COLLABORATIVE / VISIONARY / INSPIRING

CONNECT: ISEM

2012 ANNUAL REPORT

INSTITUTE FOR SUPERCONDUCTING AND ELECTRONIC MATERIALS

UNIVERSITY OF WOLLONGONG

CONTENTS

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.

2012 POSTGRADUATE STUDENT EXCELLENCE AWARD RECIPIENTS

Seng Kuok Hau

Victor Malgras

2012 POSTGRADUATE STUDENT MERIT AWARD RECIPIENTS

Tomas Katkus

Jae Geun Kim

Xuanwen Gao

David Cortie

2012 POSTGRADUATE STUDENT BEST PAPER AWARD RECIPIENTS

Chaofeng Zhang

Sergey Fedoseev

Seng Kuok Hau (Excellence Award)

Tomas Katkus (Merit Award)

Jae Geun Kim (Merit Award)

Xuanwen Gao (Merit Award))

David Cortie (Merit Award)

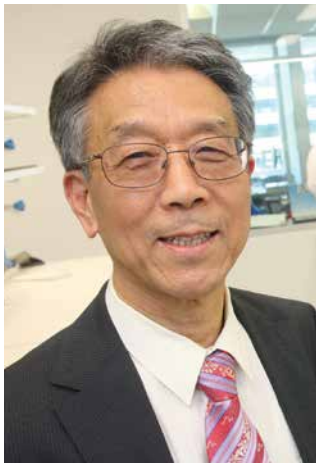
Chaofeng Zhang (Best Paper Award)

2012 CHINESE GOVERNMENT SCHOLARSHIP AWARDS

2012 Chinese Government Private Student Scholarship winners, Chao Feng Zhang (2nd left) and Fang Hong (3rd left) from ISEM

VC Outstanding partnership award winning team from ISEM, from left: Joseph Horvat, Shi Xue Dou (Team Leader), Shi Hai Zhou, Chris Cook (Dean of Engineering), Wen Xian Li, Olga Shcherbakova, Alexey Pan, Germanas Peleckis, Xiao Lin Wang, Paul Wellings (the Vice Chancellor)

DIRECTORS REPORT



This year has seen some major events in the lives of both the ISEM and the University of Wollongong.

On 25th October 2012 the Australian Institute for Innovative Materials – Processing & Devices facility was officially opened by the then Minister for Tertiary Education, Skills, Science and Research, Senator the Hon Chris Evans, the then Parliamentary Secretary for Higher Education and Skills and Member for Cunningham, the Hon Sharon Bird MP, and Member for Throsby, Stephen Jones MP. This heralded an exstension in capabilities for ISEM, providing the Institute with infrastructure dedicated to scaling-up and prototyping discoveries.

The Vice-Chancellor, Prof. Paul Wellings, also announced a major restructure of UOW faculties and set an ambitious goal of reaching top 1% of universities in the world. We have reassessed our priority research areas and put more resources into research programs that closely relate to the sustainable energy program as exampled by the success of Automotive Cooperative Research Centre 2020 (Auto CRC) program. We have continuously improved our infrastructure, safe work procedures and culture, and aim to excel in research outputs, publications, success in competitive funding applications, attracting high calibre postgraduate students and promotion of commercialisation.

ISEM outputs in 2012 can be summarised as follows:
1) Publications – more than 150 articles appeared in internationally renowned journals;
2) Postgraduate student completions/intake – 7 students graduated in 2012 with 7 new students commencing;
3) Grant success – we have been successful in 2012 major ARC grant bids 2 Discovery project, 2 DECRA Fellowships and 1 LIEF grant;
4) As part of Auto CRC we have successfully established 4 research programs attracting four top level PhD students and two outstanding research fellows;
5) Achieved mutual understanding and interest with Malaysian Automotive Institute, a major player in Auto CRC program;
6) Installed the most powerful scanning tunnelling microscope with three sets of working chambers on STM, optical properties and four probe transport characterisation.

ISEM's history shows that central to its success has been the strong links with industry. A significant development this year is the participation of Auto CRC which is sponsored by ten industry partners. As leader of the Electrification Program, the ISEM team established four projects with its industry partners: Bao Steel and Redarc Electronics, as well as four PhD programs, with another three projects being signed off by Malaysian Automotive Institute at the time of preparation of this report. The total funding for Auto CRC projects will exceed more than $4 million over the next three years. The successful first year operation of Bao Steel contract project ($660,000) has resulted in an expanded success in winning four ARC grants (DP, LP, DECRA and LIEF) and one Auto CRC grant. The longstanding collaboration with Hyper Tech Research Inc over the the last 11 years has been recognised by the Vice Chancellor's outstanding partnership award in 2012.

Being a multi-faceted research organisation, we have produced an abundance of research findings in very diverse research areas.

In superconductivity, for carbon doped MgB_2 superconductor, we found that the microscopic origins for the enhancement of high-field properties in this material are due to the boron vacancies and associated stacking faults, resulting in high critical current density which matches or even exceeds that of niobium titanium at 4.2 K (NPG Asia Materials 4, e3 (2012)). Reduced graphene oxide (rGO) and highly reduced chemically converted graphene (rCCG) samples were doped into MgB_2. Doping of MgB_2 with 1 mol% of rCCG resulted in a critical current density more than 30% improvement over that of the undoped sample. This is a significant improvement as most carbon sources adversely affect the critical current density performance at the low field (J. Mater. Chem. 22, 13941 (2012)).

For pnictide superconductors, we found that in Ba(K,Co,Ni)-122 single crystals the non-magnetic disorder is more favourable for enhancement of pinning strength as compared to magnetic induced disorder and that the pinning potential is responsible for the difference in the glass states (Appl. Phys. Lett. 100, 072603 (2012)).

For development of AC losses investigations, we employed a calorimetric method to accurately determine the losses in the concurrent application of AC transport current and DC magnetic fields that are likely to be experienced in practical devices such as generators and motors. This technique provides great simplification compared to the conventional methods and is applied to a long length superconducting tape (Supercond. Sci. Tech. 25, 115016 (2012)).

Some major advances were achieved in a hot topic of topological insulators. We demonstrated that nanosheets of a Bi_2Te_3 topological insulator, several quintuple layers thick, display giant and linear magnetoresistance. The giant and linear magnetoresistance achieved is as high as 600% at room temperature. The observation of giant and linear magnetoresistance paves the way for 3D topological insulators to be useful for practical applications in magnetoelectronic sensors (Phys. Rev. Lett. 108, 266806 (2012)).

A direct evidence for Josephson supercurrents in superconductor (Nb)–topological insulator (Bi_2Te_3)–superconductor electron-beam fabricated junctions is provided by the observation of clear Shapiro steps under microwave irradiation, and a Fraunhofer-type dependence of the critical current on magnetic field. The lateral Nb–Bi_2Te_3–Nb junctions hence provide prospects for the realization of devices supporting Majorana fermions (Nature Mater. 11, 417 (2012)).

We also advanced research in advanced renewable energy materials. A novel carbon–sulfur nanocomposite was synthesized by confining sulfur in double-shelled "soft" carbon hollow spheres with high surface area and porosity. This carbon–sulfur nanocomposite showed outstanding electrochemical performance when evaluated as a cathode material for lithium–sulfur batteries (Angew. Chem. Int. Ed. 51, 9592 (2012)). Two germanium/carbon nanostructures were synthesized through a facile self-assembly method. Controlling the size of the precursor germanium nanoparticles produces cluster and non-clustered nanostructures. The cluster-Ge/C sample showed better capacity retention and an exceptionally high rate performance (Angew. Chem. Int. Ed. 51, 5657 (2012)). Free-standing single-walled carbon nanotube/SnO_2 (SWCNT/SnO_2) anode paper was prepared by vacuum filtration method with excellent cyclic retention and improved specific capacity. The flexible electrodes hold great promise for applications requiring flexible and bendable Li-ion batteries (Carbon 50, 1289 (2012)).

In other research areas we fabricated mesoporous TiO_2 photoanodes by an evaporation-induced self-assembly method. The light-scattering layer as a top-coating was proved to be superior to nitrogen doping in enhancing not only the power conversion efficiency but also the fill factor of DSSCs. Such a photoanode configuration provides an efficient way to enhance the energy conversion efficiency of DSSCs (J. Mater. Chem. 22, 11711 (2012)). We revealed that topological insulators (TI) HgTe/CdTe quantum wells have a strong nonlinear optical property in the three-photon mixing. To produce response at terahertz frequency regime from femtosecond electrical fields, the mixing efficiency is around 10^{-4} comparable to that of nonlinear semiconductor crystals. The optimal temperature for this nonlinear effect is around 100 K (Appl. Phys. Lett. 101, 211109 (2012)).

ISEM has maintained its position as one of the flagship research groups at the University of Wollongong. From a statistical perspective, our share of total UOW publications in 2012 is 10.5%, with an average of 12% in last five years. Over the last four years our share of UOW citations has almost doubled, rising from 12% in 2008 to more than 22% in 2012. ISEM publications attracted more than double the amount of citations per paper as compared to UOW during last three years and more than any of the G8 Universities in Australia. We maintained high number of postgraduate students (61 in 2012) and secured $2.7m in research funding in 2012.

This strong performance is also reflected in international rankings of publications. Thomson Reuters Web of Knowledge ranks the University of Wollongong eighth in the world in terms of publications in the field of lithium-ion batteries and first in the area of magnesium diboride superconductors over the period 2002 to 2012.

Many of these results would not have been achieved without our PhD students. Thus, it is important to recognise the efforts of our best postgraduate students, who have received annual nominations for ISEM Excellence, Merit and Best Paper awards. Their hard work and dedication sets an outstanding example for other PhD students to strive for excellence in every step of their PhD career. In 2012 ISEM PhD students were again successful in securing highly competitive Chinese Government awards for self-supported private students. I congratulate all of the awardees and I am certain there will be many more excellent students to recognise in the future.

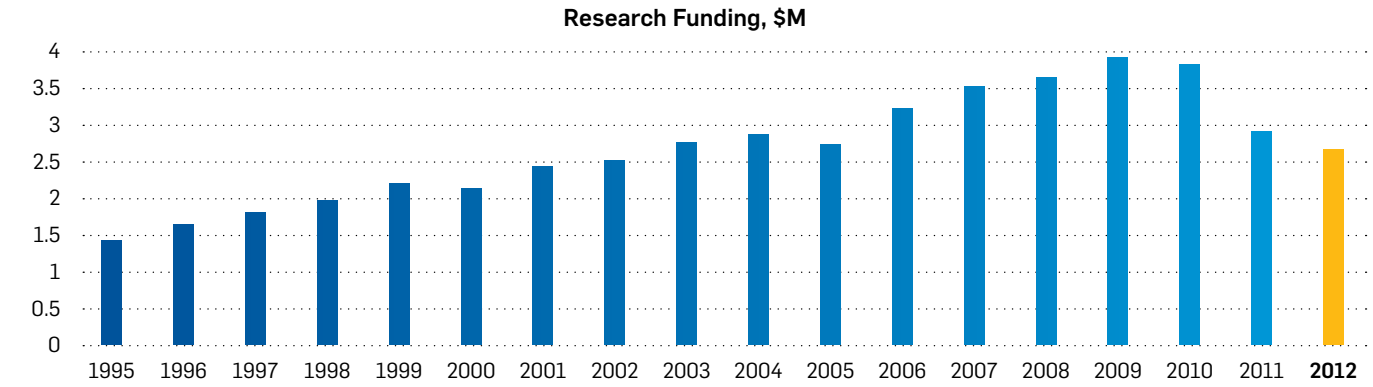
I thank all of those who helped make 2012 a success. I look forward to reporting more exciting achievements in the years to come.

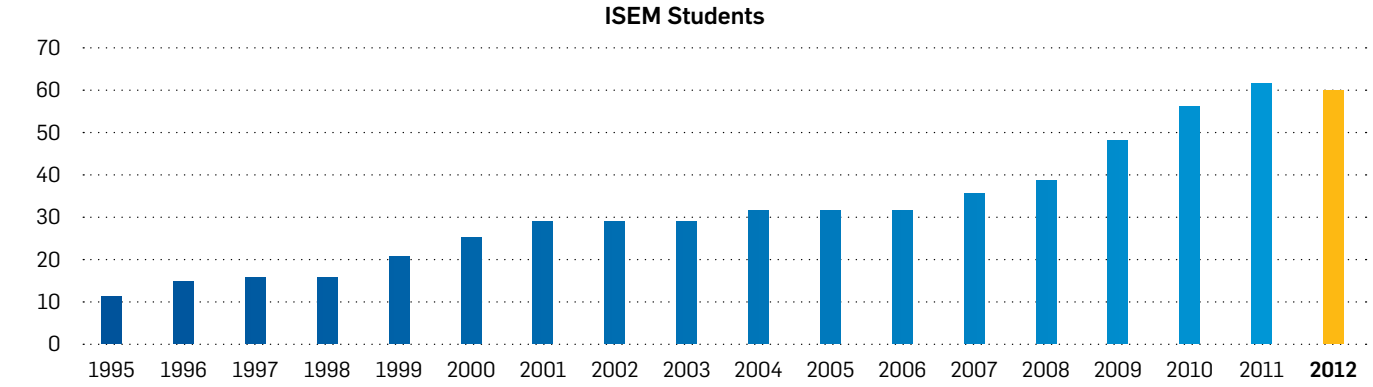
Sincerely yours,

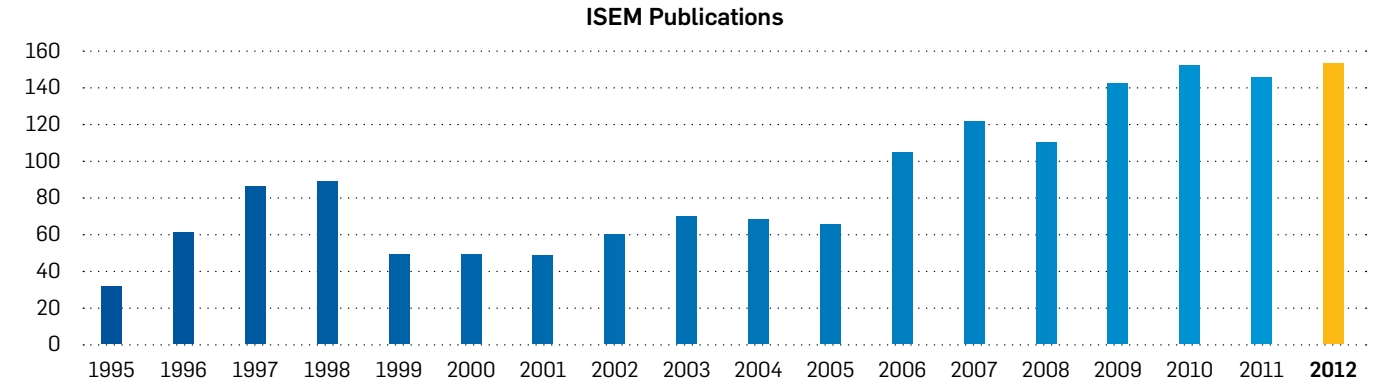
PROF. SHI XUE DOU

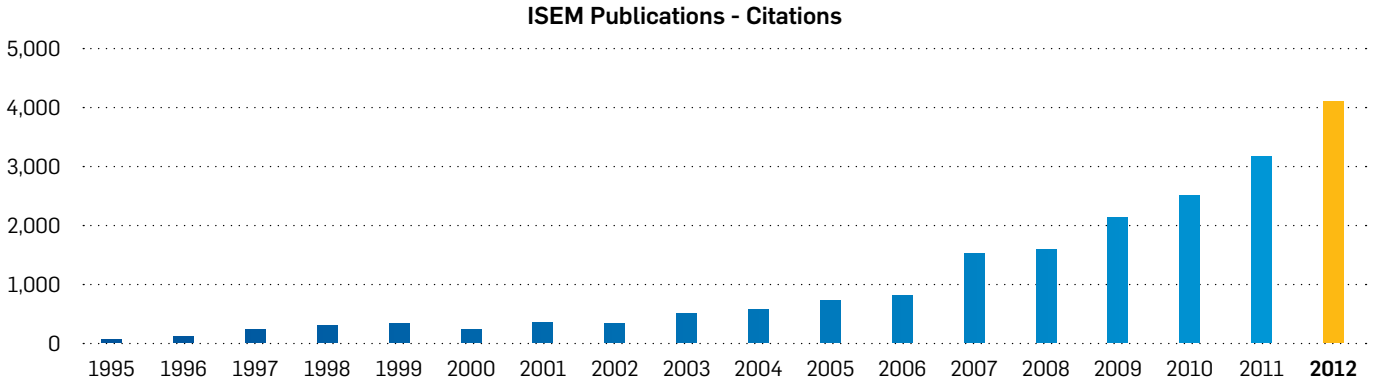
DIRECTOR, INSTITUTE FOR SUPERCONDUCTING AND ELECTRONIC MATERIALS

ISEM AT A GLANCE









MANAGEMENT

MANAGEMENT COMMITTEE

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

INDUSTRY ADVISORY GROUP

Dr. F. Darmann	Chief Engineer, Zenergy Power Ltd.
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Dr. X. F. Gao	General Manager, Lexel Batteries Co. Ltd, Shenzhen, P. R. China
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Mr. A. Kittel	Managing Director, Redarc Electronics, Adelaide, SA, Australia
Mr. R. Blade	Director, Blade Electric Vehicles Pty Ltd, QLD, Australia
Mr. J. Brown	Managing Director, Charge Point Australia, NSW, Australia
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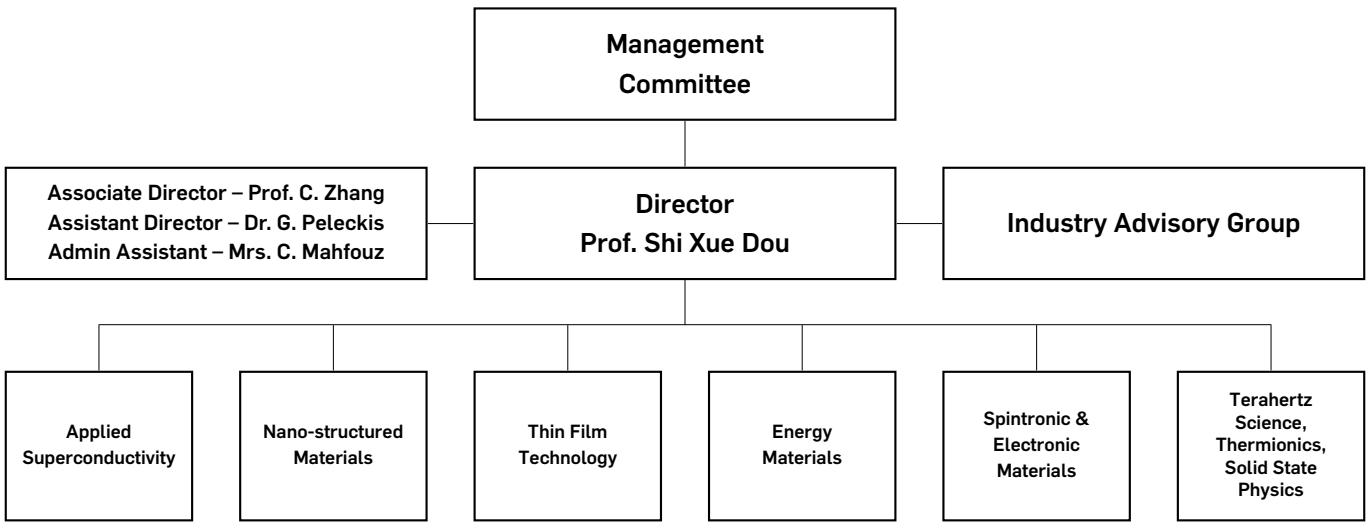
Mr. J. Y. Xu	Chief Executive Officer, Ningbo Jain Sen Mechanism Ltd
Mr. C. Fu	Chief Executive Officer, Zhuo Yi Technology Ltd, Yingko, China

ADVISORY COMMITTEE

Prof. J. H. Li	Vice President of Chinese Academy of Science
Prof. P. J. Zhang	President of Bao Steel Research Institute
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 (PhD, DSc, FTSE)

ASSOCIATE DIRECTOR

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ASSISTANT DIRECTOR

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

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

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Prof. Roger Lewis (BSc (Hons), PhD, FAIP, FRMS)

Dr. David Martin (MSc, PhD, MAIP)

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Dr. Zhi Xin Chen (BSc, MSC, PhD)

Dr. Yue Zhao (MSc, PhD)

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Dr. Jian Zhong Li

Dr. Hui Shen

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Dr. Peng Cheng

Dr. Chongjun Zhao

Dr. Chong Hong Yang

Dr. Sang Soo Oh

Dr. Goojin Jeong

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Mrs. Crystal Longin Mahfouz

Mrs. Narelle Badger

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Prof. Edward Collings, Ohio State University

Prof. Lei Jiang, Fellow of Chinese Academy of Science, Institute of Chemistry CAS

Prof. Tom Johansen, Fellow Oslo University

Prof. Shane Kennedy, Deputy Director of Bragg Institute, ANSTO

Dr. Scott Needham, Intven Ltd

Prof. Guo Xiu Wang, Future Fellow (FT-3) University of Technology, Sydney

Prof. Dongyuan Zhao, Fellow of CAS, Fudan University

Prof. Kostya Ostrikov, Future Fellow (FT-3), CSIRO

Prof. Chang Ming Li, Fellow of Royal Society of Chemistry, Southwest University

ISEM group photo (Summer 2011)

In September 2012 a delegation from UOW which included Professor Dou commenced discussions with the Chinese Academy of Sciences that resulted in the Vice President of the Academy, Professor Jinghai Li, visiting UOW in November 2012 and signing and MOU that would facilitate greater research collaboration and the development of joint PhD programs.

