUAL ENERGY HARVESTING WORKSHOP AND THE 1ST ANNUAL CEHMS CONFERENCE (7TH - 11TH AUGUST 2011, ROANOKE, VIRGINIA, USA)

"Multiferroic thin films and using as tunnel junction barrier", Z. X. Cheng (Invited Speaker)

THE ILLAWARRA MANUFACTURING EXPO (30TH AUGUST 2011, AUSTRALIAN INSTITUTE FOR INNOVATIVE MATERIALS, WOLLONGONG, AUSTRALIA)

THE 30TH PROGRESS IN ELECTROMAGNETICS RESEARCH SYMPOSIUM (12TH - 16TH SEPTEMBER 2011, SUZHOU, CHINA)

R. A. Lewis (Session Convener and Chair)

THE 5TH OVERSEAS AND DOMESTIC YOUTH FORUM ON MATERIALS SCIENCE (13TH - 16TH OCTOBER 2011, XIAN, CHINA)

"Multiferroic materials and application in memory devices", Z. X. Cheng (Invited Speaker and Session Chair)

THE 4TH INTERNATIONAL PHOTONICS AND OPTOELECTRONICS MEETINGS (2ND - 5TH NOVEMBER 2011, WUHAN, CHINA)

"Strong photomixing of terahertz waves in graphene and bilayer graphene", C. Zhang (Invited Speaker)

CHINA-AUSTRALIA SYMPOSIUM ORGANISED BY THE ACADEMY AND THE AUSTRALIAN ACADEMY OF TECHNOLOGICAL SCIENCES AND ENGINEERING (5TH - 8TH NOVEMBER 2011, SHANGHAI AND SUZHOU, CHINA)

"Nanomaterials and nanotechnologies for next generation of lithium ion batteries", H. K. Liu (Invited Speaker)

THE 3RD AUSTRALIA-CHINA SYMPOSIUM FOR MATERIALS SCIENCE (19TH - 23RD NOVEMBER 2011, GOLD COAST, AUSTRALIA)

"Electronic strain induced by chemical doping for alteration of materials performance properties", S. X. Dou (Invited Speaker)

INTERNATIONAL CONFERENCE ON ELECTROCERAMICS (ICE2011) (12TH - 16TH DECEMBER 2011, SYDNEY, AUSTRALIA)

"Multiferroic thin films in information storage application", Z. X. Cheng (Invited Speaker)

2011 INTERNATIONAL CONFERENCE ON APPLIED SUPERCONDUCTIVITY AND ELECTROMAGNETIC DEVICES (14TH - 16TH DECEMBER 2011, SYDNEY, AUSTRALIA)

"Strain engineering for improvement in J_c and H_{irr} and H_{c2} in MgB_2", S. X. Dou (Plenary Speaker)

ADVANCED ELECTROCHEMICAL ENERGY SYMPOSIUM (28TH - 30TH DECEMBER 2011, THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY, HONG KONG)

"Graphene Nanocomposites for Lithium Batteries", J. Z. Wang (Invited speaker)

INTERNATIONAL UNION OF MATERIALS RESEARCH SOCIETIES – INTERNATIONAL CONFERENCE ON ELECTRONIC MATERIALS (JULY, SINGAPORE)

"Ferroelectric domain in multiferroic $YMnO_3$ single crystals", X. L. Wang (Invited speaker)

INTERNATIONAL CONFERENCE ON ELECTROCERAMIC MATERIALS (DECEMBER 2011, SYDNEY, AUSTRALIA)

"Topological insulators", X. L. Wang (Invited speaker)

PACRIM CONFERENCE (CAIRNS, AUSTRALIA)

"Topological insulators", X. L. Wang (Invited speaker)

Representatives from ISEM join more than 100 local business representatives to show how ISEM's research can lead to new opportunities.

HONORARY APPOINTMENTS IN OVERSEAS INSTITUTES

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Institute of Physics, Chinese Academy of Science, Visiting Professor
ZhuoYi Technology Ltd, Chief Honorary Advisor
Hua Qiao University, China, Visiting professor and advisor
Asia Materials, Branch of Nature Materials, Advisory Committee
Beijing University of Science and Technology, Beijing, China,
Hubei University, China
Shanghai University, China
Nankai University, China
Institute of Electrical Engineering, Chinese Academy of Sciences, China, Visiting professor
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

H. K. LIU

Advanced Science Letters, Associate Editor
Hubei University, China
Shanghai 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
The Open Electrochemistry Journal, Member of the Editorial Board

C. ZHANG

Institute of Solid State Physics, Chinese Academy of Sciences
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