POSTGRADUATE STUDENTS

CURRENT

PhD	Thesis Title	Supervisors
Mr. Mohammad Ihsan	Li-based polymer electrolyte for solid state battery	Prof. Hua Kun Liu, Prof. Zaiping Guo
Mr. Majharul Khan	Synthesis and characterization of BN	Prof. Hua Kun Liu, Dr. Zhenguo Huang
Mr. Jun Wang	All solid state lithium ion batteries	Prof. Hua Kun Liu, Dr. Jiazhao Wang
Mr Yuede Pan	Nanostructured electrode materials for lithium ion batteries	Prof. Shi Xue Dou, Dr. Shulei Chou
Mrs Xin Liang	Study on sulfur cathode materials for high performance lithium/sulfur batteries	Dr. Jiazhao Wang, Dr. Kosta Konstantinov, Prof. Hua kun Liu
Mr Spencer Porter	Perovskite titanium and niobium oxide nitrides: synthesis and characterization	Dr Zhen Guo Huang, Prof Shi Xue Dou
Ms Weijie Li	Nano TiO_2 for applications	Prof. Shi Xue Dou, Dr. Shulei Chou, A/Prof Jong Ho Kim
Mr Hong Qing	Li-S battery	Prof. Zaiping Guo
Mr Tong Fei	Na-ion battery	Prof. Zaiping Guo
Mr Feng Xiao	Synthesis of high quality BN graphene	Dr. Zhenguo Huang, A/Prof. Huajun Li
Mr Sujith Kalluri	Design of electrospun graphene-metal oxide nanofibrous electrodes for supercapacitors	Prof. Zaiping Guo, Prof. Shi Xue Dou
Mr Mohammad Rejaul Kaiser	Development new materials for Li-Air batteries	Dr. Jiazhao Wang, Prof. Shi Xue Dou
My Monirul Islam	High performance supercapacitors	Dr. Kosta Konstantinov, Prof. Shi Xue Dou
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	Improved nano-structures in hydrolysis-derived titanium dioxide particles for dye sensitized solar cell applications	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, Dr Frank Klose
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. Dr. Xun Xu, Prof. Xiaolin Wang
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	The study of magnetic property of low dimensional spin system	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

PhD	Thesis Title	Supervisors
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
Mr. Abolfazl Jalalian	Lead free Piezoelectric materials	Prof. Shi Xue Dou, 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
Ms. Sha Li	Bio-compatible materials for batteries	Prof. Hua Kun Liu, 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 cathode 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. Jian Jian 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. Shariar Hossain
Mr. Mislav Mustapic	Enhancement of MgB_2 superconductor by magnetic nanoparticle doping	A/Prof. J. 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	Prof. Zaiping Guo, Prof. Hua Kun Liu
Ms. Mahboobeh Shahbazi	Study of iron pnictide 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. J 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, Dr. Shulei Chou

PhD	Thesis Title	Supervisors
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	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

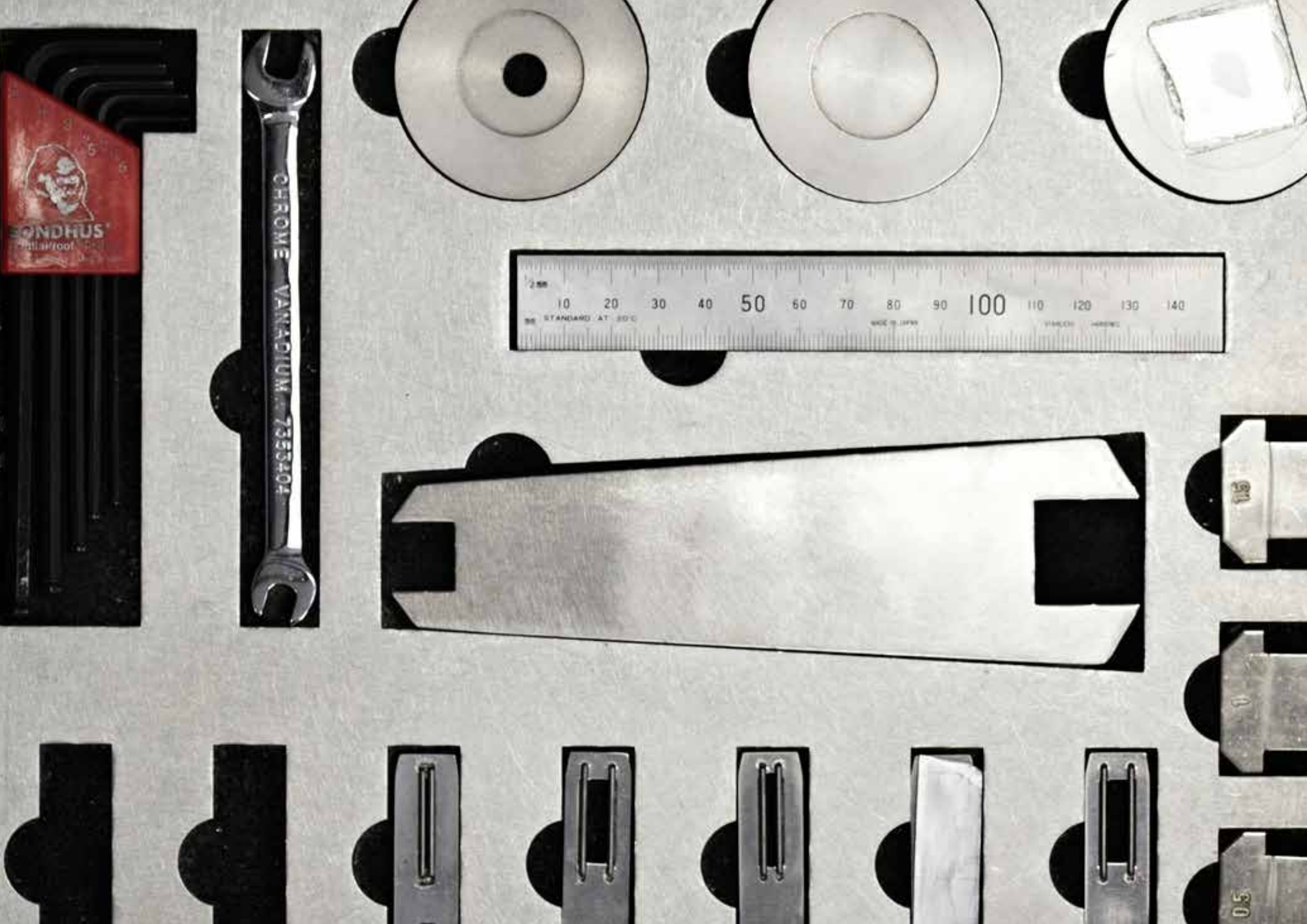
MASTER'S

Master's	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
J. Debnath	Nanostructure control of MgB_2 by chemical doping	2012	Research Fellow, University of Johannesburg, South Africa	2012
N. Idris	Nanomaterials for lithium rechargeable batteries	2012	Lecturer, University Malaysia Terengganu, Malaysia	2012
M. Ismal	Hydrogen storage materials	2012	Lecturer, University Malaysia Terengganu, Malaysia	2012
J. F. Mao	Study on hydrogen storage behaviour of $LiBH_4$	2012	Research Fellow, Max-Planck Institute, Germany	2012
K.W. See	Experimental and theoretical approaches for AC losses in practical superconducting tapes for engineering applications	2012	Research fellow, ISEM, UOW	2012
P. Jood	Oxide thermoelectric materials for high temperature power generation	2012	Research Fellow, AIST, Japan	2012
G. Du	Performance improvement of cathode materials for lithium batteries	2012	Research Fellow, University of Western Sydney	2012
Y. Du	Multiferroic transition metal oxides: structural, magnetic, ferroelectric, and thermal properties	2011	UOW VC Fellow, ISEM, University of Wollongong	2011
M. F. Hassan	Nanostructured materials for lithium ion batteries	2011	Lecturer, University Malaysia Terengganu, Malaysia	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	Postdoctoral fellow, National Chiao Tung University, Taiwan	2012
J. Park	Nanostructured semiconducting metal oxides for use in gas sensors	2011	Research Fellow, Gyeongsang National University, South Korea	2011
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


BONDHUS
CHROME VANADIUM
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PhD Name	Thesis Title	Awarded	Position	Appointed
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	Service Manager, Scanmedics, Australia	2011
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		
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 Humboldt Research Fellow, Max Planck Institute, Germany	2009 2013
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	Deputy general manager, Sinopoly Battery Co Ltd	2008
O. Shcherbakova	Development of $MgB_{2-x}C_x$ superconductors and understanding their electromagnetic behaviour	2008	Research Fellow, ISEM, University of Wollongong, Patent Officer, Australian Patent Office, Canberra	2008 2013
M. S. Park	Synthesis and characterization of nanostructured electrode materials for rechargeable lithium ion batteries	2008	Senior staff, Korean Electronic Technology Institute, 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 ARC DECRA Fellow, University of Wollongong	2008 2013
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 Fellow, 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., Australia	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

PhD Name	Thesis Title	Awarded	Position	Appointed
M. Roussel	Magneto-optical imaging in superconductors	2007	Director, 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, PR China	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		
S. H. Pilehrood	Electronic properties of semiconductor nanostructures under intense terahertz radiation	2006		
W. K. Yeoh	Control of nanostructure for enhancing superconductor performance through chemical doping	2006	Research Fellow, Cambridge University, U.K.	2007
Y. Zhao	Fabrication and characterization of superconducting PLD MgB_2 thin films	2006	APD Fellow ISEM, University of Wollongong Lecturer, University of Wollongong	2006 2008
S. Keshavarzi	Investigation of vortex dynamics of $(Tl,Pb)(Sr,Ba)_2Ca_2Cu_3O_y$ and an alternative method for determination of the lock-in angle in twinned superconductors	2005	Lecturer, Shahrekord University, Iran	2005
F. Gao	Studies on the synthesis, characterization and properties of colossal magnetoresistive (CMR) materials	2004	Research Fellow, ISEM, University of Wollongong	2004
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 Research Associate, ISEM, University of Wollongong	2005 2009
Z. P. Guo	Investigation on cathode materials for lithium-ion batteries	2003	APD Fellow, ISEM, University of Wollongong Lecturer, University of Wollongong QE II Fellow, ISEM, University of Wollongong	2003 2007 2009
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 Research Fellow, ISEM, University of Wollongong	2002 2004 2007 2010

PhD Name	Thesis Title	Awarded	Position	Appointed
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 Bi-2212 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 Professor, University of Technology, Sydney	2001 2006 2010
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, Northborough Research and Development Center, USA	2012
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, UOW Professor, ISEM, University of Wollongong	2000 2002 2005 2008
R. Zeng	Processing and characterization of Bi-2223/Ag superconducting tapes	2000	Research Fellow, ISEM, University of Wollongong Senior Research Fellow, University of Western Sydney	2000 2012
J. Chen	High energy storage material for rechargeable nickel-metal hydride batteries	1999	NEDO Fellow, Osaka National Research Institute Professor, Nankai University, PR 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 Tc 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, PR China	1997 2000 2003
M. Lerch	Optical & electrical studies of resonant tunnelling heterostructure	1998	Lecturer, School of Engineering Physics, University of Wollongong	2006

PhD Name	Thesis Title	Awarded	Position	Appointed
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 of Sciences, PR China	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, PR China CEO, Guangzhou Delong Energy Tech Ltd., PR China Research Fellow, ISEM, University of Wollongong	1997 2002 2003 2009
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 2002
N. Vo	Design and characterization of HTS coils	1997	Research Fellow, Los Alamos Nat. Lab, USA Research Staff, Intermagnetics General Co., USA	1998 1999
A. Warner	A spectroscopic study of acceptors in germanium	1997	Consultant, Computer Industry	1999
J. M. Xu	Phase formation and transformation in the R-Fe-T system (R=Nd, Gd, Tb, Dy, Er, Ho, T and Lu, T=Si, Ti & Zr	1997	Research Fellow, St. George Bank, Australia	1998
M. Yavus	Powder processing of Bi-Pb-Sr-Ca-Cu-O superconducting materials	1997	Ass. Professor, Texas A&M University, Texas USA Ass. Research Professor, Tohoku University, Sendai, Japan Ass. Professor, University of Waterloo, Canada	2000 1997 2007
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, PR China	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 Tc superconductor wire	1992	Chief Technologist, Australian Superconductors Business Development Manager, University of Sydney	1993 2004

MASTERS COURSE GRADUATES

Masters Name	Thesis Title	Awarded	Position	Appointed
I. Sultana	Biodegredable material for bio battery	2012		
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 Tc 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
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
'Ecole Polytechnique de Montreal
University of Alberta
Dalhousie University

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
Shandong University
Fudan University
Institute of Physics, Chinese Academy
Institute of Chemistry, Chinese Academy
Bi Hang University
Ji Lin 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)
Korea Electronics Technology Institute

Switzerland
University of Geneva
Paul Scherer Institute

Ukraine
Donetsk Physico-Technical Institute
Institute for Metal Physics

United Kingdom
Imperial College
Oxford University
Southampton University
University of Cambridge

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Houston University
Los Alamos Laboratory
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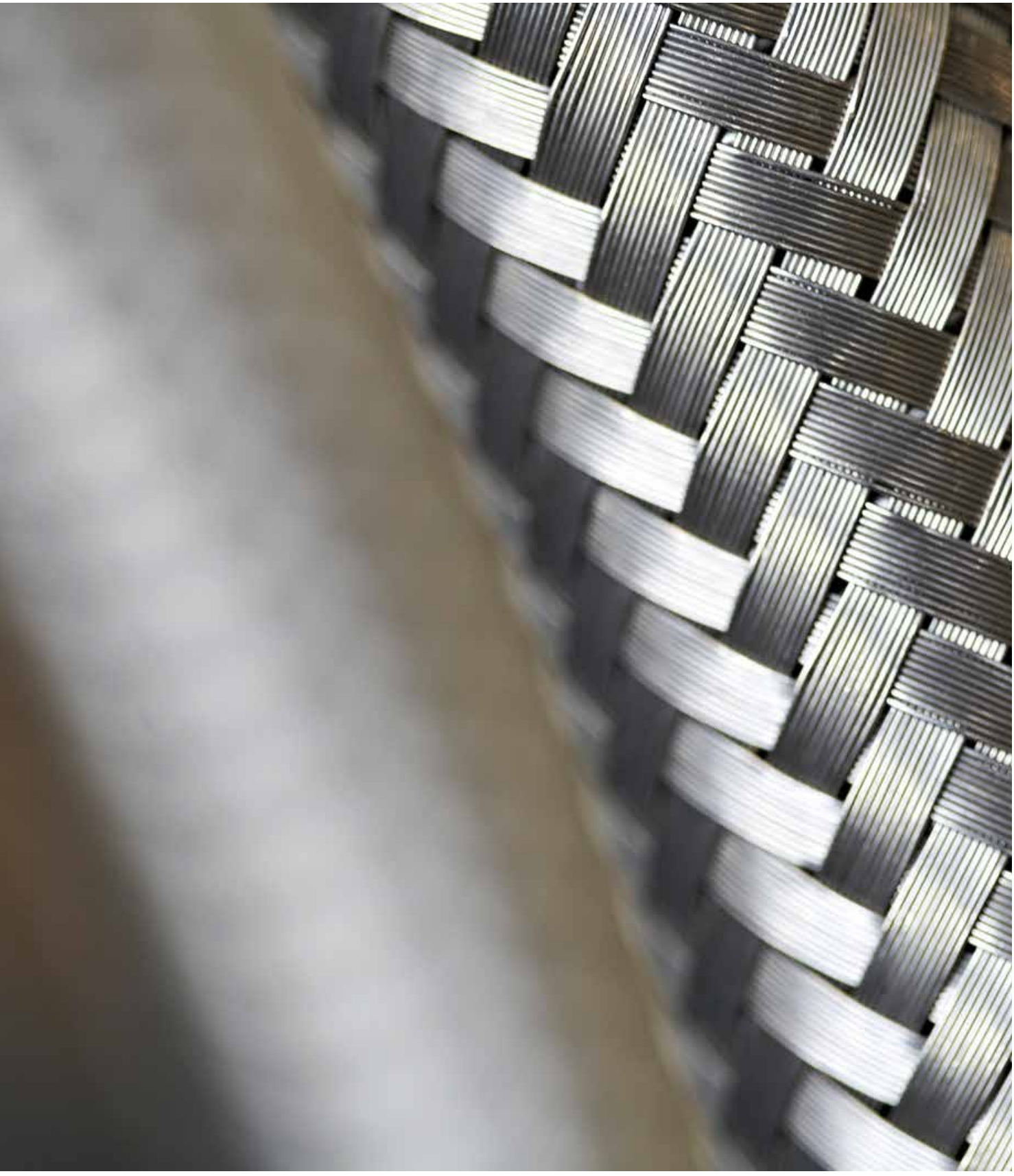
New York Polytechnic University
Ohio State University
University of Wisconsin
Rensselaer Polytechnic Institute
Case Western Reserve University
Florida State University
West Reserve University



ANNUAL ARC PROJECTS' PROGRESS REPORTS

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)

CIs/PIs: H. K. Liu

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

PhD students: M. Rahman, N. Idris, L. Noerochim, S. Li, I. Sultana

Highly flexible and bendable free-standing polypyrrole-para (toluene sulfonic acid) (PPy-pTS) films were prepared using the electropolymerization method. Electrochemical tests demonstrated that the PPy-pTS film with 30 min deposition time exhibited higher discharge capacity (85 mAh/g) beyond 80 cycles than the PPy-pTS films with 1 h deposition time (76 mAh/g) and 2 h deposition time (55 mAh/g) at 0.1 mA cm^{-2} over a potential range of 2.5–4.3 V. The free-standing films can be used as electrode materials to satisfy the new market demand for flexible and bendable polymer batteries.

Flexible free-standing polypyrrole-indigo carmine (PPy-IC) films were designed as additive-free anode material for lithium ion batteries and were produced via the electropolymerization method. The PPy-IC films prepared at lower deposition time (30 min) and lower deposition current density (0.4 mA cm^{-2}) exhibited higher discharge capacity (83 mAh/g beyond 100 cycles) in the voltage range of 0.01–3.0 V. These free-standing films can be used as possible anode materials to satisfy the new market demand for flexible/bendable lithium polymer or polymer batteries that are suitable for roll-up displays, wearable devices, and implanted medical devices used in biological and biomedical systems.

A novel all-polymer battery system was built by PPy-pTS as cathode and PPY-IC as anode. In the system, all the free-standing PPy–pTS and PPy–IC films were directly used without needing any metal substrate support to hold the electro active material. Electrochemical measurements demonstrated that the PPy–pTS/PPy–IC (commercial electrolyte) system exhibited a reversible discharge capacity of 36 mAh/g at 0.05 mA cm^{-2} after 50 cycles, is 92% of the initial discharge capacity. In the case of PPy–pTS/PPy–IC (polymer electrolyte), the reversible discharge capacity after 50 cycles was 16 mAh/g, 76% of the intial discharge capacity. This work may lead to a future generation of all polymer batteries that are suitable for implanted medical devices used in biological and biomedical systems.

Free-standing single-walled carbon nanotube/SnO_2 (SWCNT/SnO_2) anode paper was prepared by vacuum filtration of SWCNT/SnO_2 hybrid material. From FE-SEM and TEM, the CNTs form a three-dimensional nanoporous network, in which ultra-fine SnO_2 nanoparticles, which had crystallite sizes of less than 5 nm, were distributed, predominately as groups of nanoparticles on the surfaces of single walled CNT bundles. Electrochemical measurements demonstrated that the anode paper with 34 wt.% SnO_2 had excellent cyclic retention, with the high specific capacity of 454 mAh/g beyond 100 cycles at a current density of 25 mA/g, much higher than that of the corresponding pristine CNT paper. This model holds great promise for applications requiring flexible and bendable Li-ion batteries.

Publications:

1. L. Noerochim, J. Wang, S. Chou, D. Wexler, H. K. Liu, Carbon 50, 1289 (2012).
2. I. Sultana, M. Rahman, S. Li, J. Wang, G. Wallace, H. K. Liu, Electrochimica Acta 60, 201 (2012).
3. I. Sultana, M. Rahman, J. Wang, C. Wang, G. Wallace, H. K. Liu, Solid State Ionics 215, 29 (2012).
4. I. Sultana, M. Rahman, J. Wang, C. Wang, G. Wallace, H. K. Liu, Electrochimica Acta accepted (10/08/2012).
5. M. Rahman, J. Wang, R. Zeng, D. Wexler, H. K. Liu, Journal of Power Sources 206, 259 (2012).
6. N. H. Idris, M. Rahman, J. Wang, H. K. Liu, Journal of Power Sources 201, 294 (2012).

DISCOVERY PROJECTS

PROJECT ID: DP1093952

Title: Advanced nanostructured ceramic composites for ultracapacitors

CIs/PIs: K. Konstantinov, H. K. Liu, A. Calka, D. Wexler

The research project has progressed successfully. The achievements and outcomes are summarised as follows:

We 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 685 F/g) and excellent cycle life. The results are included in a Provisional Patent and partly published in a most prestigious energy related journal (Energy and Environmental Science) with IF 9.63 [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-indecember/. It has already attracted 7 citations for the first five months after being published. Recently, we have developed even better method for self-assembly of ternary systems consisting Graphene oxide/ metal oxide and CNTs using a unique spray pyrolysis of liquid crystals approach leading to materials performance up to 2000 F/g.

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 $3.5x10^5$ 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 favours the formation of oxygen vacancies in the nanocrystalline TiO_2 particles. We have also investigated the influence of phase transformations in rutile on the electrochemical capacitance [4].

Publications:

1. A. Chidembo, S. H. Aboutalebi, K. Konstantinov, M. Salari, B. Winton, S. Aminorroaya Yamini, I. P. Nevirkovets, and H. K. Liu, Energy and Environmental Science 5, 5236 (2012).
2. A. Calka, A. A. Chowdhury, and K. Konstantinov, Journal of Alloys and Compounds 536S, S3(2012).
3. M. Salari, M. Rezaee, A. T. Chidembo, K. Konstantinov, and H. K. Liu, Journal of Nanoscience and Nanotechnology 12, 4724 (2012).
4. M. Salary, S. Aboutalebi, A. Chidembo, I. Nevirkovets, K Konstantinov and H. K. Liu, Physical Chemistry Chemical Physics 14, 4770 (2012).

PROJECT ID: DP1094073

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

CIs/PIs: X. L. Wang, D. Chen, G. Peleckis, H. Hosono, X. H. Chen, A. Studer, K. Muller, E. Muromachi

This project officially started in Sep. 2010 due to the delay of the agreement from partner investigators' Institutions. The following results were obtained or published in 2012:

1) We reported vortex pinning mechanisms of $Ba_{0.72}K_{0.28}Fe_2As_2$ single crystals. Both the dl and the dTc pinning mechanisms, coexist in the crystal in fields, B< 4 T. At lower temperature and B=4T, the dl pinning is the dominant mechanism, and its contribution decreases with increasing temperature. At temperatures close to the Tc, however, there is evidence for dTc pinning. For B > 4 T, the dl pinning is the only effect. [1]

2) Underdoped $BaFe_{1.9}Co_{0.1}As_2$ crystal was studied by angular dependence of magneto-transport. Results show that pinning potential, decreases slightly, while, H_{c2}, and H_{irr}, increase. Anisotropy in the underdoped crystal is found to be temperature dependent and decreases from 2.1 to 1.8 for as T is reduced from 17 to 12.5 K[2].

3) The vortex liquid-to-glass transition has been studied in three $Ba_{0.72}K_{0.28}Fe_2As_2$, $Ba(Fe_{0.91}Co_{0.09})_2As_2$, and $Ba(Fe_{0.95}Ni_{0.05})_2As_2$ (BaNi-122) crystals. The vortex state is three-dimensional at temperatures lower than a characteristic temperature T*. The vortex phase diagram was determined based on the evolution of the vortex-glass transition temperature Tg with magnetic field and the upper critical field, H_{c2}. We found that non-magnetic K doping results in a high glass line close to the H_{c2}, while magnetic Ni and Co doping causes a low glass line which is far away from the H_{c2}. This work was published in Applied Physics Letters [3]

4) We reported on measurements and theoretical model calculations of voltage-current characteristics of a

$Ba_{0.72}K_{0.28}Fe_2As_2$ single crystal slightly below its transition temperature in perpendicular magnetic fields between 0.01 and 7 T. We proposed a model that describes the flux-line dynamics above and below the depinning current [4].

5) We reported the angular-dependent interlayer MR of up to 160% in Sb_2Te_3 bulk crystals. The interlayer MR anisotropy originates from field-induced polarization of valleys, and Coulomb interaction-induced valley distortion. The strong anisotropy of the angular-dependent interlayer MR reflects strong anisotropies of carrier scattering time and effective mass in the six valleys and their inequivalent contributions to total magneto-conductivity and interlayer MR in p-type Sb_2Te_3 bulk. This work has been published in Physical Review B [5].

6) Angular-dependences of in-plane and interlayer magneto-transport properties in n-type Bi_2Te_3 bulk single crystals have been investigated. Giant in-plane magneto-resistances (MR) of up to 500% and interlayer MR of up to 200% were observed, respectively. This work was published in APL [2].

7) We demonstrate topological band insulator (Bi_2Te_3) SQUIDs, based on Nb leads coupled to nano-fabricated $NbBi_2Te_3$-Nb Josephson junctions. Clear critical current modulation of both the junctions and the SQUID with applied magnetic fields were observed. This work was published in Applied Physics Letters [7]

8) We reported that nanosheets of a Bi_2Te_3 topological insulator several quintuple layers thick display giant and linear magneto-resistance. The giant and linear magneto-resistance achieved is as high as over 600% at room temperature, with a trend towards further increase at higher temperatures, without any sign of saturation at measured fields up to 13 T. Furthermore, we observed a magnetic field induced gap below 10 K. The observation of giant and linear magneto-resistance paves the way for 3D topological insulators to be useful for practical applications. This work was published in Physical Review Letters [8].

9) The long-sought yet elusive Majorana fermion is predicted to arise from a combination of a superconductor and a topological insulator. An essential step in the hunt for this emergent particle is the unequivocal observation of supercurrent in a topological phase. We reported the earliest work on the direct evidence for Josephson supercurrents in Nb-topological band insulator Bi_2Te_3–Nb. This junction provides significant prospects for the realization of devices supporting Majorana fermions. This work was published in Nature Materials [9].

10) Partially supported by this project, we have done a breakthrough on the antireflection glass which was published in Advanced Materials [10]. In addition, supported by the APD fellowship, a few collaborative works have been done on thermoelectric materials, an organic semiconductor and nanocarbon yarn [11-13]

Publications:

1. S. R. Ghorbani, X. L. Wang, et al., Applied Physics Letters 100, 212601 (2012).
2. M. Shahbazi, X. L. Wang, et al., Applied Physics Letters 100, 102601 (2012).
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5. Z. J. Yue, C. B. Zhu, S. X. Dou, and X. L. Wang, Physical Review B 86, 195120 (2012).
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7. M. Veldhorst, C. G. Molenaar, X. L. Wang, et al., Applied Physics Letters, 100, 072602 (2012).
8. X. L. Wang et al, Physical Review Letters 108, 266806 (2012).
9. M. Veldhorst, M. Snelder, M. Hoek, T. Gang, X. L. Wang, et al., Nature Materials 11, 417 (2012).
10. L. Q. Liu, X. L. Wang, Advanced Materials 24, 6318 (2012).
11. P. Jood, G. Peleckis, X. L. Wang, and S. X. Dou, Journal of Materials Research 27, 2278 (2012).
12. T. H. Le, G. Peleckis, et al., European Journal of Inorganic Chemistry 17, 2889 (2012).
13. J. Foroughi, G. Peleckis, G. G. Wallace, and R. H. Baughman, Nanoscale 4, 940 (2012).

PROJECT ID: DP110103909

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

CIs/PIs: J. Z. Wang, S. L. Chou, H. J. Li, Y. P. Wu, K. Ozawa

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

(1) $LiFePO_4$-graphene composite cathode materials

$LiFePO_4$ composites with different percentages of graphene (4%, 8%,15%) were synthesized. 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 highly stable reversible capacity of 80 mAh g^{-1} was obtained at the highest current density of 10 C, while the corresponding value is only 50 mAh g^{-1} for $LiFePO_4$.

(2) VO_2- graphene composite cathode materials

VO_2/graphene composite was synthesized by an in-situ hydrothermal process directly from graphene oxide and V_2O_5. Electrochemical tests showed that the VO_2/graphene composite features high discharge capacity (380 $mAhg^{-1}$) and 99% capacity retention after 50 cycles.

(3) $LiFeO_2$-polypyrrole nanocomposite cathode materials

A conducting α-$LiFeO_2$-polypyrrole nanocomposite material was prepared by the chemical polymerization method. The polypyrrole coating improves the reversible capacity and cycling stability (104 mAh g^{-1} at 0.1C after 100 cycles) for lithium-ion batteries. Even at the high rate of 10 C, the electrode showed more than 50% of the capacity at low rate (0.1C).

(4) $LiNi_{0.5}Mn_{1.5}O_4$ nanoparticles cathode with ionic liquid electrolyte

$LiNi_{0.5}Mn_{1.5}O_4$ nanoparticles were prepared via a rheological phase method. The ionic liquid was used as electrolyte. The electrochemical measurements showed that the $LiNi_{0.5}Mn_{1.5}O_4$ annealing in 750 °C using 1 M lithium bis(trifluoromethysulfony) imide (LiTFSI) in N-buty-N-methylpyrrolidinium bis(trifluoro-methanesulfonyl) imide (Py14TFSI) as electrolyte show comparable capacity to the conventional electrolyte (1 M $LiPF_6$ in EC:DEC=1:2 (v/v)) with improved columbic efficiency.

(5) Li_xCoPO_4 as cathode materials with ionic liquid electrolytes

A series of Li_xCoPO_4 (x = 0.90, 0.95, 1, 1.05) compounds with different lithium content were prepared by a sol-gel method. Cycling stability and higher coulombic efficiency was achieved when using the ionic liquid electrolyte ($[C_3mpyr][NTf_2]$ containing 1 M $LiNTf_2$) rather than the conventional electrolyte (1 M $LiPF_6$ in EC:DEC).

(6) $LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$ cathode material using different binders

The electrochemical performance results showed that the cheap and environmental friendly CMC as a binder for $LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$ can improve the high rate capability and reduce the cost of lithium ion batteries in comparison with current commercial PVDF binder. EIS test results indicated that the $LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$ electrode using CMC as binder had much lower charge transfer resistance and lower activation energy than the electrodes using alginate and PVDF binders.

Publications:

1. Y. Shi, S. L. Chou, J. Z. Wang, D. Wexler, H. J. Li, H. K. Liu, and Y. P. Wu, Journal of Materials Chemistry 22, 16465 (2012).
2. Y. Shi, S. L. Chou, J. Z. Wang, H. J. Li, H. K. Liu, Y. P. Wu, Journal of Power Sources, DOI:10.1016/j.jpowsour.2012.11.151 (2012).
3. X. W. Gao, C. Q. Feng, S. L. Chou, J. Z. Wang, J. Z. Sun, M. Forsyth, D. R. MacFarlane, H. K. Liu, Electrochimica Acta, Accepted, DOI:10.1016/j.electacta.2012.10.156. (2012).
4. J. T. Xu, S. L. Chou, M. Avdeev, M. Sale, H. K. Liu, S. X. Dou, Electrochimica Acta 88, 865 (2013).
5. J. T. Xu, S. L. Chou, Q. F. Gu, H. K. Liu, S. X. Dou, Journal of Power Sources 225, 172 (2013).

PROGRESS REPORT: DP120100095

Title: Nanostructure engineered iron-based pnictide superconductors

CIs/PIs: S. X. Dou, J. H. Kim, G. Peleckis, J. Driscoll, E. Hellstrom, Y. Ma, H. Kumakura, Xue Yan Song

1) The isovalent substitution effect of Ru in $CeFe_{1-x}Ru_xAsO$ ($0 \leq x \leq 1$) was systematically studied by powder X-ray diffraction, electrical resistivity, magnetization, and specific heat measurements. The antiferromagnetic (AFM) ordering of both d and 4f electrons are suppressed upon Ru doping, followed by Pauli paramagnetism (d electrons) and local moment paramagnetism (4f electrons) with strong ferromagnetic fluctuation, respectively. No superconductivity above 2K and no pronounced Kondo screening is observed in the substitution phase diagram. Combined with published results of the cerium- based quaternary compounds CeM X O (M = Fe, Ru; X = P, As), our data suggest that the end member CeRuAsO is on the verge of becoming an FM Kondo lattice. Meanwhile, the ground state of 4f electrons in the quaternary CeM X O system should be determined by both the interlayer d-f Kondo coupling (J(Kondo)) and the intralayer Ruderman-Kittel-Kasuya-Yosida (RKKY) interaction (J(RKKY)), which are both very sensitive to the change in crystal structure.

2) Understanding the flux-line dynamics in layered superconductors is of utmost importance for many superconductor applications, yet extracting from measurements the relevant parameters remains a major challenge. We reported on measurements and theoretical model calculations of voltage-current (V-I) characteristics of a superconducting $Ba_{0.72}K_{0.28}Fe_2As_2$ single crystal slightly below its transition temperature in perpendicular magnetic fields between 0.01 and 7 T. We proposed a model that describes the flux-line dynamics above, as well as below, the depinning

current. The model fits the experimental V-I characteristics remarkably well and is used to extract from the data the field dependence of (a) the depinning current, (b) the pinning potential barrier height, (c) the dissipative resistance, and (d) the product between flux-line bundle volume and bundle hopping distance. The model also leads to an estimate of the average distance between pins.

3) The vortex pinning mechanisms of $Ba_{0.72}K_{0.28}Fe_2As_2$ single crystal were studied systematically as a function of temperature and magnetic field. The temperature dependence of the critical current density, J(c)(T), was analysed within the collective pinning model at different magnetic fields. It was found that both the delta l pinning mechanism, i.e., pinning associated with charge-carrier mean free path fluctuation, and the delta T-c pinning mechanism, which is associated with spatial fluctuations of the transition temperature, coexist in the $Ba_{0.72}K_{0.28}Fe_2As_2$ single crystal in fields smaller than 4 T. Their contributions are strongly temperature and magnetic field dependent. At lower temperature and B ≤ 4T, the delta l pinning is the dominant mechanism, and its contributions decrease with increasing temperature. At temperatures close to the critical temperature, however, there is evidence for delta T-c pinning. At magnetic fields larger than 4 T, the delta l pinning mechanism is the only effect.

Publications:

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2. K. H. Muller, S. K. H. Lam, X. L. Wang, S. X. Dou, Physical Review B 85, 224516 (2012).
3. S. R. Ghorbani, X. L. Wang, M. Shahbazi, S. X. Dou, C. T. Lin, Applied Physics Letters 100, 212601 (2012)

FUTURE FELLOWSHIP

PROJECT ID: FT0990391

Title: Manipulation of spin by electric field

CI: Z. X. Cheng

The following results were obtained in 2012:

A careful investigation of specific heat of Er^{3+} doped $NdMnO_3$ showed that the ground state splitting of Nd^{3+} has been modified by the Er^{3+} doping, as it shows a nonlinear dependence on the Er^{3+} doping rate, due to the competition between the crystal field and the exchange field. On the contrary, the ground state splitting of Er^{3+} has a linear dependence on the doping rate, indicating its stronger dependence on the crystal field rather than the exchange field [1].

Exchange bias effects were studied in the simple perovskite $NdMnO_3$. Nd^{3+} ordering is induced by the Mn^{3+} ferromagnetic component, and they are antiferromagnetically coupled with each other. At 30 K, both negative and positive exchange bias effects are found, which are dependent on the cooling field. The exchange bias fields are around 2400 Oe and 1800 Oe, respectively. Positive and negative exchange bias effects were also observed at 8K, but the exchange bias fields are only 130 Oe and 120 Oe. The coupling intensity between Nd^{3+} ordering and Mn^{3+} ordering, and their initial states determine the polarity of the exchange bias fields [2].

Perovskite $DyMn_{0.33}Fe_{0.67}O_3$ experiences a paramagnetism-antiferromagnetism transition at 450K and spin reorientation at 290 K. Magneto-dielectric properties were studied around the spin reorientation transition. Both giant positive and giant negative magneto-dielectric coupling (MDC) were observed near room temperature. The MDC shows strong temperature and frequency dependence, and the sign changes from positive to negative when magnetic state transits from a canted antiferromagnetic state to a collinear antiferromagnetic state. Possible mechanisms are proposed based on the Maxwell-Wagner model, phase transition, the magneto-resistance effect, and spin-phonon coupling [3].

The dielectric constant and loss of perovskite $DyMn_{1-x}Fe_xO_3$ samples show strong dispersion in various frequencies, which is indicative of relaxation. The activation energies were obtained through Arrhenius law fitting and range from 0.213 eV to 0.385 eV. The Fe content dependence of the characteristic frequency f0 and the activation energy E_a shows two transitions that are well consistent with the change in orbital ordering. Meanwhile, different magnetic orderings could affect the relaxation and induce the change in E_a [4].

The coherent longitudinal acoustic (LA) phonons in La and Nb codoped polycrystalline $BiFeO_3$ films are photo-induced and detected by the ultrafast reflectance spectroscopy. The

generation mechanism of LA phonons is strongly connected with the ferroelectric polarization and is attributed to the transient photostriction effect, which is a combination of the optical rectification effect and the electrostriction effect. The strain modulation of sound velocity and out-of-plane elastic properties are demonstrated in BFO film on $SrTiO_3$, which gives the insight on the dynamical coupling between electrical polarization and lattice deformation [5].

We presented the magnetic dipole transition at 0.299 THz excited by magnetic component of terahertz electromagnetic pulse in an antiferromagnetic $YFeO_3$ crystal. The impulsive magnetic field of the terahertz pulse tilts the macroscopic magnetization, causing deviation from the equilibrium position, which is manifested by a sharp absorption at the frequency of the quasiferromagnetic mode of the crystal. The rotating coherent macroscopic magnetization radiates elliptically polarized emission at the frequency of the quasiferromagnetic resonance due to the dichroic absorption in the crystal [6].

Publications:

1. F. Hong, Z. X. Cheng, et al, Applied Physics Letters 101, 121913 (2012).
2. F. Hong, Z. X. Cheng, et al, Applied Physics Letters 101, 102411 (2012).
3. F. Hong, Z. X. Cheng, Journal of Applied Physics 112, 013920 (2012).
4. F. Hong, Z. Cheng, Journal of Applied Physics 111, 034104 (2012).
5. Z. M. Jin et al., Applied Physics Letters 101, 242902 (2012).
6. R. Z. Zhou et al., Applied Physics Letters 100, 061102 (2012).

DECRA FELLOWSHIP

PROJECT ID: DE120101496

Title: Diammoniate of diborane for hydrogen storage

CI: Z. Huang

This project officially started on April 2nd, 2012. Crucial preliminary results have been obtained so far which will greatly facilitate the future progress of this project. These include:

1. Successfully developed a different large-scale synthesis of diammoniate of diborane. Compared with the literature method, this new route produces high quality compounds, which lays solid foundation for this DECRA project.

2. Improved the synthesis of ammonia-monochloroborane (NH_3BH_2Cl) and unsubstituted aminodiboranate $Na(H_3B\text{-}NH_2\text{-}BH_3)$,which will enable the studies of the thermal decomposition pathways of these compounds under controlled environment, i.e. various pressures, atmosphere, and heating rates.

3. New synthesis of unsolvated NaB_3H_8. This new procedure, to the best of our knowledge, is so far the most safe and efficient. Syntheses of novel compounds based upon unsolvated NaB_3H_8 are currently underway.

Publications:

1. Z. Huang, T. Autrey, Energy & Environmental Science, 5, 9257 (2012).
2. Z. Huang, M. Eagles, S. Porter, E. G. Sorte, B. Billet, R. L. Corey, M. S. Conradi, J.-C. Zhao, Dalton Transactions 42, 701 (2012).
3. Z. Huang, H. K. Lingam, X. Chen, S. Porter, A. Du, P. M. Woodard, S. G. Shore, and J.-C. Zhao, RSC advances, accepted.