Z. P. GUO

East China University of Science and Technology
Xinjiang University

X. L. WANG

Chinese Science Bulletin, Editorial Board Member

J. HORVAT

The Open Superconductors Journal, Editorial Advisory Board member
Advanced Materials Letters, Editorial Advisory Board member
World Journal of Condensed Matter Physics, Editorial Board member

R. A. LEWIS

Chinese Academy of Sciences, Visiting Professorship for Senior International Scientists
Invited Presentations / Seminars at other Institutions

INVITED PRESENTATIONS / SEMINARS AT OTHER INSTITUTIONS

J. Z. WANG

"Nanocomposite Materials for Lithium Batteries"
National Institute of Materials Science, Japan, 26 September 2011

"Nanocomposite Materials for Lithium Batteries"
National Institute of Advanced Industrial Science and Technology, Japan, 27 September 2011

"Composite Materials for Lithium Batteries"
Fudan University, China, 8 June 2011

"Composite Materials for Lithium Batteries"
Jiaotong University, China, 9 June 2011

"Graphene Composite Materials for Lithium Batteries"
Institute of Physics, China, 24 June 2011

H. K. LIU

"Advanced materials for lithium ion batteries and supercapacitors"
Metallurgy and Materials Physical Chemistry, North-eastern University, China, 17 May 2011

"Advanced materials for lithium ion batteries"
School of Materials Science & Engineering, East China University of Science and Technology, China, 12 May 2011

X. L. WANG

"Topological insulators"
National Taiwan University, National Synchrotron Center, Taiwan

S. X. DOU

"Nanostructured materials for energy applications"
East China University of Science and Technology, China

"Postgraduate student training for research excellence"
North-eastern University, China