LINKAGE PROJECTS

PROJECT ID: LP100100802

Title: Room temperature rechargeable sulphur batteries

CIs/PIs: J. Z. Wang, H. K. Liu, K. Konstantinov, Z. X. Wang

(1) MoS_2-CNT composites

Layered MoS_2 prepared by liquid-phase exfoliation was blended with single-walled carbon nanotubes (SWNTs) to form novel composite thin films. The resulting composite films were transferred onto Cu foil electrodes via a facile filtration/wet transfer technique from nitrocellulose membranes. The morphology of the film was characterised by field emission scanning electron microscopy, which suggests that the MoS_2-SWNT composite film shows good adherence to the Cu foil substrate. The MoS_2-SWNT composite thin films show strong electrochemical performance at different charge-discharge rates. The capacity of a MoS_2-SWNT composite film with thickness of 1 µm is approximately 992 mAh g^{-1} after 100 cycles. The morphology study showed that the MoS_2-SWNT thin film retains structural integrity after 100 cycles, while the MoS_2 thin film without SWNTs displays significant cracking.

(2) S-CNT-PPy composite

A novel ternary composite, polypyrrole (PPy) coated sulphur - carbon nanotubes (CNT), was synthesised using an in situ one-pot chemical method. Firstly, elemental sulfur was loaded into the CNT network by a solution-based processing technique. Then conducting PPy was coated on the surface of the S-CNT composite to form the S-CNT-PPy ternary composite by in situ chemical polymerization of the pyrrole monomer. The ternary composite was tested as a cathode for lithium/sulfur (Li/S) batteries. The results show that PPy coating improves significantly the performance of the binary composites (S-CNT and S-PPy). The conducting PPy is believed to serve multiple functions in the composite: as a conduction additive, an active material, and an adsorbent and container to confine the polysulfides from dissolution into the electrolyte. As a result, PPy coating on the S-CNT composite enhances its conductivity, capacity, and cycling stability.

(3) MoS_2

This work is intended to evaluate the electrochemical performances of molybdenumdisulfide (MoS_2) and find out its lithium storage mechanism at different lithium insertion stages. It is found that although the MoS_2 shows excellent cycling stability in different voltage ranges, its structural transition is irreversible in the initial cycling. In contrast to the traditional beliefs, metallic Mo is found inert and Li_2S/S is the redox couple in a deeply discharged MoS_2/Li cell (0.01 V vs. Li/Li+). The metallic Mo nanoparticles are believed to be responsible for the enhanced cycling stability of the cell and act as the electronically conducting phase in the capacitive energy storage on the interfaces or grain boundaries of Mo/Li_2S_x nanocomposite. In addition, the Mo/Li_2S nanocompositecan be used as cathode material for lithium–sulfur batteries.

(4) PPy-S-PPy composites

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. Lotya, J. N. Coleman, S. L. Chou, H. K. Liu, A. I. Minett, and J. Chen, Advanced Energy Materials, Accepted, DOI: 10.1002/aenm.201201000 (2012).
2. J. Z. Wang, L. Lu, D. Q. Shi, R. Tandiono, Z. X. Wang, K. Konstantinov, and H. K. Liu, ChemPlusChem, Accepted, DOI: 10.1002/cplu.201200293) (2012).
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PROGRESS REPORT: LP100100440

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

Cis/PIs: S. X. Dou, J. Horvat, X.Xu, J. W. Moscrop

Background: The project is aimed at the design, building, and testing of a low AC loss MgB_2 coil for a Fault current Limiter which will improve the power grid's reliability and availability. The design aspects include thermodynamic and electromagnetic modeling to optimize the superconducting coil and a cryogenic system in order to cool the coil to 20-25 K. The main expected outcome is a demonstration of the first prototype MgB_2 Fault Current Limiter for industrial application. The project was conducted with industry partner Zenergy Power Pty Ltd.

Progress: New design of the coil, its former, mechanical support structure and cryostat was performed. This was needed in view of the new type of wires that will be used in the coil, which will be provided by Hypertech after all IP issues between contributing partners were cleared. The former will be made of G10, with Oxygen Free Copper acting as thermal bus ensuring sufficient heat transfer between the coil and the cooling head. Detailed analysis of thermal, mechanical and electrical properties was performed, resulting in a superior design that will suit manufacturing capacities of wire and coil producers, cryostat manufacturers, cold head properties and characteristics of the wire and coil fixing technologies used by the contributors (Hypertech).

Early in 2012, the mother company of our industry partner, Zenergy Power, went through a major internal restructure as a

consequence of global financial crisis and finally it was taken over by another company, Applied Superconductor Ltd, ASL. As a consequence, a halt was put on all our activities associated with production of the Fault Current Limiter in mid-2012. After a visit of our facilities by the ASL managers in late 2012, decision was made to continue our collaboration as before and permission was obtained to continue negotiations for production of the Fault Current Limiter. All IP issues with the new management of our industry partner have been finalized and the purchase order is soon to be issued. It is expected the Fault current limiter will be delivered by mid-2013. Because this project started late to begin with, it is expected that all goals will be achieved in time.

Personnel: X. Xu continues his fellowship under the project. K. W. See is supported by UOW as a researcher fellow 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 were set up.

Publications:

1. K. W. See, X. Xu, J. Horvat, C. D. Cook, and S. X. Dou, Superconductor Science & Technology 25, 115016 (2012).

Note: the results of the coil simulation could not been published due to IP issues.

PROGRESS REPORT: LP120100173

Title: Synergetic combination of localized internal magnesium diffusion process with cold compaction technique for fabrication of MgB_2 superconductor wires

CIs/PIs: S. X. Dou, J. H. Kim, M. S. A. Hossain, G. Peleckis

The main aim of this project is to develop novel fabrication techniques by combining a localised internal magnesium diffusion process, with a cold compaction technique and highly reactive amorphous boron powder with carbon coating, for the manufacture of MgB_2 superconductor wires with electromagnetic performance superior to low temperature Nb-Ti superconductors. In one year, the following objectives were achieved. The work according to the other objectives is continuing to achieve the goals of the proposed project: Design, test and construct a four- anvil compaction device for scalable fabrication of long-length MgB_2 superconductor wires with reduced porosity, dense core and improved grain connectivity; Develop a novel MgB_2 wire fabrication process by combining the localized internal magnesium diffusion process with a cold impaction technique; Devise an economical fabrication route, suitable for scaling-up production of amorphous boron as a critical precursor for MgB_2 manufacture.

Personnel: Dr Hossain started his Research Associate role under the project. One PhD student is also contributing tothe project in fabricating MgB_2 wires and measuring transport properties of the wire at various magnetic fields and operating temperatures.

Equipment: As a preliminary step, a prototype cold pressure densification device for the fabrication of short and dense MgB_2 wire was designed and tested by the CIs. Now the device was modified to apply densification on 20 cm long wire with homogeneous pressure along the length. The functional principle is that pressure on the wire is applied from four-sides via hard-metal anvils at room temperature. Another device called two axial rolling machine was designed and set to the drawing machine for the fabrication of isotropic square wires suitable for pressing the wire surface without any stress concentration.

Progress: Project progress over this period is in-line with the original objectives and if anything, slightly ahead of the original planned milestones. The prototype densification device and two axial rolling machines were tested for the fabrication of long length of wires. Very cheap nano sized amorphous boron source were found and tested the powder in wire forms. The monofilamentary MgB_2 wires were fabricated and analyzed using the combined effect of localized internal magnesium diffusion (LIMD) and cold compaction processes. The results were accepted and published soon in a peer reviewed journal. The advanced microstructure analysis with high resolution TEM and SEM of these samples is now under progress.

Publications:

1. M. S. A. Hossain, A. Motaman, O. Cicek, H. Agil, E. Ertekin, A. Gencer, X. L. Wang, S. X. Dou, Materials Letters 91, 356 (2013).
2. H. Agıl, Ö. Çiçek, E. Ertekin, A. Motaman, M. S. A. Hossain, S. X. Dou, A. Gencer, Journal of Superconductivity and Novel Magnetism in press published online (11th January 2013).
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4. M. S. A. Hossain, A. Motaman, O. Cicek, H. Agil, E. Ertekin, A. Gencer, X. L. Wang, S. X. Dou, Cryogenics 52, 755 (2012).

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

ARC DISCOVERY PROJECTS

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 Investigators:	A. V. Pan;				
Partner Investigators:	C. P. Foley, T. H. Johansen, H. Hilgenkamp				

Project Summary: This project focuses on the development of new scientific and technological aspects of the fabrication, properties and operation of novel hybrid systems for 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.

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 Investigator:	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 Investigator:	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 Investigator:	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 Investigator:	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 Investigator:	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.

NANOSTRUCTURE ENGINEERED IRON-BASED SUPERCONDUCTORS

Years Funded:	2012	2013	2014
Amount funded:	$140,000	$140,000	$140,000
Total Funding:	$420,000		
Project ID:	DP120100095		
Chief Investigators:	S. X. Dou, G. Peleckis, J. H. Kim		
Partner Investigator:	J. Driscoll, E. Hellstrom, Y. W. Ma, H. Kumakura, X. Y. Song		

Project Summary: This project is focused on establishing Australia as a world authority in the field of novel Fe-based superconductors by utilising unique sample fabrication methods and a network of world renowned experts. It will provide excellent postgraduate student training to foster development of new outstanding specialists in this challenging research field.

FUTURE FELLOWSHIPS

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 Investigators:	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.

DEVELOPMENT OF A SOLID NITROGEN COOLED MAGNESIUM DIBORIDE (MgB_2) MAGNET FOR PERSISTENT MODE OPERATION

Years Funded:	2011	2012	2013	2014	2015
Amount funded:	$86,000	$172,000	$172,000	$172,000	$86,000
Total Funding:	$688,000				
Project ID:	FT110100170				
Chief Investigators:	J. H. Kim				

Project Summary: Soaring price for liquid helium has increased demand for cryogen-free superconducting magnets more than ever. If magnetic resonance imaging magnets, which represent over 50 per cent of the world superconducting markets, could be operated without liquid helium, magnetic resonance imaging would be much more affordable and enable reduced health care costs.

DECRA FELLOWSHIPS

DIAMMONIATE OF DIBORANE FOR HYDROGEN STORAGE

Years Funded:	2012	2013	2014
Amount funded:	$125,000	$125,000	$125,000
Total Funding:	$375,000		
Project ID:	DE120101496		
Chief Investigators:	Z. Huang		

Project Summary: The project will study diammoniate of diborane and its related compounds and systems for hydrogen storage. The research outcome will be extremely beneficial for the fundamental research and potential application of new compounds for hydrogen storage.

ARC LINKAGE PROJECTS

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

Years 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 Investigator:	H. Zhu, X. J. Zhu			
Industry Partner:	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.

DESIGN, BUILD AND TEST A FAULT CURRENT LIMITER EMPLOYING MAGNESIUM DIBORIDE (MgB_2) SUPERCONDUCTING COILS

Years 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 Partner:	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.

SYNERGETIC COMBINATION OF LOCALISED INTERNAL MAGNESIUM DIFFUSION PROCESS WITH COLD COMPACTION TECHNIQUE FOR FABRICATION OF MAGNESIUM DIBORIDE (MgB_2) SUPERCONDUCTOR WIRES

Years Funded:	2012	2013	2014
Amount funded:	$90,000	$90,000	$90,000
Total Funding:	$270,000		
Project ID:	LP120100173		
Chief Investigators:	S. X. Dou, J. H. Kim, M. S. A. Hossain, G. Peleckis		
Industry Partner:	Hyper Tech Research Inc		

Project Summary: This project seeks major advancements in magnesium diboride (MgB_2) superconductor performance through the development of novel techniques for the fabrication of MgB_2 wire. Further improvement in MgB_2 wire performance holds the key to a number of significant commercial applications, including Magnetic Resonance Imaging, fault current limiters and wind turbines.

DEVELOPMENT OF NOVEL COMPOSITE ANODE MATERIALS COMBINED WITH NEW BINDERS FOR HIGH ENERGY, HIGH POWER AND LONG LIFE LITHIUM-ION BATTERIES

Years Funded:	2012	2013	2014	2015
Amount funded:	$45,000	$90,000	$90,000	$45,000
Total Funding:	$270,000			
Project ID:	LP100200432			
Chief Investigators:	S. L. Chou, J. Z. Wang, H. K. Liu, D. Wexler			
Partner Investigator:	Y. M. Kang			
Industry Partner:	DLG Battery Co Ltd, Wuxi Xirun Petrochemical			

Project Summary: This project will lead to better lithium-ion batteries with high energy, high power and long life. Novel composite anode materials combined with new binders will be investigated. The development of new scientific knowledge during this project will significantly enhance the international competitiveness of Australia in the area of clean energy.

NEW GENERATION HIGH EFFICIENCY THERMOELECTRIC MATERIALS AND MODULES FOR WASTE HEAT RECOVERY IN STEELWORKS

Years Funded:	2012	2013	2014	2015	2016
Amount funded:	$60,000	$120,000	$110,000	$80,000	$30,000
Total Funding:	$400,000				
Project ID:	LP100200289				
Chief Investigators:	S. X. Dou, S. Li, W. X. Li, C. Zhang, S. Aminorroaya-Yamini				
Industry Partner:	Baosteel Company				

Project Summary: The development of thermoelectric materials and devices, and their subsequent uptake by the steel industry, will bring tremendous socio-economic benefits in terms of decreased operational costs, a significantly reduced carbon footprint and will set an excellent example for other industries on how to comply with strict environmental regulations.

URC SMALL GRANTS & ARC NEAR-MISS GRANTS 2012

DEVELOPING N-TYPE PbTe THERMOELECTRICS FOR WASTE HEAT RECOVERY APPLICATION

Total Funding:	$10,000
Chief Investigators:	S. Aminorroaya-Yamini

A GENERAL STRATEGY FOR HIGHLY CRYSTALLINE NANOMATERIAL SYNTHESIS

Total Funding:	$12,500
Chief Investigators:	D. P. Chen

DESIGN, TEST AND CONSTRUCT A 4-ANVILS PROTOTYPE COMPACTION DEVICE FOR THE FABRICATION OF DENSE MgB_2 SUPERCONDUCTOR WIRES WITH IMPROVED CONNECTIVITY

Total Funding:	$10,500
Chief Investigators:	M. S. A. Hossain

MAGNETIC AND STRUCTURAL PHASE RELATIONSHIP IN LAYERED STRUCTURE COMPOUNDS WITH LARGE MAGNETOCALORIC EFFECT

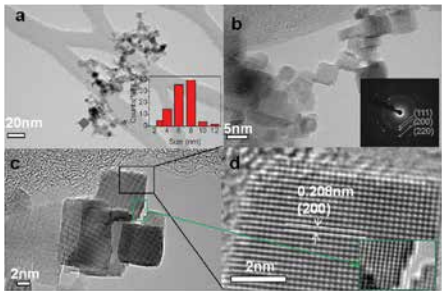
Total Funding:	$11,000
Chief Investigators:	J. L. Wang

DESIGN AND SYNTHESIS OF AMMONIA-BORANE COMPLEXES FOR HYDROGEN STORAGE

Total Funding:	$12,000
Chief Investigators:	S. X. Dou, X. Yu, P. Chen, I. Takayuki, S. Kennedy

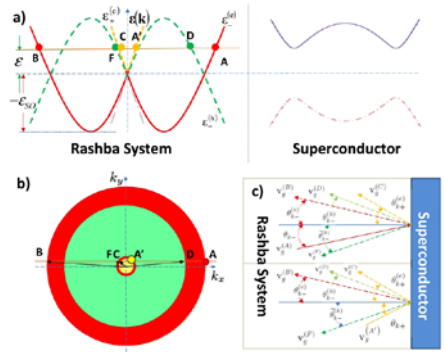
SELECTED ABSTRACTS

GROWTH MECHANISM AND MAGNETIC PROPERTIES OF HIGHLY CRYSTALLINE NIO NANOCUBES AND NANORODS FABRICATED BY EVAPORATION



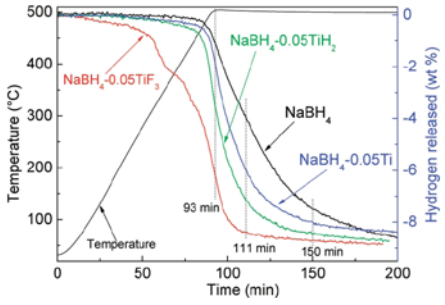
A new approach to the preparation of regularly shaped NiO nanocubes and nanorods by an infrared heating evaporation method is presented. The growth model is proposed to be a vapor–solid mechanism. The morphology of the nanocrystals can be tuned by the carrier gasflow rate. The samples consist of nanocrystals that are highly crystallized with atomic-scale smooth surfaces. This novel method could be extended to nanocrystal growth of other oxides with low volatility or high melting points. The results of magnetic characterization indicate that the NiO nanorods and nanocubes grown from a mixed target both show weak ferromagnetic states at low and room temperature due to uncompensated spins at the surfaces of the nanocrystals (D. P. Chen et al., *Crystal Growth & Design* 12, 2842 (2012))

SPECULAR ANDREEV REFLECTION IN THE INTERFACE OF A TWO-DIMENSIONAL SEMICONDUCTOR WITH RASHBA SPIN-ORBIT COUPLING AND A D-WAVE SUPERCONDUCTOR



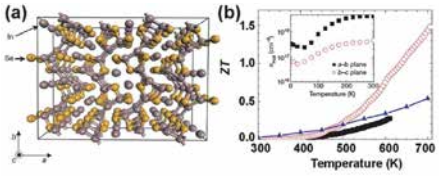
We reveal that the recently discovered specular Andreev reflection (SAR) [C. W. J. Beenakker, Phys. Rev. Lett.97, 067007 (2006)] can occur in semiconductors where the spin-orbit coupling is finite. We demonstrate this finding in the hybrid of a two-dimensional electron gas with Rashba spin-orbit coupling and a superconductor. In the limit of low density or a strong spin-orbit coupling, specular Andreev reflection is finite. We also show that unit electron-hole conversion is possible in a specular Andreev reflection due to the different topological structures of the equal-energy surface between electrons and holes. The SAR in the semiconductor is determined by the relative orientation of wave vector to group velocity, which can be analyzed by ray equations. (B. Lv et al., *Physical Review Letters* 108, 077002 (2012))

HYDROGEN DE-/ABSORPTION IMPROVEMENT OF $NaBH_4$ CATALYZED BY TITANIUM-BASED ADDITIVES



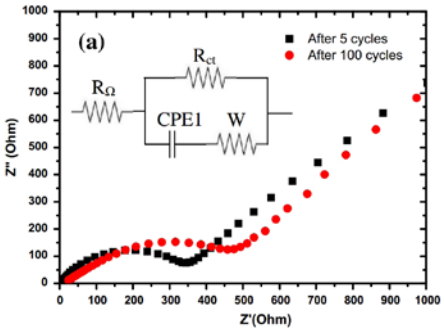
$NaBH_4$ is considered as a promising candidate material for solid-state hydrogen storage due to its high hydrogen content of 10.6 wt %. However, its practical use is hampered by its high thermodynamic stability and slow H-exchange kinetics. In the present work, the effects of Ti-based additives, including Ti, TiH_2, and TiF_3, on the dehydrogenation and rehydrogenation of $NaBH_4$ (NaH+B) were investigated. It was revealed that all of the titanium-based additives were effective in improving the hydrogen desorption and absorption reactions of $NaBH_4$, and, among them, TiF_3 possessed the highest catalytic activity. The whole dehydrogenation process for the $NaBH_4$-0.05TiF_3 sample can be regarded as a two-step process: (i) a preferential reaction ($3NaBH_4 + TiF_3 \rightarrow 3NaF + TiB_2 + B + 6H_2$) occurring at around 300 °C, and (ii) the formation of Ti- and F-containing species catalyze the dehydrogenation of the remaining $NaBH_4$. It was also indicated that the F anion can substitute for anionic H in NaH to form $NaF_{1-x}H_x$ in the case of NaH-B-0.05TiF_3 during the hydrogenation process. Therefore, the observed promotion effect of TiF_3 on the reversible dehydrogenation of $NaBH_4$ should be understood as arising from the combined effects of active Ti- and F-containing species. Also, FTIR spectroscopy confirmed the presence of amorphous $Na_2B_{12}H_{12}$, in both the dehydrogenated and the rehydrogenated states, which may play a role in the partial dehydrogenation and reversibility observed in $NaBH_4$ with and without catalyst doping (J. F. Mao et al., *The Journal of Physical Chemistry C* 116, 1596 (2012))

SEMICONDUCTOR NANOWIRES FOR THERMOELECTRICS



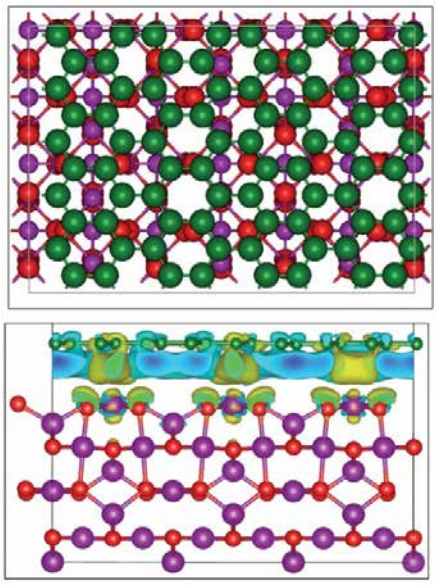
Semiconductor nanowires have been an intensive research subject due to their unique properties and great potential in diverse applications. This highlight presents a review of the state-of-the-art semiconductor nanowires for thermoelectric applications. Different types of thermoelectric semiconductor nanowires including those from IV, IV–VI, V, V–VI, II–VI and III–V groups are reviewed. Bulk and other nanostructured thermoelectric materials are also briefly discussed. (Z. Li et al., *Journal of Materials Chemistry* 22, 22821 (2012))