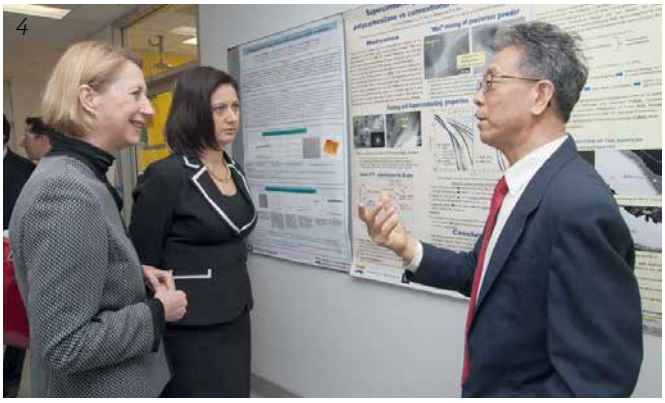
SEMINARS BY VISITING SCIENTISTS

Date	Name	Institute	Title
06/01/2011	Prof. Xiaoxing Xi	Department of Physics, Temple University, Philadelphia	Nanoscale Engineering of Epitaxial Metal Oxide Thin Films and Heterostructures
06/01/2011	Prof. Qi Li	Department of Physics and Department, Pennsylvania State University, University Park 16802, USA	Multiferroic tunnel junctions: towards quaternary state device and electric field control of magnetic state
08/02/2011	Dr. E W Collings	Dept. of Materials Science and Engineering and Welding Engineering The Ohio State University, Columbus, OH, U.S.A.	Normal and Superconducting Radio-Frequency Cavities for High Energy Particle Accelerators
09/02/2011	Prof. Qiuliang Wang	Institute of Electrical Engineering, Chinese Academy of Science	Design of 9.4T/800mm High Magnetic Field Superconducting Magnet System for Neuroscience Research
09/02/2011	Dr. Gregory L. Fisher & Dr. Sankar N. Raman	Physical Electronics Inc, Chanhassen, MN	New Developments & Applications of TOF-SIMS, SAM and XPS for Surface, Thin Film & 3D Analysis
10/02/2011	Prof. Mukunda P Das	Department of Theoretical Physics, The Australian National University, Canberra	Meso/Nanoscopic Systems: Fundamental Science and Applications
14/02/2011	Dr. Heiner Jaksch	Carl Zeiss, Oberkocxhen, Germany	The contrast mechanisms of LL-BSE electrons in FE-SEM Characterization of polymer, single proteins, and oxidization states of elements
18/02/2011	Dr. Nestor Zaluzec	Electron Microscopy Center, Argonne National Laboratory, Argonne IL USA	Advanced Spectroscopic Characterization of Materials in the Analytical Electron Microscope
09/03/2011	Masato Murakami	Shibaura Institute of Technology, Japan	Recent progress in superconductor research in Japan
04/05/2011	Prof. Alex Hamilton	School of Physics, University of New South Wales, Sydney 2052, Australia	The unusual properties of spin-3/2 holes in semiconductor nanostructures
13/05/2011	Dr. Wen-Xin Tang	School of Physics, Monash University, Australia	Low energy electron and its applications in low dimensional systems
02/06/2011	Prof. Hans Coster	Biophysics and Bioengineering, School of Chemical and Biomolecular Engineering, University of Sydney, Australia	Characterization of Self Assembled Molecular films, Solar Cells and Polymer films using High Resolution Electrical Impedance Spectroscopy (HiRes EIS).
10/06/2011	A/Prof. Clemens Ulrich	University of New South Wales, Australia	Spin, Charge, and Orbital Fluctuations in Transition Metal Oxides
21/06/2011	Dr. Aijun Du	Centre for Computational Molecular Science University of Queensland, Australia	Exploring Electronic Functionality in Carbon/Boron-Nitride based Materials via Theoretical Modelling
03/08/2011	Dr. Axel Hoffmann	Materials Science Division, Argonne National Laboratory, Argonne, IL, USA.	Pure Spin Currents: Discharging Spintronics
08/09/2011	Dr. Wolfgang Gruenewald	EM Product and Applications Specialist, Leica Microsystems	Specimen Preparation for Electron Microscopy
19/09/2011	Prof. Enrico Traversa	International Center for Materials Nanoarchitectonics (MANA), National Institute for Materials Science (NIMS), 1-1 Namiki, Tsukuba, Ibaraki 305-0044, Japan	Towards the next generation of solid oxide fuel cells operating at 600°C based on chemically stable proton conducting electrolytes
15/11/2011	Prof. Hans-A Bachor	Australian National University	Lasers Help with Everything
09/12/2011	Weijia Wen	The University of Science & Technology, Hong Kong	Functional Material & Its Application in Micro fluidics
12/12/2011	Dr. Giovanni Giunchi	Edison Spa, Milan Italy	Carbon & borides doping of the MgB2 superconductors by the Mg-RLI process
19/12/2011	Dr. YouXing Yu	School of Materials Science & Engineering, Beihang University	Perpendicular Magnetic anisotropy in CoPt/AlN layered structures: Roles of internal stress and interface roughness

VISITING DELEGATIONS

Date	Name		Institute
16/03/2011	Vice Minister Liu Chen Yuming	Other senior officials	Chinese Government
09/03/2011	Prof. Masato Murakami Prof. Akira Aiba Prof. Masahiro Inoue Prof. Kazuhiko Kudo	Prof. Kayoko Murakami Mr. Ichiro Sofue Mr.Yoshihiro Kodama Ms. Ayumi Marmot	Shibaura Institute of Technology, Japan
10/05/2011	Ms. Liya Gu Zhang Hua Prof. Jianxin Liu	Prof. Pan Wei Yanjun Qiu Yuan Yong	Southwest Jiaotong University, China
17/06/2011	Ms. Justine Elliot MP Ms. Sharon Bird MP	Mr. Stephen Jones MP	Federal Parliamentary Secretary for Trade and Regional NSW, Australia
28/06/2011	Mr. Gareth Ward MP		NSW Member for Kiama, Australia
26/07/2011	Prof. Tim Flannery Prof. Will Steffen	Gerry Hueston Prof. Lesley Hughes	Australian Government Climate Commissioners, Australia
30/07/2011	Prime Minister Julia Gillard MP Minister for Innovation, Industry, Science and Research, Senator Kim Carr Illawarra regional leaders		
28/10/2011	Ms. Ling Wang Mr. Jianbao Li Mr. Shouguang Sun Mr. Jianhua Zhang Ms. Wenbin Chen Mr. Jinsheng Wu Mr. Chongguang Li Mr. Shiyou Yu Mr. Zhi Zhuo Mr. Shijian Chen Mr. Jianhua Ma Mr. Xiaohong Si Mr. Jujin Cai	Mr. Xiaowen Xu Mr. Hanjing Zhang Mr. Fengming Wang Mr. Yunqing Huang Mr. Yuangong Lou Mr. Jianmin Huang Ms. Xi Chen Mr. Yimin Jia Mr. Guolin Liu Mr. Yiqun Zhang Mr. Deyi Xiong Ms. Yunjie He	Various Chinese Universities

Prof. Chao Zhang and invited speaker Dr. Wen Xing Tang.



1. *Prof. Shi Xue Dou and Chief Climate Commissioner Professor Tim Flannery*
2. *Group shot of the visiting Chinese delegation and senior UOW representatives*
3. *Minister for Innovation, Industry, Science and Research, Senator The Hon. Kim Carr, launched the Illawarra Manufacturing Expo at AIIM*
4. *Federal Member for Cunningham Ms. Sharon Bird MP, Federal Parliamentary Secretary for Trade and Regional NSW Ms. Justine Elliot MP and Prof. Shi Xue Dou*
5. *Visiting delegation from Southwest Jiaotong University, China*
6. *University members and the Climate Commissioners from Federal Government*
7. *Prof. Shi Xue Dou and Mr. Gareth Ward MP, NSW Member for Kiama*

EQUIPMENT AND FACILITIES

In 2011 ISEM continued to improve its laboratory equipment and expand its capabilities in materials fabrication and characterisation.

Currently ISEM has approximately 1600m^2 and 35 labs in the Australian Institute for Innovative Materials (AIIM) at the University of Wollongong's Innovation Campus.

Many critical pieces of equipment have been funded through a number of Australian Research Council RIEF and LIEF grants. Our consecutive success in LIEF funding has resulted in the purchase and installation of facilities such as high magnetic field scanning tunnelling microscope (STM), variable temperature scanning probe microscope (SPM), variable temperature scanning near field optical microscope (SNOM), complete thermoelectric and thermal conductivity characterization facility, high magnetic field (9T) furnace and 15T critical current density measurement facility, 9T and 14T PPMS systems.

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

- Australian Nuclear Science & Technology Organisation
  Dr. M. Ionescu, Dr. S. Kennedy, Dr. F. Klose
- James Cook University
  Prof. J. Mazierska, A/Prof. M. Jacob
- 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 New South Wales
  Prof. M. Skyllas-Kazacos, Dr. S. Li, Dr. R. Ramer, Prof. S. Campbell, Dr. Y. B. Zhang, Dr. C. Ulrich
- University of Queensland
  Prof. M. G. Lu, Dr. L. Wang, Prof. D. R. Mackinnon
- University of Sydney
  Prof. S. Ringer, Prof. C. Stampfl, 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 Western Sydney
  Prof. J. Nowotny
- Deakin University of Technology
  Prof. Y. Chen
- University of Western Australia
  Prof R. Stamps, Prof. M. Martyniuk
- Swinburne University of Technology
  Prof. C. Berndt, A/Prof. X. S. Gan, Prof. M. Gu

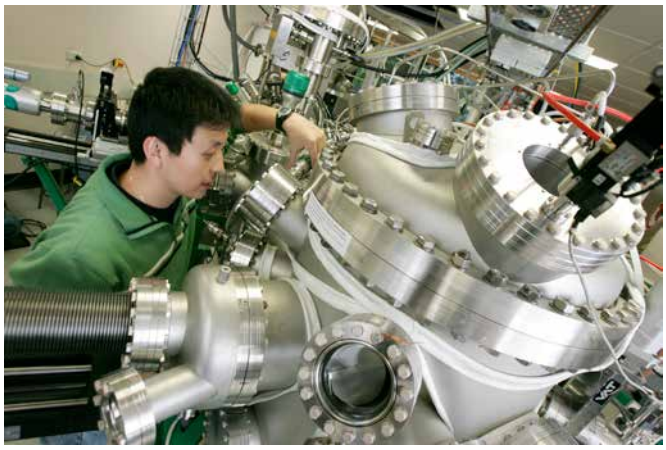
MATERIALS PROCESSING FACILITIES

- 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

High vacuum, high temperature furnace (up to 3000°C).

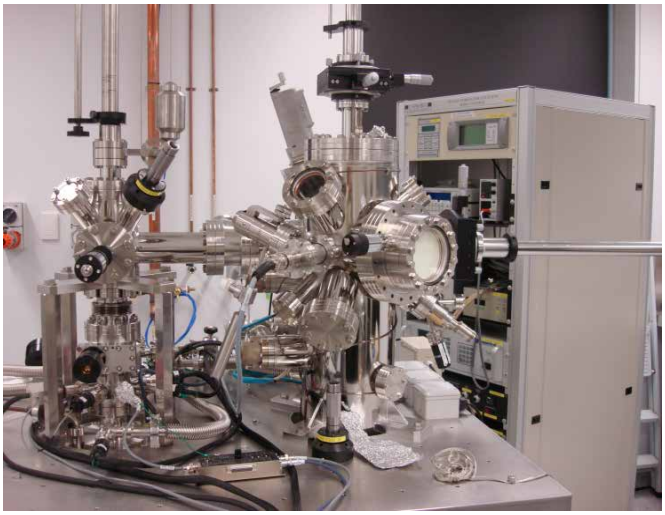
THIN FILM DEPOSITION AND STRUCTURING FACILITIES

- 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°C
- 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



8T variable temperature scanning tunnelling microscope.