FREE-STANDING SINGLE-WALLED CARBON NANOTUBE/SnO_2 ANODE PAPER FOR FLEXIBLE LITHIUM-ION BATTERIES



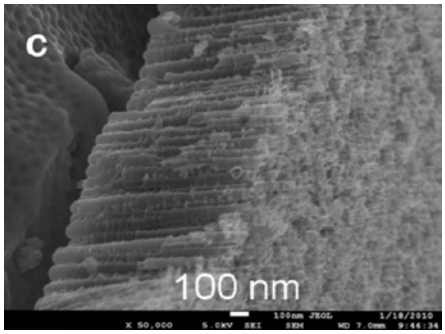
Free-standing single-walled carbon nanotube/SnO_2 (SWCNT/SnO_2) anode paper was prepared by vacuum filtration of SWCNT/SnO_2 hybrid material which was synthesized by the polyol method. From field emission scanning electron microscopy and transmission electron microscopy, the CNTs form a three-dimensional nanoporous network, in which ultra-fine SnO_2 nanoparticles, which had crystallite sizes of less than 5 nm, were distributed, predominately as groups of nanoparticles on the surfaces of single walled CNT bundles. Electrochemical measurements demonstrated that the anode paper with 34 wt.% SnO_2 had excellent cyclic retention, with the high specific capacity of 454 mAh g^{-1} beyond 100 cycles at a current density of 25 mA g^{-1}, much higher than that of the corresponding pristine CNT paper. The SWCNTs could act as a flexible mechanical support for strain release, offering an efficient electrically conducting channel, while the nanosized SnO_2 provides the high capacity. The SWCNT/SnO_2 flexible electrodes can be bent to extremely small radii of curvature and still function well, despite a marginal decrease in the conductivity of the cell. The electrochemical response is maintained in the initial and further cycling process. Such capabilities demonstrate that this model hold great promise for applications requiring flexible and bendable Li-ion batteries. (L. Noerochim et al., *Carbon* 50, 1289 (2012))

RAPID MICROWAVE-ASSISTED SYNTHESIS OF Mn_3O_4–GRAPHENE NANOCOMPOSITE AND ITS LITHIUM STORAGE PROPERTIES



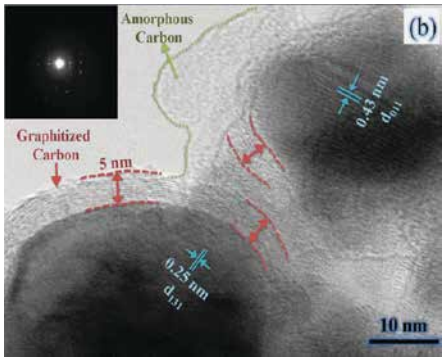
A nanocomposite of Mn_3O_4 wrapped in graphene sheets (GSs) was successfully synthesizedviaa facile, effective, energy-saving, and scalable microwave hydrothermal technique. The morphology and microstructures of the fabricated GS–Mn_3O_4 nanocomposite were characterized using various techniques. The results indicate that the particle size of the Mn_3O_4 particles in the nanocomposite markedly decreased to nearly 20 nm, significantly smaller than that for the bare Mn_3O_4. Electrochemical measurements demonstrated a high specific capacity of more than 900 mAh g^{-1} at 40 mA g^{-1}, and excellent cycling stability with no capacity decay can be observed up to 50 cycles. All of these properties are also interpreted by experimental studies and theoretical calculations. (L. Li et al., *Journal of Materials Chemistry* 22, 3600 (2012))

ENHANCEMENT OF THE ELECTROCHEMICAL CAPACITANCE OF TiO_2 NANOTUBE ARRAYS THROUGH CONTROLLED PHASE TRANSFORMATION OF ANATASE TO RUTILE



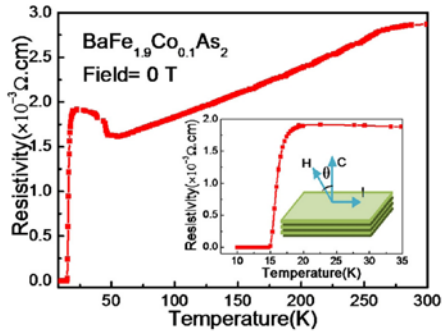
Here, we report the fabrication of self-organized titania (TiO_2) nanotube array supercapacitor electrodes through controlled phase transformation of TiO_2, with aerial capacitances as high as 2.6 mF cm^{-2}, which far exceeds the values so far reported in the literature. The role of phase transformation in the electrochemical charge – discharge behaviour of nanocrystalline TiO_2 nanotubes is investigated and discussed in detail. The ease of synthesis and the exceptional electrochemical properties make these nanotube arrays an alternative candidate for use in energy storage devices. (M. Salari et al., *Physical Chemistry Chemical Physics* 14, 4770 (2012))

ENHANCED ELECTROCHEMICAL PROPERTIES OF $LiFePO_4$ BY Mo-SUBSTITUTION AND GRAPHITIC CARBON-COATING VIA A FACILE AND FAST MICROWAVE-ASSISTED SOLID-STATE REACTION



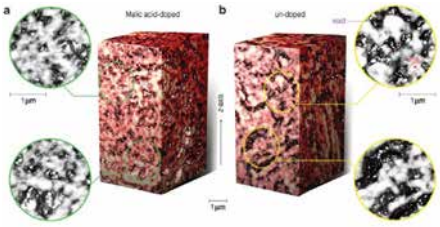
A composite cathode material for lithium ion battery applications, Mo-doped $LiFePO_4$/C, is obtained through a facile and fast microwave-assisted synthesis method. Rietveld analysis of $LiFePO_4$-based structural models using synchrotron X-ray diffraction data shows that Mo-ions substitute onto the Fe sites and displace Fe-ions to the Li sites. Supervalent Mo^{6+} doping can act to introduce Li ion vacancies due to the charge compensation effect and therefore facilitate lithium ion diffusion during charging/discharging. Transmission electron microscope images demonstrate that the pure and doped $LiFePO_4$ nanoparticles were uniformly covered by an approximately 5 nm thin layer of graphitic carbon. Amorphous carbon on the graphitic carbon-coated pure and doped $LiFePO_4$ particles forms a three-dimensional (3D) conductive carbon network, effectively improving the conductivity of these materials. The combined effects of Mo-doping and the 3D carbon network dramatically enhance the electrochemical performance of these $LiFePO_4$ cathodes. In particular, Mo-doped $LiFePO_4$/C delivers a reversible capacity of 162 mAh g^{-1} at a current of 0.5 C and shows enhanced capacity retention compared to that of undoped $LiFePO_4$/C. Moreover, the electrode exhibits excellent rate capability, with an associated high discharge capacity and good electrochemical reversibility (D. Li et al., *Physical Chemistry Chemical Physics* 14, 3634 (2012))

ANGULAR DEPENDENCE OF PINNING POTENTIAL, UPPER CRITICAL FIELD, AND IRREVERSIBILITY FIELD IN UNDERDOPED $BaFe_{1.9}Co_{0.1}As_2$ SINGLE CRYSTAL



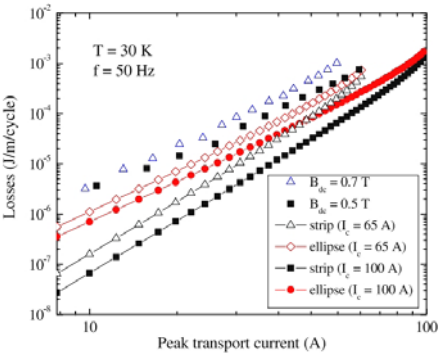
Underdoped $BaFe_{1.9}Co_{0.1}As_2$ single crystal was studied by angular dependence of magneto-transport at fields up to 13 T over a wide range of temperature. Our results show that pinning potential, Uo, decreases slightly for $\theta \leq 45^\circ$ and remains constant for $\theta \geq 45^\circ$, while the upper critical field, H_{c2}, and the irreversibility field, H_{irr}, increase with θ. According to anisotropic Ginzburg-Landau theory, the anisotropy was determined by scaling the resistivity under different magnetic fields below the superconducting critical temperature, T_c. Anisotropy, Γ, in the underdoped crystal is found to be temperature dependent and decreases from 2.1 to 1.8 for as T is reduced from 17 to 12.5 K. (M. Shahbazi et al., *Applied Physics Letters* 100, 102601 (2012))

MICROSCOPIC ROLE OF CARBON ON MgB_2 WIRE FOR CRITICAL CURRENT DENSITY COMPARABLE TO NbTi



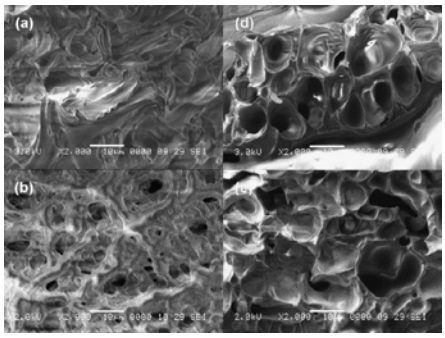
Increasing dissipation-free supercurrent has been the primary issue for practical application of superconducting wires. For magnesium diboride, MgB_2, carbon is known to be the most effective dopant to enhance high-field properties. However, the critical role of carbon remains elusive, and also low-field critical current density has not been improved. Here, we have undertaken malic acid doping of MgB_2 and find that the microscopic origin for the enhancement of high-field properties is due to boron vacancies and associated stacking faults, as observed by high-resolution transmission electron microscopy and electron energy loss spectroscopy. The carbon from the malic acid almost uniformly encapsulates boron, preventing boron agglomeration and reducing porosity, as observed by three-dimensional X-ray tomography. The critical current density either exceeds or matches that of niobium titanium at 4.2 K. Our findings provide atomic-level insights, which could pave the way to further enhancement of the critical current density of MgB_2 up to the theoretical limit. (J. H. Kim et al., *NPG Asia Materials* 4, e3 (2012))

CALORIMETRIC AC LOSS MEASUREMENT OF MgB_2 SUPERCONDUCTING TAPE IN AN ALTERNATING TRANSPORT CURRENT AND DIRECT MAGNETIC FIELD



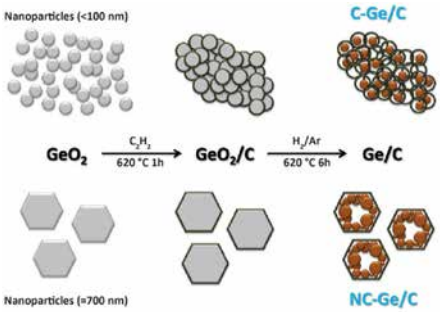
Applications of MgB_2 superconductors in electrical engineering have been widely reported, and various studies have been made to define their alternating current (AC) losses. However, studies on the transport losses with an applied transverse DC magnetic field have not been conducted, even though this is one of the favored conditions in applications of practical MgB_2 tapes. Methods and techniques used to characterize and measure these losses have so far been grouped into 'electrical' and 'calorimetric' approaches with external conditions set to resemble the application conditions. In this paper, we present a new approach to mounting the sample and employ the calorimetric method to accurately determine the losses in the concurrent application of AC transport current and DC magnetic fields that are likely to be experienced in practical devices such as generators and motors. This technique provides great simplification compared to the pickup coil and lock-in amplifier methods and is applied to a long length (~10 cm) superconducting tape. The AC loss data at 20 and 30 K will be presented in an applied transport current of 50 Hz under external DC magnetic fields. The results are found to be higher than the theoretical predictions because of the metallic fraction of the tape that contributes quite significantly to the total losses. The data, however, will allow minimization of losses in practical MgB_2 coils and will be used in the verification of numerical coil models. (K. W. See et al., *Superconductor Science & Technology* 25, 115016 (2012))

MICROPOROUS GEL POLYMER ELECTROLYTES FOR LITHIUM RECHARGEABLE BATTERY APPLICATION



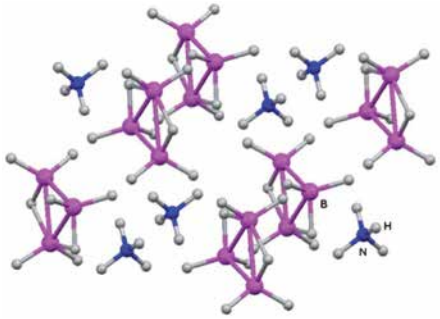
Microporous poly (vinylidene fluoride) / poly (methyl methacrylate) (PVDF/PMMA) membranes were prepared using the phase-separation method. Then, the membranes were immersed in liquid electrolyte to form polymer electrolytes. The effects of PMMA on the morphology, degree of crystallinity, porosity, and electrolyte uptake of the studied. The addition of PMMA increased the pore size, porosity and electrolyte uptake of the PVDF membrane, which in turn increased the ionic conductivity of the polymer electrolyte. The maximum ionic conductivity at room temperature was 1.21×10^{-3} S cm^{-1} for Sample E70. The polymer electrolyte was investigatet, along with lithium iron phosphate ($LiFePO_4$) as cathode for solid-state lithium-ion rechargeable batteries. The lithium metal/E70/$LiFePO_4$ cell yielded a stable discharge capacity of 133 mAh g^{-1} after up to 50 cycles at a current density of 8.5 mA g^{-1}. (N. H. Idris et al., *Journal of Power Sources* 201, 294 (2012))

SELF-ASSEMBLED GERMANIUM/CARBON NANOSTRUCTURES AS HIGH-POWER ANODE MATERIAL FOR THE LITHIUM-ION BATTERY



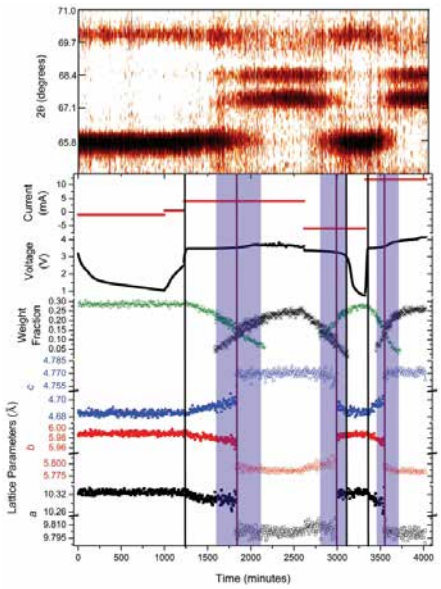
Two germanium/carbon nanostructures were synthesized through a facile self-assembly method. Controlling the size of the precursor germanium nanoparticles produces cluster and non-clustered nanostructures. The cluster-Ge/C sample showed better capacity retention and an exceptionally high rate performance. (K. H. Seng, *Angewandte Chemie International Edition* 51, 5657 (2012))

BORON–NITROGEN–HYDROGEN (BNH) COMPOUNDS: RECENT DEVELOPMENTS IN HYDROGEN STORAGE, APPLICATIONS IN HYDROGENATION AND CATALYSIS, AND NEW SYNTHESES



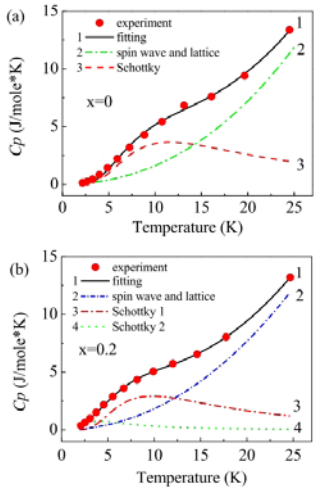
The strong efforts devoted to the exploration of BNH compounds for hydrogen storage have led to impressive advances in the field of boron chemistry. This review summarizes progress in this field from three aspects. It starts with the most recent developments in using BNH compounds for hydrogen storage, covering NH_3BH_3, $B_3H_8^-$ containing compounds, and CBN compounds. The following section then highlights interesting applications of BNH compounds in hydrogenation and catalysis. The last part is focused on breakthroughs in the syntheses and discovery of new BNH organic analogues. The role of $N–H^{\delta+}\cdots H^{\delta-}–B$ dihydrogen interactions in molecule packing, thermal hydrogen evolution, and syntheses is also discussed within the review. (Z. Huang et al., *Energy & Environmental Science* 5, 9257 (2012))

DIRECT EVIDENCE OF CONCURRENT SOLID-SOLUTION AND TWO-PHASE REACTIONS AND THE NON-EQUILIBRIUM STRUCTURAL EVOLUTION OF $LiFePO_4$



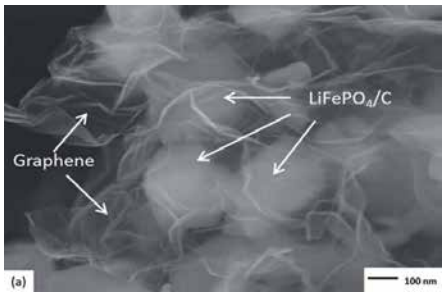
Lithium-ion batteries power many portable devices and in the future are likely to play a significant role in sustainable-energy systems for transportation and the electrical grid. $LiFePO_4$ is a candidate cathode material for second-generation lithium-ion batteries, bringing a high rate capability to this technology. $LiFePO_4$ functions as a cathode where delithiation occurs via either a solid-solution or a two-phase mechanism, the pathway taken being influenced by sample preparation and electrochemical conditions. The details of the delithiation pathway and the relationship between the two-phase and solid-solution reactions remain controversial. Here we report, using real-time in situ neutron powder diffraction, the simultaneous occurrence of solid-solution and two-phase reactions after deep discharge in nonequilibrium conditions. This work is an example of the experimental investigation of nonequilibrium states in a commercially available $LiFePO_4$ cathode and reveals the concurrent occurrence of and transition between the solid-solution and two-phase reactions. (N. Sharma et al., *Journal of the American Chemical Society* 134, 7867 (2012))

COMPETITION BETWEEN THE CRYSTAL FIELD AND THE EXCHANGE FIELD IN Er^{3+} DOPED $NdMnO_3$



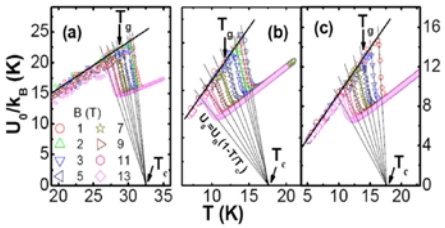
A careful investigation of specific heat shows that the ground state splitting of Nd^{3+} has been modified by the Er^{3+} doping, as it shows a nonlinear dependence on the Er^{3+} doping rate, due to the competition between the crystal field and the exchange field. This competition could be further confirmed by the anomalies in the magnetic entropy and the ground state splitting found in $Nd_{0.9}Er_{0.1}MnO_3$. On the contrary, the ground state splitting of Er^{3+} has a linear dependence on the doping rate, indicating its stronger dependence on the crystal field rather than the exchange field. (F. Hong et al., *Applied Physics Letters* 101, 121913 (2012))

GRAPHENE WRAPPED $LiFePO_4$/C COMPOSITES AS CATHODE MATERIALS FOR LI-ION BATTERIES WITH ENHANCED RATE CAPABILITY



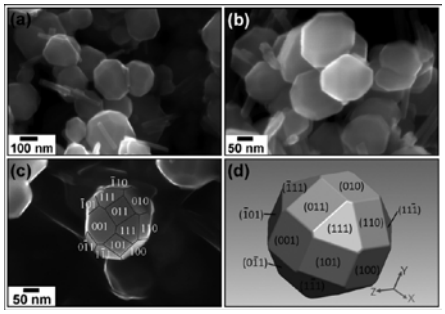
To reduce the reaction time, electrical energy consumption, and cost, $LiFePO_4$/C/graphene has been synthesized by a rapid, one-pot, microwave-assisted hydrothermal method within 15 min at a temperature of 200 °C, followed by sintering at 600 °C for 2 h under a H_2/Ar (5:95, v/v) atmosphere. The micro-structure and morphology of the $LiFePO_4$/C/graphene products were characterized by means of X-ray diffraction, Raman spectroscopy, field emission scanning electron microscopy, and transmission electron microscopy. The carbon coated $LiFePO_4$/C nanoparticles, around 200 nm in size, are thoroughly wrapped by crumpled micrometer-size graphene sheets. In this kind of structure, the bridging graphene nanosheets can form an effective conducting network and provide interconnected open pores that favor electrolyte absorption and reduce the diffusion path of the lithium ions. The cyclic voltammograms, charge/discharge profiles, and AC impedance measurements indicated that the kinetics of the $LiFePO_4$/C/graphene was better than that of $LiFePO_4$/C. The $LiFePO_4$/C/graphene composite exhibited a discharge capacity of 165 mAh g^{-1} at 0.1 C and 88 mAh g^{-1} at 10 C, respectively. Therefore, the $LiFePO_4$/C/graphene composite is a promising candidate for the development of high performance, cost-effective lithium batteries for the hybrid vehicle and electric vehicle markets. (Y. Shi et al., *Journal of Materials Chemistry* 22, 16465 (2012))

FLUX PINNING AND VORTEX TRANSITIONS IN DOPED $BaFe_2As_2$ SINGLE CRYSTALS



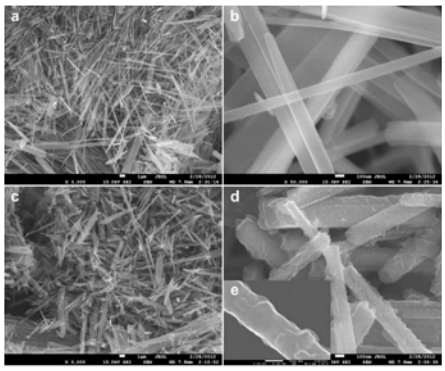
The vortex liquid-to-glass transition has been studied in $BaK_{0.28}Fe_2As_2$ (BaK-122), $Ba(Fe_{0.91}Co_{0.09})_2As_2$ (BaCo-122), and $Ba(Fe_{0.95}Ni_{0.05})_2As_2$ (BaNi-122) single crystal with superconducting transition temperature, T_c = 31.7, 17.3, and 18 K, respectively, by magnetoresistance measurements. For temperatures below T_c, the resistivity curves were measured in magnetic fields within the range of $0 \le B \le 13$ T, and the pinning potential was scaled according to a modified model for vortex liquid resistivity. Good scaling of the resistivity $\rho(B, T)$ and the effective pinning energy $U_0(B,T)$ were obtained. The vortex state is three-dimensional at temperatures lower than a characteristic temperature T*. The vortex phase diagram was determined based on the evolution of the vortex-glass transition temperature Tgwith magnetic field and the upper critical field, H_{c2}.We found that non-magnetic K doping results in a high glass line close to the H_{c2}, while magnetic Ni and Co doping causes a low glass line which is far away from the H_{c2}. Our results suggest that non-magnetic induced disorder is more favourable for enhancement of pinning strength compared to magnetic induced disorder. Our results show that the pinning potential is responsible for the difference in the glass states. (S. R. Ghorbani et al., *Applied Physics Letters* 100, 072603 (2012))

POLYHEDRAL MAGNETITE NANOCRYSTALS WITH MULTIPLE FACETS: FACILE SYNTHESIS, STRUCTURAL MODELLING, MAGNETIC PROPERTIES AND APPLICATION FOR HIGH CAPACITY LITHIUM STORAGE



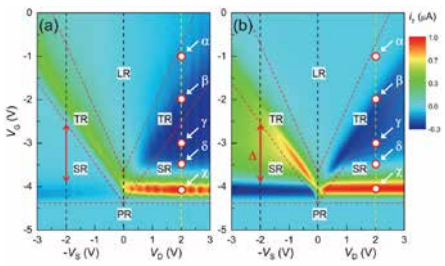
Polyhedral magnetite nanocrystals with multiple facets were synthesised by a low temperature hydrothermal method. Atomistic simulation and calculations on surface attachment energy successfully predicted the polyhedral structure of magnetite nanocrystals with multiple facets. X-ray diffraction, field emission scanning electron microscopy, and high resolution transmission microscopy confirmed the crystal structure of magnetite, which is consistent with the theoretical modelling. The magnetic property measurements show the superspin glass state of the polyhedral nanocrystals, which could originate from the nanometer size of individual single crystals. When applied as an anode material in lithium ion cells, magnetite nanocrystals demonstrated an outstanding electrochemical performance with a high lithium storage capacity, a satisfactory cyclability, and an excellent high rate capacity. (D. W. Su et al., *Chemistry – A European Journal* 18, 488 (2012))

SYNTHESIS AND ELECTROCHEMICAL PERFORMANCE OF LiV_3O_8/POLYANILINE AS CATHODE MATERIAL FOR THE LITHIUM BATTERY



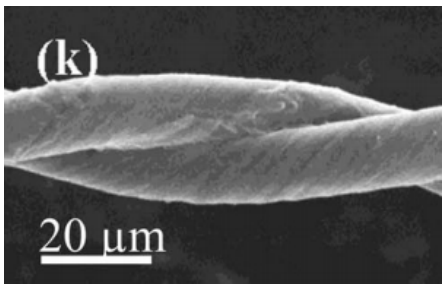
LiV_3O_8-polyaniline nanocomposites have been synthesized via chemical oxidative polymerization directed by the anionic surfactant sodium dodecyl benzene sulfate. The polyaniline particles are uniformly coated on the LiV_3O_8 nanorods. The composite with 12 wt.% polyaniline retains a discharge capacity of 204 mAh g^{-1} after 100 cycles and had better rate capability (175 mAh g^{-1} at 2 C and 145 mAh g^{-1} at 4 C) than the bare LiV_3O_8 electrode in the potential range of 1.5e4.0 V. The polyaniline coating can buffer the dissolution into the $LiPF_6$ electrode that occurs in LiV_3O_8 during cycling. The charge transfer resistance of the composite electrode was much lower than that of the bare LiV_3O_8 electrode, indicating that polyaniline coating significantly increases the electrical conductivity between the LiV_3O_8 nanorods. Polyaniline is a conductive binder which buffers the dissolution of LiV_3O_8 into the electrolyte and reduces the contact resistance among nanorods, so performance of the composite is significantly improved. (X. W. Gao et al., *Journal of Power Sources* 220, 47 (2012))

PROBING AND MODELLING THE LOCALIZED SELF-MIXING IN A GaN/AlGaN FIELD-EFFECT TERAHERTZ DETECTOR



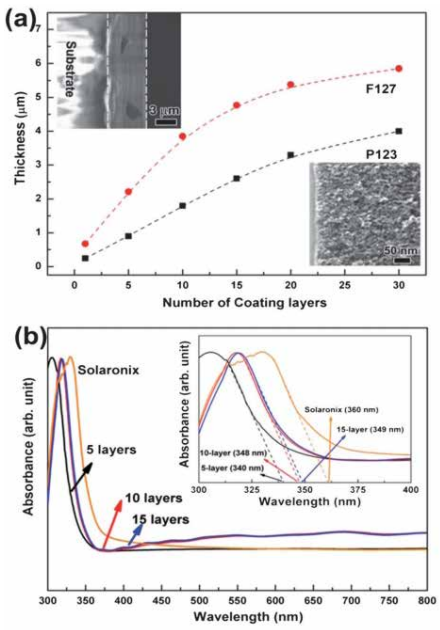
In our previous work [Sunet al., Appl. Phys. Lett. 100, 013506 (2012)], we inferred the existence of localized self-mixing in an antenna-coupled field-effect terahertz detector. In this Letter, we report a quasistatic self-mixing model taking into account the localized terahertz fields and its verification by comparing the simulated results with the experimental data in a two-dimensional space of the gate voltage and the drain/source bias. The model well describes the detector characteristics: not only the magnitude, but also the polarity, of the photocurrent can be tuned. The existence of strongly localized self-mixing in such detectors is confirmed. (J. D. Sun et al., *Applied Physics Letters* 100, 173513 (2012))

PREPARATION AND CHARACTERIZATION OF HYBRID CONDUCTING POLYMER–CARBON NANOTUBE YARN



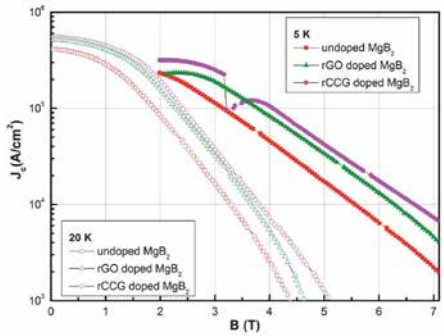
Hybrid polypyrrole (PPy)–multi walled carbon nanotube (MWNT) yarns were obtained by chemical and electrochemical polymerization of pyrrole on the surface and within the porous interior of twisted MWNT yarns. The material was characterized by scanning electron microscopy, electrochemical, mechanical and electrical measurements. It was found that the hybrid PPy-MWNT yarns possessed significantly higher mechanical strength (over 740 MPa) and Young's modulus (over 54 GPa) than the pristine MWNT yarn. The hybrid yarns also exhibited substantially higher electrical conductivity (over 235 S cm^{-1}) and their specific capacitance was found to be in excess of 60 F g^{-1}. Measurements of temperature dependence of electrical conductivity revealed semiconducting behaviour, with a large increase of band gap near 100 K. The collected low temperature data are in good agreement with a three dimensional variable range hopping model (3D-VRH). The improved durability of the yarns is important for electrical applications. The composite yarns can be produced in commercial quantities and used for applications where the electrical conductivity and good mechanical properties are of primary importance. (J. Foroughi et al., *Nanoscale* 4, 940 (2012))

IMPROVED PHOTOVOLTAIC PERFORMANCE OF DYE-SENSITIZED SOLAR CELLS WITH MODIFIED SELF-ASSEMBLING HIGHLY ORDERED MESOPOROUS TiO_2 PHOTOANODES



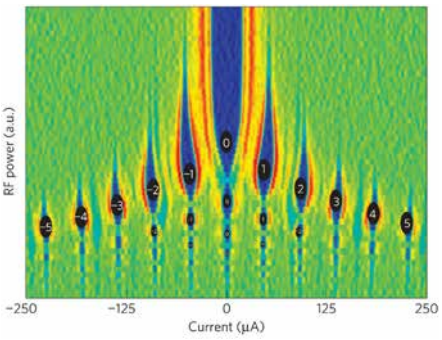
Strategies for improving the photovoltaic performance of dye-sensitized solar cells (DSSCs) are proposed by modifying highly transparent and highly ordered multilayer mesoporous TiO_2 photoanodes through nitrogen-doping and top-coating with a light-scattering layer. The mesoporous TiO_2 photoanodes were fabricated by an evaporation-induced self-assembly method. In regard to the modification methods, the light-scattering layer as a top-coating was proved to be superior to nitrogendoping in enhancing not only the power conversion efficiency but also the fill factor of DSSCs. The optimized bifunctional photoanode consisted of a 30-layer mesoporous TiO_2 thin film (4.15 μm) and a Degussa P25 light-scattering top-layer (4 μm), which gives rise to a ~200% higher cell efficiency than for unmodified cells and a fill factor of 0.72. These advantages are attributed to its higher dye adsorption, better light scattering, and faster photon–electron transport. Such a photoanode configuration provides an efficient way to enhance the energy conversion efficiency of DSSCs. (Z. Q. Sun et al., *Journal of Materials Chemistry* 22, 11711 (2012))

THE EFFECT OF REDUCED GRAPHENE OXIDE ADDITION ON THE SUPERCONDUCTIVITY OF MgB_2



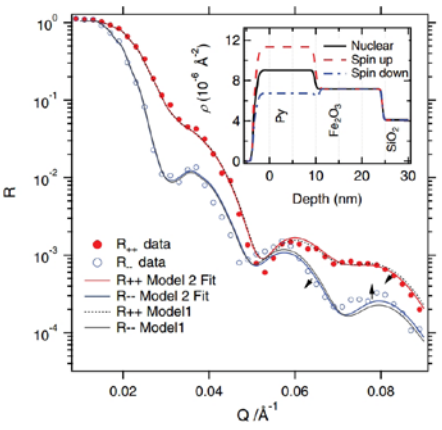
Reduced graphene oxide (rGO) and highly reduced chemically converted graphene (rCCG) samples were prepared under different processing conditions and were doped into MgB_2 by a diffusion process at 800 °C for 10 hours. It was demonstrated that a small addition rCCG can significantly improve the superconducting properties of MgB_2. Doping of MgB_2 with 1 mol% of rCCG resulted in a J_c of 5.45 × 10^5 Acm^{-2} at 20 K in self-fields, which is nearly 32% improvement over that of the undoped sample. This is a significant improvement as most carbon sources adversely affect the J_c performance at the zero field. (K. S. B. De Silva et al., *Journal of Materials Chemistry* 22, 13941 (2012))

JOSEPHSON SUPERCURRENT THROUGH A TOPOLOGICAL INSULATOR SURFACE STATE



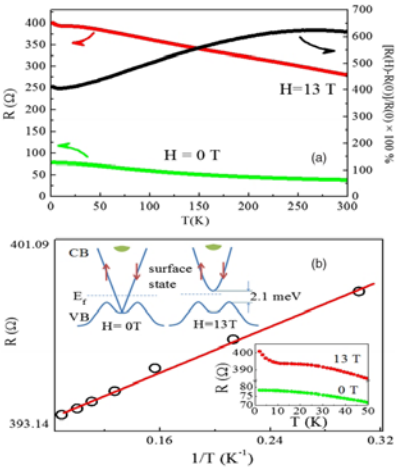
The long-sought yet elusive Majorana fermion is predicted to arise from a combination of a superconductor and a topological insulator. An essential step in the hunt for this emergent particle is the unequivocal observation of supercurrent in a topological phase. Here, direct evidence for Josephson supercurrents in superconductor (Nb)–topological insulator (Bi_2Te_3)–superconductor electron-beam fabricated junctions is provided by the observation of clear Shapiro steps under microwave irradiation, and a Fraunhofer-type dependence of the critical current on magnetic field. Shubnikov–de Haas oscillations in magnetic fields up to 30 T reveal a topologically non-trivial two-dimensional surface state. This surface state is attributed to mediate the ballistic Josephson current despite the fact that the normal state transport is dominated by diffusive bulk conductivity. The lateral Nb–Bi_2Te_3–Nb junctions hence provide prospects for the realization of devices supporting Majorana fermions. (M. Veldhorst et al., *Nature Materials* 11, 417 (2012))

EXCHANGE BIAS IN A NANOCRYSTALLINE HEMATITE/PERMALLOY THIN FILM INVESTIGATED WITH POLARIZED NEUTRON REFLECTOMETRY



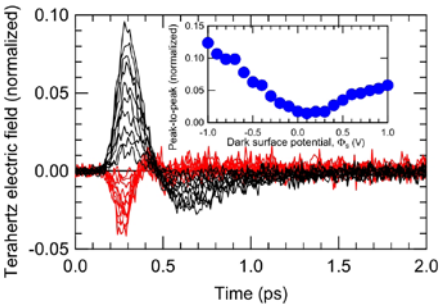
We investigated a hematiteα-Fe_2O_3/permalloy $Ni_{80}Fe_{20}$ bilayer film where the antiferromagnetic layer consisted of small hematite grains in the 2 to 16 nm range. A pronounced exchange bias effect occurred below the blocking temperature of 40 K. The magnitude of exchange bias was enhanced relative to reports for identical compounds in large grain, epitaxial films. However, the blocking temperature was dramatically reduced. As the Néel temperature of bulk α-Fe_2O_3 is known to be very high (860 K), we attribute the low-temperature onset of exchange bias to the well-known finite-size effect which suppresses the Morin transition for nanostructured hematite. Polarized neutron reflectometry was used to place an upper limit on the concentration and length scale of a layer of uncompensated moments at the antiferromagnetic interface. The data were found to be consistent with an induced magnetic region at the antiferromagnetic interface of 0.5–1.0 μ_B per Fe atom within a depth of 1–2 nm. The field dependence of the neutron spin-flip signal and spin asymmetry was analyzed in the biased state, and the first and second magnetic reversal were found to occur by asymmetric mechanisms. For the fully trained permalloy loop, reversal occurred symmetrically at both coercive fields by an in-plane spin rotation of ferromagnetic domains. (D. L. Cortie et al., *Physical Review B* 86, 054408 (2012))

ROOM TEMPERATURE GIANT AND LINEAR MAGNETORESISTANCE IN TOPOLOGICAL INSULATOR Bi_2Te_3 NANOSHEETS



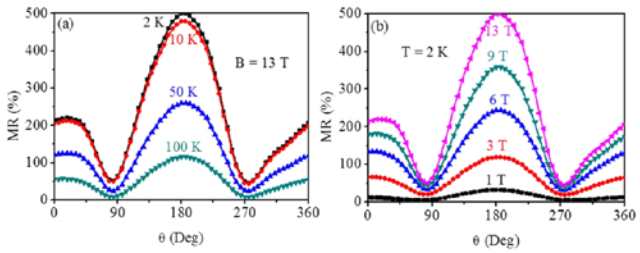
Topological insulators, a new class of condensed matter having bulk insulating states and gapless metallic surface states, have demonstrated fascinating quantum effects. However, the potential practical applications of the topological insulators are still under exploration worldwide. We demonstrate that nanosheets of a Bi_2Te_3 topological insulator several quintuple layers thick display giant and linear magnetoresistance. The giant and linear magnetoresistance achieved is as high as over 600% at room temperature, with a trend towards further increase at higher temperatures, as well as being weakly temperature-dependent and linear with the field, without any sign of saturation at measured fields up to 13 T. Furthermore, we observed a magnetic field induced gap below 10 K. The observation of giant and linear magnetoresistance paves the way for 3D topological insulators to be useful for practical applications in magnetoelectronic sensors such as disk reading heads, mechatronics, and other multifunctional electromagnetic applications. (X. L. Wang et al., *Physical Review Letters* 108, 266806 (2012))

THE IMPORTANCE OF SCATTERING, SURFACE POTENTIAL, AND VANGUARD COUNTER-POTENTIAL IN TERAHERTZ EMISSION FROM GALLIUM ARSENIDE



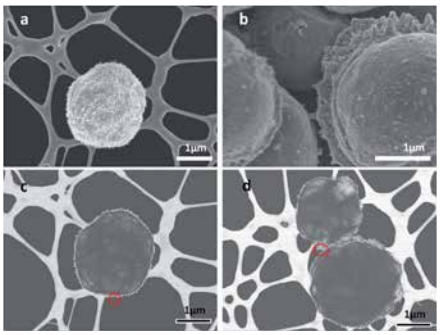
It is well established that under excitation by short (<1 ps), above-band-gap optical pulses, semiconductor surfaces may emit terahertz-frequency electromagnetic radiation via photocarrier diffusion (the dominant mechanism in InAs) or photocarrier drift (dominant in GaAs). Our three-dimensional ensemble Monte Carlo simulations allow multiple physical parameters to vary over wide ranges and provide unique direct insight into the factors controlling terahertz emission. We find for GaAs (in contrast to InAs), scattering and the surface potential are key factors. We further delineate in GaAs (as in InAs) the role of a vanguard counter-potential. The effects of varying dielectric constant, band-gap, and effective mass are similar in both emitter types. (D. L. Cortie et al., *Applied Physics Letters* 100, 261601 (2012))

ANGULAR-DEPENDENCES OF GIANT IN-PLANE AND INTERLAYER MAGNETORESISTANCES IN Bi_2Te_3 BULK SINGLE CRYSTALS



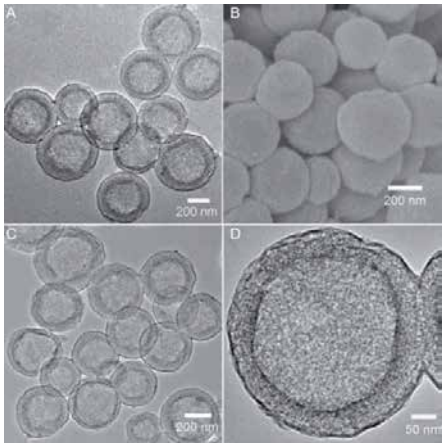
Angular-dependences of in-plane and interlayer magnetotransport properties in n-type Bi_2Te_3 bulk single crystals have been investigated over a broad range of temperatures and magnetic fields. Giant in-plane magnetoresistances (MR) of up to 500% and interlayer MR of up to 200% were observed, respectively. The observed MR exhibits quadratic field dependences in low fields and linear field dependences in high fields. The angular dependences of the MR represent strong anisotropy and twofold oscillations. The observed angle-dependent, giant MR might result from the strong coulomb scattering of electrons as well as impurity scattering in the bulk conduction bands of n-type Bi_2Te_3. The strong anisotropy of the MR may be attributable to the anisotropy of electron mobility, effective mass, and relaxation time in the Fermi surface. The observed giant anisotropic MR in n-type Bi_2Te_3 bulk single crystals paves the way for Bi_2Te_3 single crystals to be useful for practical applications in magnetoelectronic devices such as disk reading heads, anisotropic magnetic sensors, and other multifunctional electromagnetic applications. (Z. J. Yue et al., *Applied Physics Letters* 101, 152107 (2012))