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

14T Physical Property Measurement 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

Electrochemical Workstation.

REFEREED PUBLICATIONS

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1. S. H. Aboutalebi, A. T. Chidembo, M. Salari, K. Konstantinov, D. Wexler, H. K. Liu, and S. X. Dou, "Comparison of GO, GO/MWCNTs composite and MWCNTs as potential electrode materials for supercapacitors", Energy and Environmental Science 4, 1855 (2011). (IF: 9.61)
2. S. Aminorroaya, A. Ranjbar, Y. H. Cho, H. K. Liu, and A. K. Dahle, "Hydrogen storage properties of Mg-10 wt% Ni alloy co-catalysed with niobium and multi-walled carbon nanotubes", International Journal of Hydrogen Energy 36, 571 (2011). (IF: 4.054)
3. Y. S. Ang and C. Zhang, "Subgap optical conductivity in semihydrogenated graphene", Applied Physics Letters 98, 042107 (2011). (IF: 3.844)
4. Y. S. Ang, C. Zhang, and C. Y. Kee, "Energy-loss rate of a fast particle in graphene", Applied Physics Letters 99, 053111 (2011). (IF: 3.844)
5. V. Aravindan, J. Gnanaraj, S. Madhavi, and H. K. Liu, "Lithium-ion conducting electrolyte salts for lithium batteries", Chemistry – A European Journal 17, 14326 (2011). (IF: 5.925)
6. C. Z. Chen, Z. Y. Liu, Y. M. Lu, L. Zeng, C. B. Cai, R. Zeng, and S. X. Dou, "Robust high-temperature magnetic pinning induced by proximity in $YBa_2Cu_3O_{7-delta}$/$La_{0.67}Sr_{0.33}MnO_3$ hybrids", Journal of Applied Physics 109, 073921 (2011). (IF: 2.168)
7. Z. X. Cheng, H. Y. Zhao, Y. Du, H. Kimura, K. Ozawa, and X. L. Wang, "Exchange bias in multiferroic $BiFeO_3$ and $YMnO_3$ multilayers: One more parameter for magnetoelectric manipulation", Scripta Materialia 65, 249 (2011). (IF: 2.699)
8. Z. X. Cheng, X. L. Wang, S. X. Dou, M. Osada, and H. Kimura, "Strain modulated magnetization and colossal resistivity of epitaxial $La_{2/3}Ca_{1/3}MnO_3$ film on $BaTiO_3$ substrate", Applied Physics Letters 99, 092103 (2011). (IF: 3.844)
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10. Y. H. Cho, S. Aminorroaya, H. K. Liu, and A. K. Dahle, "The effect of transition metals on hydrogen migration and catalysis in cast Mg-Ni alloys", International Journal of Hydrogen Energy 36, 4984 (2011). (IF: 4.054)
11. S. Choi, T. Kiyoshi, J. H. Kim, and S. X. Dou, "AC loss in MgB_2 superconducting wires at various operating temperatures", IEEE Transactions on Applied Superconductivity 21, 3342 (2011). (IF: 1.041)
12. K. Y. Choi, G. S. Jeon, X. F. Wang, X. H. Chen, X. L. Wang, M. H. Jung, S. I. Lee, and G. Park, "Giant magnetic flux jumps in single crystals of $Ba_{0.6}K_{0.4}Fe_2As_2$", Applied Physics Letters 98, 182505 (2011). (IF: 3.844)
13. S. L. Chou, J. Z. Wang, H. K. Liu, and S. X. Dou, "Rapid synthesis of $Li_4Ti_5O_{12}$ microspheres as anode materials and its binder effect for lithium-ion battery", Journal of Physical Chemistry C 115, 16220 (2011). (IF: 4.805)
14. S. L. Chou, J. Z. Wang, Z. X. Chen, H. K. Liu, and S. X. Dou, "Hollow hematite nanosphere/carbon nanotube composite: mass production and its high-rate lithium properties", Nanotechnology 22, 265401 (2011). (IF: 3.979)
15. S. L. Chou, L. Lu, J. Z. Wang, M. M. Rahman, C. Zhong, and H. K. Liu, "The compatibility of transition metal oxide/carbon composite anode and ionic liquid electrolyte for the lithium-ion battery", Journal of Applied Electrochemistry 41, 1261 (2011). (IF: 1.745)
16. S. L. Chou, X. W. Gao, J. Z. Wang, D. Wexler, Z. X. Wang, L. Q. Chen, and H. K. Liu, "Tin/polypyrrole composite anode using sodium carboxymethyl cellulose binder for lithium-ion batteries", Dalton Transactions 40, 12801 (2011). (IF: 3.838)
17. D. L. Cortie and R. A. Lewis, "Role of vanguard counter-potential in terahertz emission due to surface currents explicated by three-dimensional ensemble Monte Carlo simulation", Physical Review B 84, 155328 (2011). (IF: 3.691)
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19. J. C. Debnath, R. Zeng, J. H. Kim, and S. X. Dou, "Improvement of refrigerant capacity of $La_{0.7}Ca_{0.3}MnO_3$ material with a few percent Co doping", Journal of Magnetism and Magnetic Materials 323, 139 (2011). (IF: 1.780)
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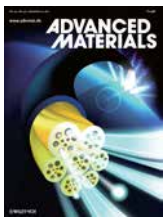
51. 