GLOBULAR REDUCED GRAPHENE OXIDE-METAL OXIDE STRUCTURES FOR ENERGY STORAGE APPLICATIONS



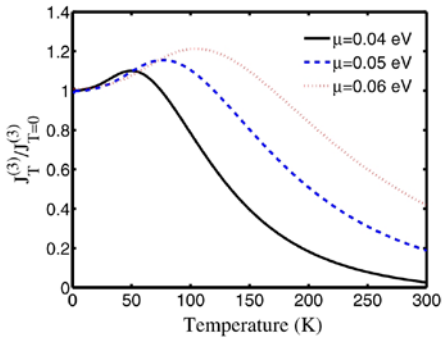
In this work, we employed anin situ spray pyrolysis approach to fabricate metal oxide-graphene composites with highly porous morphologies. The materials exhibited unique globular structures comprising metal oxide nanoparticles embedded between graphene sheets with high capacitance. (A. Chidembo et al., *Energy & Environmental Science* 5, 5236 (2012))

CONFINING SULFUR IN DOUBLE-SHELLED HOLLOW CARBON SPHERES FOR LITHIUM–SULFUR BATTERIES



A novel carbon–sulfur nanocomposite has been synthesized by confining sulfur in double-shelled "soft" carbon hollow spheres with high surface area and porosity. This carbon–sulfur nanocomposite shows outstanding electrochemical performance when evaluated as a cathode material for lithium–sulfur batteries. (C. F. Zhang et al., *Angewandte Chemie International Edition* 51, 9592 (2012))

PHOTOMIXING IN TOPOLOGICAL INSULATOR HgTe/CdTe QUANTUM WELLS IN TERAHERTZ REGIME



We reveal that topological insulators (TI) HgTe/CdTe quantum well have a strong nonlinear optical property in the three-photon mixing. While the gapless surface state in TI can exhibit strong nonlinear effect due to the linear energy dispersion, the nonparabolic energy dispersion of the bulk state is responsible for the photo mixing effect reported here. To produce response at terahertz frequency regime from femtosecond electrical fields, the mixing efficiency is around 10^{-4} comparable to that of nonlinear semiconductor crystals. The optimal temperature for this nonlinear effect is around 100 K. The results suggest a potential application of TI in terahertz photonics. (Q. J. Chen et al., *Applied Physics Letters* 101, 211109 (2012))

CONFERENCES

36TH ANNUAL AUSTRALIAN AND NEW ZEALAND CONDENSED MATTER AND MATERIALS MEETING (31ST JANUARY – 3RD FEBRUARY 2012, WAGGA WAGGA, AUSTRALIA)

"Advanced materials for lithium rechargeable batteries, supercapacitors and hydrogen storage", H. K. Liu (Invited talk)

2012 TMS ANNUAL MEETING & EXHIBITION (TMS2012) (11TH – 15TH MARCH 2012, ORLANDO, USA)

"Morphology engineering of 1D, 2D and 3D TiO_2 nanostructures and their application in dye-sensitized solar cells", Z. Q. Sun (Invited talk)

10TH SPRING MEETING OF THE INTERNATIONAL SOCIETY OF ELECTROCHEMISTRY (14TH – 19TH APRIL 2012, PERTH, AUSTRALIA)

"$LiNi_{0.5}Mn_{1.5}O_4$ Spinel cathodes using room temperature ionic liquid as electrolyte", S. L. Chou

INTERNATIONAL CONFERENCE ON SUPERCONDUCTIVITY AND MAGNETISM (ICSM 2012) (29TH APRIL – 4TH MAY 2012, ISTANBUL, TURKEY)

"Mechanism and potentiality of carbon encapsulated boron powder for enhancing the transport properties of MgB_2 wires", M. S. A. Hossain

INTERNATIONAL CONFERENCE ON OPTICAL, OPTOELECTRONIC AND PHOTONIC MATERIALS AND APPLICATIONS (3RD – 7TH JUNE 2012 NARA, JAPAN)

"Monte Carlo simulations of the emission of terahertz-frequency electromagnetic radiation from semiconductors", R. A. Lewis

16TH INTERNATIONAL MEETING ON LITHIUM BATTERIES (17TH – 22ND JUNE 2012, JEJU, SOUTH KOREA)

"New binders for $LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$ cathode materials", S. L. Chou

TERA 2012 (20TH – 22ND JUNE 2012, MOSCOW, RUSSIAN FEDERATION)

"Nonlinear optical properties of graphene ribbons in terahertz regime", C. Zhang (Invited talk)

THIRTEENTH INTERNATIONAL CONFERENCE ON THE SCIENCE AND APPLICATION OF NANOTUBES (24TH – 29TH JUNE 2012, BRISBANE, AUSTRALIA)

Carbon nanotube – metal oxide composites for lithium rechargeable batteries and supercapacitors, H. K. Liu (Invited talk)

OZ CARBON CONFERENCE (2ND – 3RD JULY 2012, ADELAIDE, AUSTRALIA)

"Carbon doping and strain control for improvement of materials properties", S. X. Dou (Keynote talk)

WORLDWIDE UNIVERSITIES NETWORK OF SPINTRONICS (WUN-SPIN 2012) (23RD – 25TH JULY 2012, SYDNEY, AUSTRALIA)

"Magnetoelectric coupling in magnetoelectric system", Z. X. Cheng (Invited talk)

63RD ANNUAL MEETING OF THE INTERNATIONAL SOCIETY OF ELECTROCHEMISTRY (19TH – 24TH AUGUST 2012, PRAGUE CZECH REPUBLIC)

"$Li_4Ti_5O_{12}$ Microspheres: fast synthesis and binder effect as anode materials for lithium-ion battery", S. L. Chou (Invited talk)

14TH HIGH TEMPERATURE MATERIALS CONFERENCE (12TH SEPTEMBER 2012, BEIJING, P. R. CHINA)

"Al-Doped zinc oxide nanocomposites with enhanced thermoelectric properties", S. X. Dou (Invited talk)

FEDERATION OF CHINESE SCHOLARS ASSOCIATION-2012 (FOCSA-2012) (17TH – 19TH SEPTEMBER 2012, PERTH, AUSTRALIA)

"Coexistence of opposite elements at small scales leads to miracles at International conference on science and education", S. X. Dou (Plenary talk)

EVOLVING ENERGY CONGRESS, CONVENTION CENTRE (17TH – 18TH SEPTEMBER 2012, SYDNEY, AUSTRALIA)

"Energy and environment global challenge program at UoW", S. X. Dou (Plenary talk)

INTERNATIONAL FORUM ON LI-ION BATTERIES TECHNOLOGY AND INDUSTRIAL DEVELOPMENT (22ND – 23RD SEPTEMBER 2012, P. R. CHINA)

"Materials design and formulation for Li-ion batteries", J. Z. Wang

15TH INTERNATIONAL CONFERENCE IN ADVANCES IN MATERIALS & PROCESSING TECHNOLOGY (23RD SEPTEMBER 2012, WOLLONGONG, AUSTRALIA)

"Electronic strain by chemical doping to improve materials performance properties", S. X. Dou (Invited talk)

INTERNATIONAL UNION OF MATERIALS RESEARCH SOCIETIES-INTERNATIONAL CONFERENCE ON ELECTRONIC MATERIALS 2012 (IUMRS-ICEM 2012) (23RD – 28TH SEPTEMBER 2012, YOKOHAMA, JAPAN)

"Spin reorientation, dielectric relaxation and magnetoelectric coupling in novel magnetoelectric system", Z. X. Cheng (Invited talk and session chair)

37TH IRMMW-THZ (24TH – 28TH SEPTEMBER 2012, WOLLONGONG, AUSTRALIA)

C. Zhang – Conference chair:

"Nonlinear response of topological insulators in the terahertz regime", C. Zhang

"Intraband nonlinear terahertz waves absorption of gapped graphene", C. Zhang

"Terahertz photon mixing effect in graphene and topological insulator", C. Zhang

BUAA—UOW JOINT WORKSHOP ON ADVANCED ENERGY MATERIALS (27TH SEPTEMBER 2012, BEIJING, P. R. CHINA)

"A fault current limiter (FCL) employing magnesium diboride (MgB_2)", X. Xu

PACIFIC RIM MEETING ON ELECTROCHEMICAL AND SOLID-STATE SCIENCE (7TH – 12TH OCTOBER, HONOLULU, USA)

"Parameters controlling emission of terahertz frequency electromagnetic radiation from InAs and GaAs: an ensemble Monte Carlo simulation study", R. A. Lewis

APPLIED SUPERCONDUCTIVITY CONFERENCE (ASC 2012) (7TH – 12TH OCTOBER 2012, PORTLAND, USA)

"Synergetic combination of LIMD with CHPD for the production of economical and high performance MgB_2 wires", M. S. A. Hossain

POEM 2012 (1ST – 2ND NOVEMBER 2012, WUHAN, P. R. CHINA)

"Nonlinear optical properties in graphene in terahertz regime", C. Zhang (Invited talk)

INSTITUTE OF PHOTONICS AND OPTICAL SCIENCE SYMPOSIUM (5TH – 6TH NOVEMBER 2012, SYDNEY, AUSTRALIA)

"Monte Carlo simulations of terahertz emission", R. A. Lewis

INTERNATIONAL CONFERENCE OF FUNCTIONAL MATERIALS (15TH – 16TH NOVEMBER 2012, SYDNEY AUSTRALIA)

"Nano structured materials for energy applications", S. X. Dou (Plenary talk)

"Preparation of colloidal semiconductor nanowires for thermoelectrics, advances in functional nanomaterials", Z. Li

2012 PHOTONICS GLOBAL CONFERENCE (PGC2012) (13TH – 16TH DECEMBER 2012, SINGAPORE, SINGAPORE)

"TiO_2 nanostructure design and its application in dye-sensitized solar cells", Z. Q. Sun (Invited talk)

THE 5TH INTERNATIONAL SYMPOSIUM OF FUNCTIONAL MATERIALS (17TH – 20TH DECEMBER 2012, PERTH, AUSTRALIA)

"Nano structured materials for energy applications at UoW", S. X. Dou (Plenary talk)

"Functional nanostructured materials for lithium rechargeable batteries, supercapacitors and hydrogen storage", H. K. Liu (Invited talk)

INVITED PRESENTATIONS AND SEMINARS AT OTHER INSTITUTIONS

M. S. A. HOSSAIN

"Comparison of MgB_2 wires made with Boron from various sources"
National Superconductivity Center, Ankara University, Turkey, 13th June 2012

"Comparison of MgB_2 wires made with Borons from various sources"
Department of Physics, Karadeniz Technical University, Turkey, 18th June 2012

"Present State of high performance MgB_2 wires and cables for Industrial Scale-up"
Department of Physics, King Saud University, Kingdom of Saudi Arabia, 6th November 2012

C. ZHANG

"Specular Andreev reflection at an interfacce between a superconductor and a semiconductor with Rashba spin-orbit coupling"
Institute of Solid State Physics, Chinese Academy of Science, China, 29th October 2012

"Quantum transport in high mobility systems"
Shanghai Institute of Microsystems and Information Technology, Chinese Academy of Sciences, China, 4th December 2012

"Linear and nonlinear optical properties of graphene"
Changzhou University, China, 6th November 2012

"Optical conductance in graphene"
Jiangsu University, China, 8th November 2012

S. L. CHOU

"Carbon composite materials for energy storage"
Wenzhou medical college, China, 9th November 2012

"Binder effect to the performance of Li-ion battery materials"
University of Science and Technology in China, China, 10th November 2012

"Composite and binder effect for high energy cathode and anode materials"
Institute of Solid-state Physics, Chinese Academy of Sciences, China, 10th November 2012

R. A. LEWIS

"A taste of terahertz"
University of Technology, Sydney, Australia, 26th October 2012

J. Z. WANG

"Flexible materials for the bendable batteries"
Advanced Batteries Research Center, KETI, South Korea, 15th June 2012

"Flexible materials for the bendable batteries"
School of Chemical Engineering, Chonbuk National University, South Korea, 15th June 2012

"Nanomaterials for the Lithium batteries"
School of Chemical Engineering, Wuhan University, China, 17th September 2012

S. X. DOU

"Coexistence of opposite elements at small scales leads to miracles"
Edith Cowen University, Australia, 18th December 2012

Honorary Professorship to Prof S.X. Dou by Hua Qiao University

SEMINARS BY VISITING SCIENTISTS

Date	Name	Institute	Title
08/03/2012	Dr Michael Johnston	Clarendon Laboratory, University of Oxford, United Kingdom	Terahertz spectroscopy of functional nanomaterials
14/03/2012	A/Prof Stefan Adams	National University of Singapore, Singapore	Fast lithium ion conductors for high power solid state batteries
28/03/2012	Dr Neeraj Sharma	Bragg Institute, ANSTO, Australia	Neutron scattering: Tools to study lithium-ion batteries
04/04/2012	Dr Goojin Jeong	Advance Batteries Research Centre (ABRC) in Korea Electronics Technology Institute (KETI), South Korea	Overview of Si based anodes research in Samsung SDI & KETI
05/04/2012	Prof Xi Wang	Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Science, PR China	Research at SIMIT
20/04/2012	Dr Jeom-Soo Kim	Korea Electronics Technology Institute / Advanced Battery Research Center, South Korea	Novel concept of using Li_2MO_3 as Li sources for lithium ion capacitors
02/05/2012	Dr Vijay K. Pillai	CSIR-CECRI (Central Electrochemical Research Institute) Karaikudi, Tamil Nad, India	Electrochemical transformation of multiwalled carbon nanotubes to graphene quantum dots
14/05/2012	Prof Lei Jiang	Institute of Chemistry, Chinese Academy of Sciences, PR China	Bio-inspired: smart, multiscale interfacial materials
07/06/2012	Prof Sang-Soo Oh	Korea Electrotechnology Research Institute, Changwon, South Korea	R&D of HTS wire and its applications in Korea
06/06/2012	Dr Kostya Ostrikov	CEO Science Leader, Director of the Plasma Nanoscience Center Australia (PNCA), CSIRO, Australia	Plasma-made nanomaterials: synthesis and applications
15/06/2012	Prof Tony Talaie	Currently president of TT Polymer Device Research Consultancy, Japan	Adding artificial intelligence to artificial based polymeric organs: Does ISEM need to collaborate on Electronics of "Polyhuman" Project
15/06/2012	Dr. Qiaoliang Bao	Department of Materials Engineering, Monash University, Australia	Graphene photonics: light creation, modulation and detection
16/07/2012	Dr Xiong Wen (David) Lou	School of Chemical and Biomedical Engineering, Nanyang Technological University, Singapore	Metal oxide based nanostructured anode materials for Li-ion batteries
30/07/2012	Prof Antony J. Bourdillon	School of Chemical and Biomedical Engineering, Nanyang Technological University, Singapore	The Metric for the Quasi-Bragg law measured for the first time
01/08/2012	Prof Yuanxu Wang	Henan University, PR China	First principles study of hard transition-metal compounds, thermoelectrics, and multiferroics
17/08/2012	Dr Xuebin Yu	Department of Materials Science, Fudan University, Shanghai, PR China	Hydrogen-enriched B-N-based materials for advanced hydrogen storage
16/08/2012	A/Prof Yong-Mook Kang	Department of Chemistry, Dongguk University-Seoul, South Korea	Strategic design for oxide-based electrode materials and the dependence of their electrochemical properties on morphology and architecture
28/09/2012	Prof John Bell	Queensland University of Technology, Australia	Storage in electricity networks – is it a game changer?
26/10/2012	Prof Dongyuan Zhao	Department of Chemistry, Fudan University, Shanghai, PR China	Synthesis and applications of ordered mesoporous carbon materials
02/11/2012	Prof David Jamieson	Centre for Quantum Computation and Communication Technology (CQC2T), University of Melbourne, Australia	Towards the quantum internet of the mid-21st C: building quantum bits in silicon
04/12/2012	Prof Kevin Kendall	Chemical Engineering, University of Birmingham, United Kingdom	Hydrogen & fuel cells for transport: energy storage problem
07/12/2012	Dr Peng Cheng	Institute of Physics, Chinese Academy of Sciences, PR China	STM study of topological insulators

EQUIPMENT AND FACILITIES

In 2012 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) and AIIM Processing & Devices Facility 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 were involved in the preparation and submission of 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, Dr K-F. Aguey-Zinson
University of Queensland	Prof. G.Q. 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
- Bull Block, 22cm diameter
- Spray Drier, GA-32, ~100g/h
- Rolling mill, 2 x 60mm flat & square rollers, 5cm/s
- Spray Drier OPD8 3l/hour
- Rolling mill, 2 x 55mm supported rollers, 5cm/s
- Attrition Mill, 01-HD, 0-660rpm
- Swagging machine, 15-1mm diameter
- Planetary Mill, pulverisette 5, 0-300rpm agate
- Hydraulic press, 10t-100t
- Drawing Bench, 8m, fixed die, 11.5kW
- More than 30 various furnaces
- High energy ring mill
- Four mirror floating zone single crystal growth
- Ultrasonic spray unit
- Controlled atmosphere glove boxes
- Thermal Technology SPS system
- Thermal Technology high temp/vacuum furnace
- 9T High Magnetic Field furnace

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.
- Heidelberg Maskless Laser Lithography system.
- Mantis Thin Film Deposition System located in Class 1000 Clean Room.
- Electron Beam Lithography (EBL) system on the base of SEM (LaB_6).
- Optical lithography.

MATERIALS CHARACTERISATION

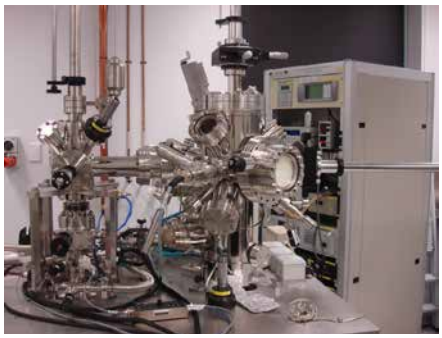
- DTA/TG, Setaram, 18-92, 1750°C
- Mettler Toledo DTA/TGA system, 1600°C
- TEM, J2000FX1, with EDS
- Gas absorption analyser Nova 1000 for BET and pore size analyses
- XRD, M18XHFCu with HT 2000°C camera
- XRD, GBC MMA with solid detector for fast and accurate reading of reflections.
- XPS, AES, ISS, 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
- Unisoku USM-1500 STM, 2K-300K, 8T
- Unisoku USM-1400 4Probe SPM, 2K-300K, 1T
- Unisoku USM-1500 SNOM SPM, 2K-300K, 1T, Rahman system
- AFM, Nanoscope IIIa
- Particle Size Analyser, Cilas, 0.05-900µm
- Linseis Seebeck coefficient (RT to 1100°C) and Thermal conductivity measurement system (RT to 1600°C)
- DSC, TA300,-170°C+600°C

PHYSICAL PROPERTY CHARACTERISATION

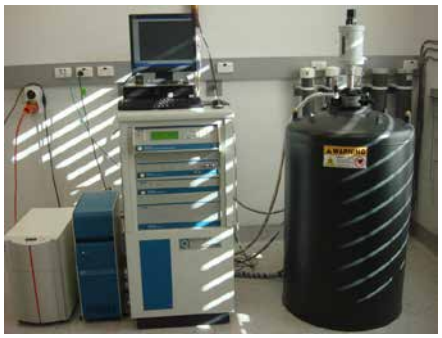
- MPMS, 1.5-400K, 0-5T DC field
- PPMS, 4-400K, 0-9T DC field
- PPMS, 4-1000K (VSM), 0-14T DC field (multiple options such as thermal transport, heat capacity, AC transport are available)
- 15T VTI magnet, 200A DC current leads for critical current measurements
- Lock-in Amplifier, SR510; Lock-in Amplifier, 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
- American Magnetics 600A DC Power Supply
- Ballantine 1620 transconductance amplifier (up to 100A)
- Various multimeters, HP and Keithley, including a nano-voltmeter
- Function Generator, DSC340; Digital Oscilloscope, TDS320
- Digital Teslameter, DTM-132, with Hall Probe; Fluxmeter, 916
- 3 He liquefiers from CryoMech – 18 LHe/day each, Helium purifier
- Eddy current generator
- Electromagnet, 3473-70, 2T, 150mm pole diameter, Rawson-Lush Gaussmeter
- Lasers, Spectra Physics Model 2040 25 W Ar+, Spectra Physics Model 165 6 W Ar+, Spectra Physics Model 3900 Titanium-sapphire, Spectra Physics Model 380 Dye, Spectra Physics 15 mW HeNe
- Detectors, 4xInfrared Laboratories bolometers, Infrared Laboratories Ga-doped Ge photoconductor, N. Coast Scient. Corp Ge photoconductor, Photomultiplier with GaAs photo-cathode
- Cryostats, A number of L He with optical access, L N cryostats, 60 L He storage, 30 L He storage, 60 L N storage, 50 L N storage, 2x30 L N storage, 25 L N storage
- Leak detector Vacuum system

ELECTRO-CHEMICAL PROPERTY CHARACTERISATION

- Cyclic Voltammograph, BAS CV-27
- Impedance Analyser, M6310
- 4 Channels Data Collection System, MacLab/4e
- ICP-OES, 167-785nm range 0.009nm resolution 200nm
- Scanning Potentiostat, M326; Potentiostat, M363
- Power Supply, DCS 20-50, 0-20V, 0-50A 8 Channels Data Collection System, MacLab/8
- Amplifiers, PAR 124A Lock-in, 2xPAR 5209 Lock-in, Stanford Research SR510
- CHI 660B Electrochemical Workstation
- Arbin MSTAT8000 Electrochemical Workstation
- Automatic PCT Measuring System
- Biologic VMP3 electrochemical workstation
- Thermal Hazard Technology – Accelerating Rate Calorimeter
- Arbin Instruments Electrochemical Workstation for characterization of Supercapacitors



8T variable temperature scanning tunnelling microscope.