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COMMONWEALTH OF AUSTRALIA

PARLIAMENTARY DEBATES

HOUSE OF REPRESENTATIVES

CONSTITUENCY STATEMENTS

Australian Institute for Innovative Materials

SPEECH

Tuesday, 21 June 2011

BY AUTHORITY OF THE HOUSE OF REPRESENTATIVES

SPEECH

Date Tuesday, 21 June 2011 **Source** House
Page 6774 **Proof** No
Questioner **Responder**
Speaker Ms BIRD **Question No.**

(Cunningham) (NaN.NaN pm)

Ms BIRD (Cunningham) (16:28): I visited the Australian Institute for Innovative Materials facility on 9 June with Parliamentary Secretary Justine Elliot and member for Throsby Stephen Jones. The University of Wollongong, which is the facility that runs AIIM, is a recognised world leader in multifunctional materials research, and I had the opportunity to find out more about the groundbreaking research being led by Professor Gordon Wallace and Professor Dou. The research groups housed at the AIIM—the ARC Centre for Excellence for Electromaterials Science and the Institute for Superconducting and Electronic Materials—together have more than 200 researchers and postgraduate students working to tackle some of the biggest global challenges. This includes energy technology that is developing new methods of energy generation, transportation and storage, including battery technologies that will be of considerable importance to the future of electric vehicles, and building on the breakthrough research they have done. Secondly, there is health and medical bionics to advance muscle and nerve regeneration and cochlear implants and to develop wearable bionics to assist with injury prevention and rehabilitation, as well as advances in medical devices such as improved MRI systems. Thirdly, there are innovative materials and manufacturing. There is some amazing 3-D printing technology and rapid prototyping systems and there is the development of materials to help lower costs and prove the efficiency of mechanical and electrical equipment. This facility continues to grow with the support from the Gillard government. We have invested $43 million in the future of the facility to create the first materials research facility to bridge the gap between lab based research and commercial applications. The expanded facility will now be able to undertake groundbreaking research and help turn those research breakthroughs into reality. It is a state-of-the-art facility, housing internationally recognised researchers who, from their Wollongong base, have established strong collaborative research and industry partnerships that give them a global reach. It is once again an example of the Wollongong area leading the nation and the world in important research and in new technology development for the future of the nation.

The DEPUTY SPEAKER (Ms AE Burke): Order! In accordance with standing order 193 the time for constituency statements has concluded.

(Chisholm) (NaN.NaN pm)

Impressed by her visit, Federal Member for Cunningham, Sharon Bird MP, praised the work of ISEM in the Australian Parliament.

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141. W. X. Li, R. Zeng, L. Lu, and S. X. Dou, "Effect of thermal strain on J_c and T-c in high density nano-SiC doped MgB_2", Journal of Applied Physics 109, 07E108 (2011). (IF: 2.168)
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PUBLICATION STATISTICS

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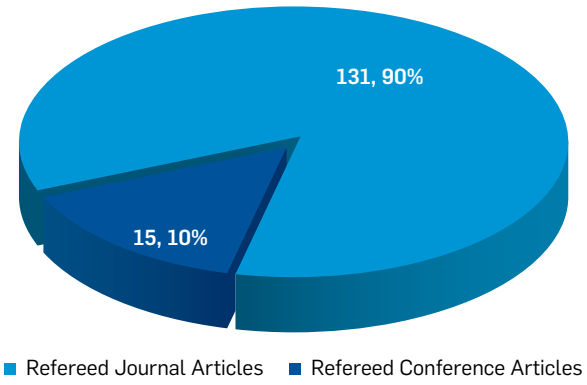

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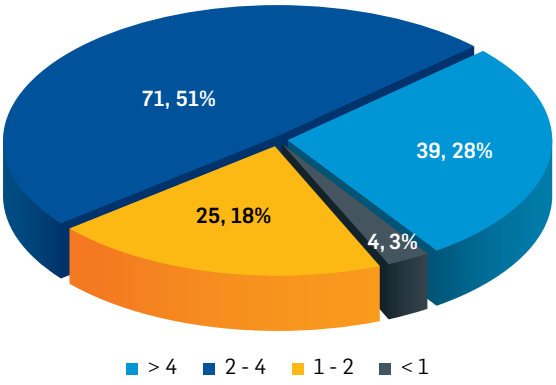

FUNDING 2011

AUSTRALIAN RESEARCH COUNCIL GRANTS

ARC CENTRE OF EXCELLENCE GRANTS

Chief Investigators	Title	2011 Funding
H. K. Liu	Nano-materials for energy storage	$90,000
Total		**$90,000**

ARC DISCOVERY SCHEME GRANTS

Chief Investigators	Title	2011 Funding
S. X. Dou, J. Driscoll, R. L. Flukiger, H. Kumakura, M. D. Sumption	Current limiting mechanisms in magnesium diboride superconductors	$210,000
R. A. Lewis, J. Horvat, W. Xu	Better emitters, enhanced optics, superior detectors: advancing terahertz science and technology for applications in medicine, agriculture, industry and national security	$90,000
S. X. Dou, J. H. Kim, T. H. Johansen, E. Bruck	Giant magnetocaloric materials and room temperature refrigeration	$120,000
A. V. Pan, C. P. Foley, T. H. Johansen, H. Hilgenkamp	Tailoring superconducting hybrid multilayered film systems for electric and electronic applications	$120,000
J. Z. Wang	Development of inorganic-conducting polymer composites and ionic liquid based electrolytes for rechargeable lithium batteries	$110,000
Z. P. Guo, Z. Chen, J. Dahn, J. Chen	New directions to miniaturised power sources: integrated all solid-state rechargeable batteries	$145,000
X. L. Wang, Z. X. Cheng, D. P. Chen, T. Kimura, F. Klose	Frustrated magnets: a new platform for multiferroic materials	$115,000
Z. P. Guo, Z. Chen, J. Dahn, J. Chen	New directions to miniaturized power sources: integrated all-solid-state rechargeable batteries	$135,000
J. H. Kim, Y. Zhao, X. Zhu, Z. Sun	Directed assembly and photoelectric properties of core-shell nanowire networks of PbSe-TiO_2 heterostructures for high efficiency low-cost solar cells	$95,000
K. Konstantinov, H. K. Liu, A. Calka, D. Wexler	Advanced nanostructured ceramic composites for ultracapacitors	$90,000
X. L. Wang, G. Peleckis, D. P. Chen, H. Hosono, X. Chen, K. H. Muller, E. Muromachi, A. J. Studer	Materials science and superconductivity in the new Fe-based high temperature superconductors	$150,000
A. V. Pan, O. V. Shcherbakova, S. H. Zhou, I. P. Nevirkovets, K. H. Muller, T. H. Johansen, H. Hilgenkamp	New approach to control grain boundary behaviour in superconducting thin films	$70,000
J. Z. Wang, S. L. Chou, H. J. Li, Y. P. Wu, K. Ozawa	A novel hybrid electrochemical energy system for both high energy and high power	$90,000
Total		**$1,540,000**

ARC FUTURE FELLOWSHIP

Chief Investigators	Title	2011 Funding
Z. X. Cheng	Manipulation of spin by electric field	$172,000
J. H. Kim	Development of a solid nitrogen cooled magnesium diboride (MgB_2) magnet for persistent-mode operation	$89,000
Total		**$261,000**

ARC LINKAGE PROJECTS

Chief Investigators	Title	2011 Funding
Z. P. Guo, H. K. Liu, C. D. Cook, D. Wexler, H. Zhu, X. J. Zhu	Development of advanced lithium ion battery and battery management system for electric/hybrid electric vehicle applications (including industry partner Redarc Electronics contribution of $40,000)	$120,000
S. X. Dou, X. L. Wang, C. D. Cook, X. Xu, E. W. Collings, J. Yoo	Magnesium diboride superconductor magnets for applications (including industry partner Hyper Tech Research Ltd contribution of $30,000)	$130,000
S. X. Dou, J. Horvat, X. Xu, J. W. Moscrop	Design, build and test a fault current limiter employing magnesium diboride (MgB_2) superconducting coils (including industry partner Zenergy Power Ltd contribution of $60,000)	$250,000
J. Z. Wang, H. K. Liu, K. K. Konstantinov, Z. X. Wang	Room temperature rechargeable sulphur batteries (including industry partner Nipress TBK Pt contribution of $17,500)	$75,500
Total		**$575,500**