14T Physical Property Measurement System.

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

High temperature Seebeck coefficient, electrical conductivity, and thermal conductivity systems.

Accelerating rate Calorimeter

Liquid helium production plant.

REFEREED PUBLICATIONS

REFEREED JOURNAL ARTICLES

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2) S. Aminorroaya-Yamini, C. Zhang, X. L. Wang, and I. Nevirkovets, "Crystal structure, electronic structure and thermoelectric properties of n-type $BiSb_STe_2$", Journal of Physics D – Applied Physics 45, 125301 (2012).
3) Y. S. Ang, Z. S. Ma, C. Zhang, "Retro reflection of electrons at the interface of bilayer graphene and superconductor", Scientific Reports 2, 1013 (2012).
4) Y. S. Ang, S. Sultan, A. Tawfiq, J. C. Cao, and C. Zhang, "Terahertz photon mixing effect in gapped graphene", Journal of Infrared Millimeter and Terahertz Waves 33, 816 (2012).
5) Y. S. Ang and C. Zhang, "Enhanced optical conductance in graphene superlattice due to anisotropic band dispersion", Journal of Physics D – Applied Physics 45, 395303 (2012).
6) M. G. Babaoğlu, S. Safran, Ö. Çiçek, H. Ağıl, E. Ertekin, M. S. A. Hossain, E. Yanmaz, A. Gencer, "Microstructural and superconducting properties of C_6H_6 added bulk MgB_2 superconductor", Journal of Magnetism and Magnetic Materials 324, 3455 (2012).
7) A. Calka, A. A. Chowdhury, and K. Konstantinov, "Rapid synthesis of functional oxides by electric discharge assisted mechanical milling method", Journal of Alloys and Compounds 536, S3 (2012).
8) D. P. Chen, X. L. Wang, Y. Du, S. Ni, Z. B. Chen, and X. Z. Liao, "Growth mechanism and magnetic properties of highly crystalline NiO nanocubes and nanorods fabricated by evaporation", Crystal Growth & Design 12, 2842 (2012).
9) D. P. Chen, Y. Du, X. L. Wang, Z. X. Cheng, S. X. Dou, Z. W. Lin, J. G. Zhu, and B. Xu, "Oxygen-vacancy effect on structural, magnetic, and ferroelectric properties in multiferroic $YMnO_3$ single crystals", Journal of Applied Physics 111, 07D913 (2012).
10) Q. J. Chen, Y. S. Ang, R. A. Lewis, X. L. Wang, and C. Zhang, "Photomixing in topological insulator HgTe/CdTe quantum wells in terahertz regime", Applied Physics Letters 101, 211109 (2012).
11) Y. Cheng, W. C. Hao, H. Z. Xu, Y. X. Yu, T. M. Wang, R. Chen, L. J. Zhang, Y. Du, X. L. Wang, and S. X. Dou, "Improving the solubility of Mn and suppressing the oxygen vacancy density in $Zn_{0.98}Mn_{0.02}O$ nanocrystals via octylamine treatment", ACS Applied Materials & Interfaces 4, 4470 (2012).
12) 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 111, 034103 (2012).
13) A. T. Chidembo, S. H. Aboutalebi, K. Konstantinov, M. Salari, B. Winton, and S. A. Yamini, I. P. Nevirkovets, and H. K. Liu, "Globular reduced graphene oxide-metal oxide structures for energy storage applications", Energy & Environmental Science 5, 5236 (2012).
14) S. L. Chou, M. Ionescu, J. Z. Wang, B. Winton, and H. K. Liu, "Irradiation Si on carbon nanotube paper as a flexible anode material for lithium-ion batteries", Nanoscience and Nanotechnology Letters 4, 169 (2012).
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18) D. L. Cortie, K. W. Lin, C. Shueh, H. F. Hsu, X. L. Wang, M. James, H. Fritzsche, S. Bruck, and F. Klose, "Exchange bias in a nanocrystalline hematite/permalloy thin film investigated with polarized neutron reflectometry", Physical Review B 86, 054408 (2012).
19) D. L. Cortie, A. P. J. Stampfl, F. Klose, Y. Du, X. L. Wang, H. Y. Zhao, H. Kimura, and Z. X. Cheng, "The magnetic structure of an epitaxial $BiMn_{0.5}Fe_{0.5}O_3$ thin film on $SrTiO_3$ (001) studied with neutron diffraction", Applied Physics Letters 101, 172404 (2012).
20) K. S. B De Silva, X. Xu, X. L. Wang, D. Wexler, D. Attard, F. Xiang, and S. X. Dou, "A significant improvement in the superconducting properties of MgB_2 by co-doping with graphene and nano-SiC", Scripta Materialia 67, 802 (2012).
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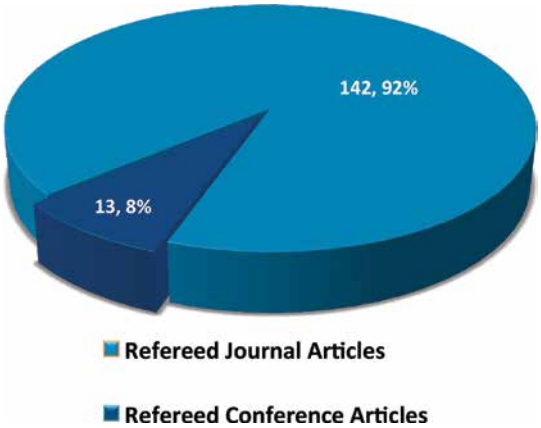

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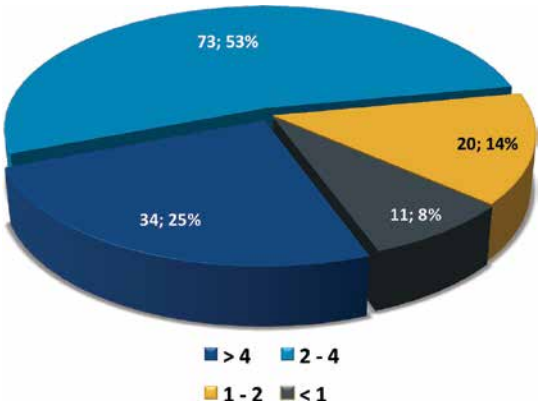
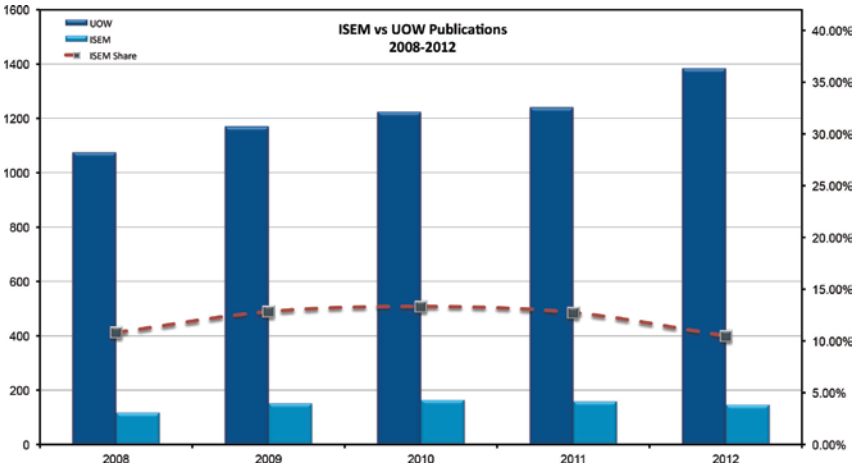


ISEM vs UOW Publications (2008-2012)



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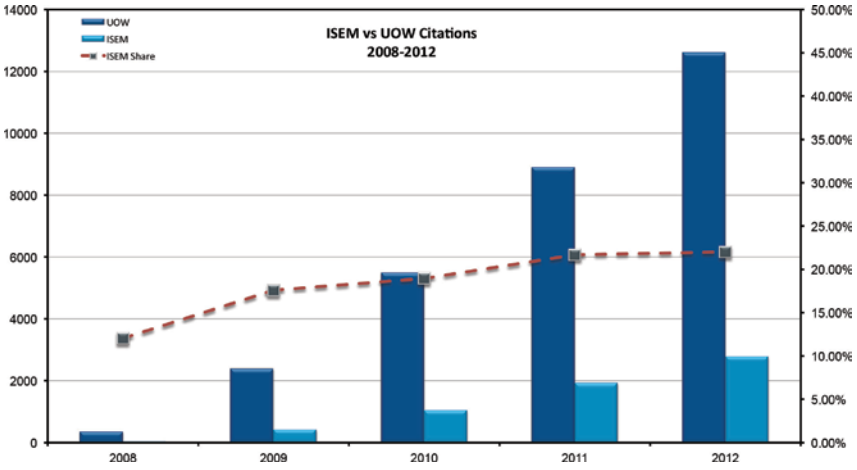
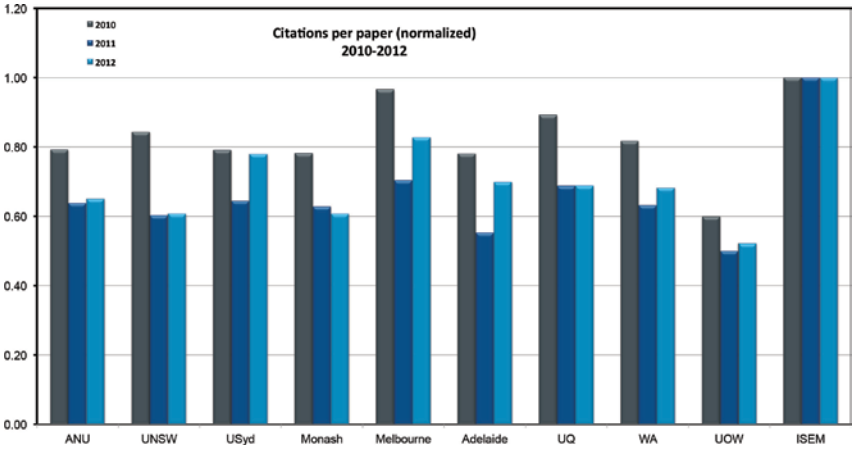


Citations per paper (normalised) (2010-2012)



Web of Knowledge rankings – magnesium diboride superconductors (2002-2012)

Institution	Records (Total 1907)	% of Total
University of Wollongong	127	6.660
National Institute of Materials Science	70	3.761
Pohang University of Science and Technology	55	2.884
Chinese Academy of Sciences	54	2.832
Tohoku University	50	2.622
University of Cambridge	46	2.412
Univerwity of Tokyo	44	2.307
Slovak Academy of Science	41	2.150
University of New South Wales	41	2.150
Russian Academy of Science	39	2.045

Web of Knowledge rankings – lithium-ion batteries (2002-2012)

Institution	Records (Total 19242)	% of Total
Chinese Academy of Sciences	877	4.588
Central South University	421	2.188
Argonne National Lab	355	1.845
Zhejiang University	346	1.798
Fudan University	326	1.694
Hanyang University	320	1.663
University of Science Technology China	283	1.471
University of Wollongong	280	1.455
National University Singapore	262	1.362
Tsinghua University	261	1.356

FUNDING 2012

AUSTRALIAN RESEARCH COUNCIL GRANTS

ARC CENTRE OF EXCELLENCE GRANTS

Chief Investigators	Title	2012 Funding
H. K. Liu	Nano-materials for energy storage	$90,000
Total		**$90,000**

ARC DISCOVERY SCHEME GRANTS

Chief Investigators	Title	2012 Funding
S. X. Dou, G. Peleckis, J. H. Kim, J. Driscoll, E. Hellstrom, Y. W. Ma, H. Kumakura,	Nanostructure engineered iron-based superconductors	$140,000
A. V. Pan, C. P. Foley, T. H. Johansen, H. Hilgenkamp	Tailoring superconducting hybrid multilayered film systems for electric and electronic applications	$105,000
Z. P. Guo, Z. Chen, J. Dahn, J. Chen	New directions to miniaturized power sources: integrated all-solid-state rechargeable batteries	$140,000
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	$105,000
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		**$890,000**

ARC FUTURE FELLOWSHIP

Chief Investigators	Title	2012 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	$179,000
Total		**$351,000**

ARC DECRA FELLOWSHIP

Chief Investigators	Title	2012 Funding
Z. G. Huang	Diammoniate of diborane for hydrogen storage	$125,000
Total		**$125,000**

ARC LINKAGE PROJECTS

Chief Investigators	Title	2012 Funding
S. L. Chou, J. Z. Wang, H. K. Liu, D. Wexler, Y. M. Kang	Development of novel composite anode materials combined with new binders for high energy, high power and long life lithium-ion batteries	$45,000
S. X. Dou, J. Horvat, X. Xu, J. Moscrop	Design, build and test a fault current limiter employing magnesium diboride (MgB_2) superconducting coils	$195,000
S. X. Dou, J. H. Kim, M. S. A. Hossain, G. Peleckis	Synergetic combination of localised magnesium diffusion process with cold compaction technique for fabrication of MgB_2 superconductor wires	$90,000
S. X. Dou, S. Li, W. X. Li, C. Zhang, S. Aminorroaya - Yamini	New generation high efficiency thermoelectric materials and modules for waste heat recovery from steelworks	$60,000
Z. P. Guo, H. K. Liu, C. Cook, H. Zhu, D. Wexler, X. J. Zhu	Development of advanced lithium ion battery and battery management system for electric vehicle/ hybrid electric vehicle application	$40,000
J. Z. Wang, H. K. Liu, K. Konstantinov, Z. X. Wang	Room temperature rechargeable sulphur batteries	$100,000
Total		**$530,000**

ARC LINKAGE INFRASTRUCTURE, EQUIPMENT AND FACILITIES (LIEF)

Chief Investigators	Title	2012 Funding
X. L. Wang, S. X. Dou, G. Peleckis, L. Ye, T. S. Zhang, M. Martyniuk, C. Zhang, J. B. Yi, W. K. Yeoh, G. Umana-Membreno, R. A. Lewis, Y .B. Zhang, C. Ulrich	A complete thermo-electric characterization facility for exploration of novel materials and devices at high temperatures	$200,000
Total		**$200,000**

2012 AUSTRALIAN RESEARCH COUNCIL GRANTS TOTAL: $2,096,000

NON-ARC GRANTS

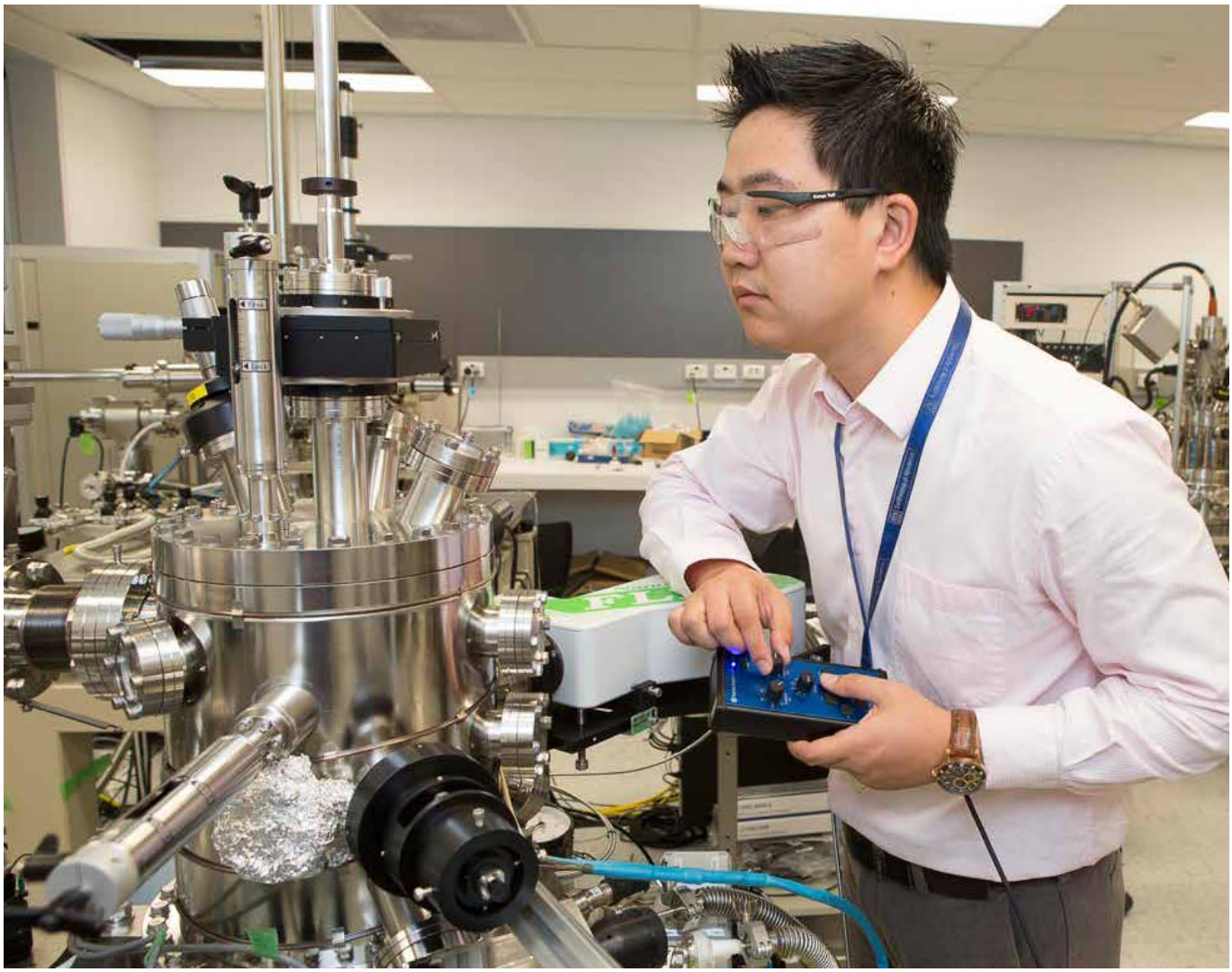
Chief Investigators	Title	2012 Funding
S. X. Dou, S. Li, C. Zhang	Waste heat recovery from steelworks using advanced thermoelectric materials and generator technology (BAJC Research Grant)	$250,000
Z. Q. Sun	ECR travel grant for TMS 2012 conference (CASS Foundation)	$3,500
S. L. Chou	Novel carbon materials for high energy supercapacitors (Australian Academy of Science)	$10,000
Z. P. Guo	Investigation of the structural changes in Li_2FeSiO_4 upon charging/discharging by in-situ synchrotron diffraction (Australian Synchrotron Research Program)	$1,400
Z. P. Guo	Dehydrogenation of pathway of ammine aluminium borohydrides system (Australian Synchrotron Research Program)	$1,000
S. L. Chou	Using Synchrotron to investigate the phase details of microwave hydrothermal synthesized battery materials (Australian Synchrotron Research Program)	$1,400
J. L. Wang	Magnetovolume effects in $NdMn_{2-x}Cr_xSi_2$ compounds (Australian Synchrotron Research Program)	$1,300
R. Zeng	Investigation of the pressure response of the structural transition in the novel $Mn_{0.94}Ti_{0.06}CoGe$ magnetic refrigerant (Australian Synchrotron Research Program)	$1,000
Total		**$269,600**

UOW URC GRANTS & ARC NEAR-MISS GRANTS

Chief Investigators	Title	2012 Funding
S. Aminorroaya-Yamini	Developing n-type PbTe thermoelectrics for waste heat recovery application	$10,000
D. P. Chen	A general strategy for highly crystalline nanomaterial synthesis	$12,500
M. S. A. Hossain	Design, test and construct a 4-anvils prototype compaction device for the fabrication of dense MgB_2 superconductor wires with improved connectivity	$10,500
J. L. Wang	Magnetic and structural phase relationship in layered structure compounds with large magnetocaloric effect	$11,000
S. X. Dou, X. Yu, P. Chen, I. Takayuki, S. Kennedy	Design and synthesis of ammonia-borane complexes for hydrogen storage	$12,000
Total		**$56,000**

UOW Support (Performance, Management, PGS Maintenance) **$300,000**

TOTAL FUNDING 2012 **$2,721,600**



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