ARC LINKAGE INFRASTRUCTURE, EQUIPMENT AND FACILITIES (LIEF)

Chief Investigators	Title	2011 Funding
S. X. Dou, G. Peleckis, Y. B. Zhang, M. Martyniuk, M. P. in het Panhuis, O. P. Sushkov, C. Zhang, H. K. Liu, R. Ramer, H. Yang, G. Parish	A complete near-field scanning optical microscope for advanced characterization of novel and functional materials	$290,000
Total		**$290,000**

2011 AUSTRALIAN RESEARCH COUNCIL GRANTS TOTAL: $2,756,500

NON-ARC GRANTS

Chief Investigators	Title	2011 Funding
Z. Sun	CASS Foundation travel grant	$4,000
X. Liu, K. Kontantinov, X. L. Wang, W. Yeo	An improved breast tumour immunotherapy by delivery of anti IL10 antibodies using multifunctional nanomaterials	$5,000
Total		**$9,000**

UOW URC GRANTS & ARC NEAR-MISS GRANTS

Chief Investigators	Title	2011 Funding
Y. Zhao	Cost-efficient surface engineering on light metals/alloys	$12,000
O. V. Shcherbakova	Development of high-Tc superconducting single photon detectors	$9,000
X. Xu	Reveal the flux pinning mechanisms of graphene doped MgB_2 single crystals by vapour transport method with optical floating zone systems	$7,000
H. K. Liu, Z. P. Guo, J. Wang, K. Konstantinov	Integrated high performance Li-ion battery and smart charger for electric vehicle, tolerant to hot weather conditions	$18,000
Total		**$46,000**

UOW SUPPORT (PERFORMANCE, MANAGEMENT, PGS MAINTENANCE) $300,000

TOTAL FUNDING 2011 $3,111,500

CONTACT DETAILS

INSTITUTE FOR SUPERCONDUCTING AND ELECTRONIC MATERIALS

AIIM Facility

University of Wollongong Innovation Campus
Squires Way, North Wollongong NSW 2500
Australia

www.isem.uow.edu.au

Professor Shi Xue Dou

Director

email: shi@uow.edu.au

Professor Chao Zhang

Associate Director

Telephone: (+61) 2 4221 3458
Facsimile: (+61) 2 4221 3238
email: czhang@uow.edu.au

Mrs Crystal Longin Mahfouz

Administration Officer

Telephone: (+61) 2 4221 5730
Facsimile: (+61) 2 4221 5731
email: crystal_mahfouz@uow.edu.au

APPLIED SUPERCONDUCTIVITY

Associate Professor Josip Horvat

Telephone: (+61) 2 4221 8073
Facsimile: (+61) 2 4221 5731
e-mail: jhorvat@uow.edu.au

SPINTRONIC & ELECTRONIC MATERIALS

Professor Xiaolin Wang

Telephone: (+61) 2 4221 5766
Facsimile: (+61) 2 4221 5731
e-mail: xiaolin@uow.edu.au

ENERGY MATERIALS

Professor Hua Kun Liu

Telephone: (+61) 2 4221 4547
Facsimile: (+61) 2 4221 5731
e-mail: hua@uow.edu.au

THIN FILM TECHNOLOGY

Associate Professor Alexey V. Pan

Telephone: (+61) 2 4221 4729
Facsimile: (+61) 2 4221 5731
e-mail: pan@uow.edu.au

NANOSTRUCTURED MATERIALS

Dr. Kosta Konstantinov

Telephone: (+61) 2 4221 5765
Facsimile: (+61) 2 4221 5731
e-mail: konstan@uow.edu.au

TERAHERTZ SCIENCE, THERMIONICS & SOLID STATE PHYSICS

Professor Chao Zhang

Telephone: (+61) 2 4221 3458
Facsimile: (+61) 2 4221 5944
e-mail: czhang@uow.edu.au

INSTITUTE FOR SUPERCONDUCTING
AND ELECTRONIC MATERIALS

AIIM Facility
University of Wollongong Innovation Campus
Squires Way, North Wollongong, NSW 2500 Australia

www.isem.uow.edu.au

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