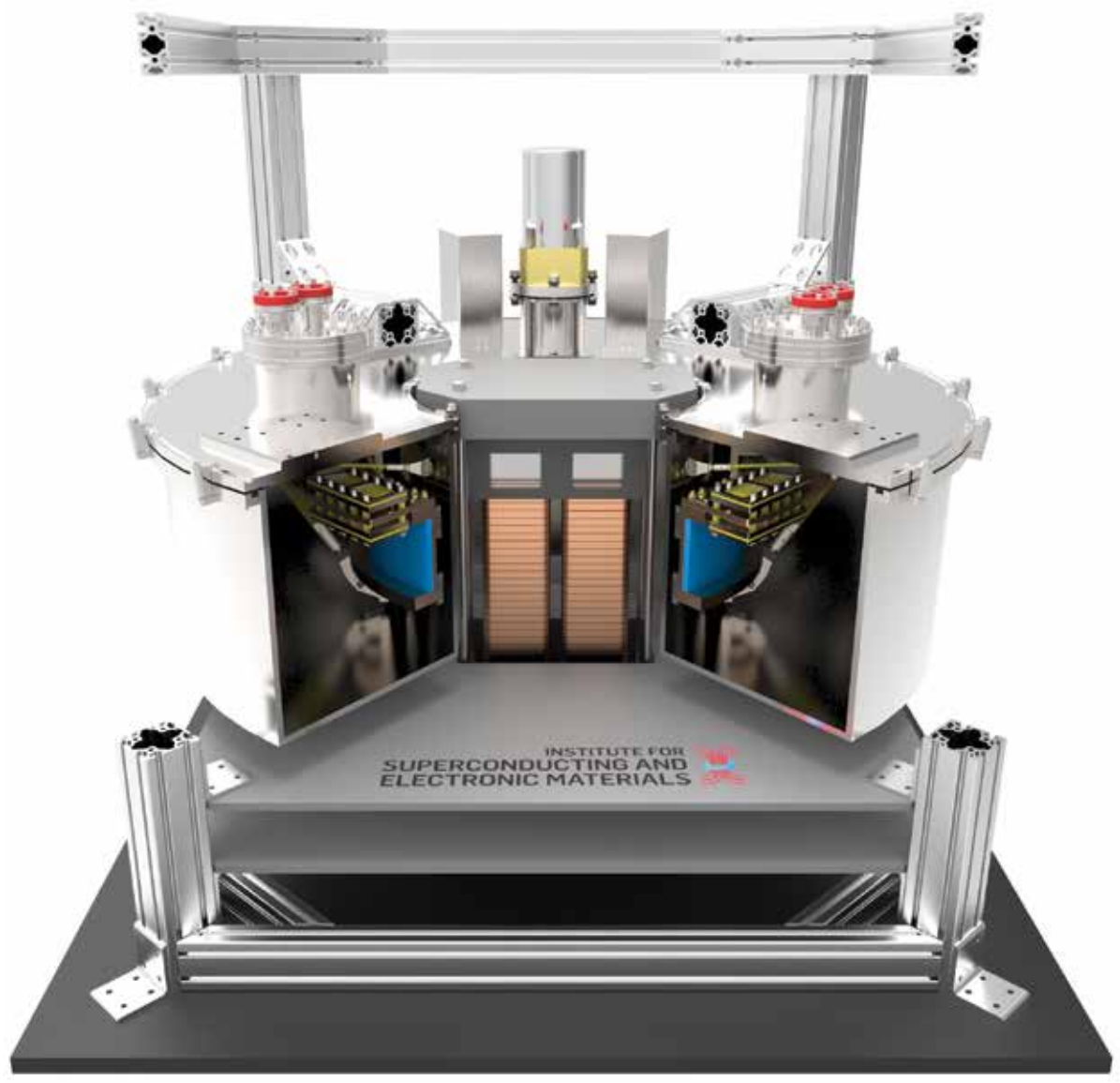
COLLABORATIVE / VISIONARY / INSPIRING
ISEM 2014 ANNUAL REPORT



INSTITUTE FOR SUPERCONDUCTING AND ELECTRONIC MATERIALS

UNIVERSITY OF WOLLONGONG AUSTRALIA

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Cover: A superconducting fault current limiter

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.

2014 POSTGRADUATE STUDENT EXCELLENCE AWARD RECIPIENTS

Jincheng Zhuang
Wenbin Luo
Sujith Kalluri

2014 POSTGRADUATE STUDENT MERIT AWARD RECIPIENTS

Jianjian Lin
Xin Liang
Zhijia Zhang
Xinqi Chen

2014 POSTGRADUATE STUDENT BEST PAPER AWARD RECIPIENTS

Chao Han

2014 CHINESE GOVERNMENT SCHOLARSHIP AWARDS

Guang Lin Xia

Past ISEM Chinese government private postgraduate student award winners

	Name	Year awarded
1	Yue Zhao	2006
2	Zhen Guo Huang	2007
3	Jerry Zhao	2007
4	Wen Xian Li	2008
5	Da Peng Chen	2008
6	Shulei Chou	2009
7	Hao Liu	2009
8	Peng Zhang	2009
9	Guo Dong Du	2010
10	Yi Du	2010
11	Jian Feng Mao	2010
12	Chao Zhong	2011
13	Chao Feng Zhang	2012
14	Hong Fang	2012
15	Xuan Wen Gao	2013
16	Yi Shi	2013
17	Zengji Yue	2013
18	Guang Lin Xia	2014

Mr. Wenbin Luo

Ms Xinqi Chen

Mr. Zhijia Zhang

Mr. Chao Han

DIRECTOR'S REPORT

2014 marked the 20th anniversary of ISEM in UOW and was one of the best years in our history.

ISEM has made significant advances and breakthroughs in energy storage materials, topological, thermoelectric, solar, and catalytic materials, as well as in THz science and photonics. Patented novel ion-selective membranes, high capacity yolk-shell structured silicon based anode, edge-doped graphene composites, low-cost sulphur cathode, phosphorus based anode, and high power density cathode cycled up to 10,000 times have shown a great potential for commercialisation of Li ion, Na ion, and Li – S batteries. Our recently installed pilot production line has produced a first batch of ISEM-UOW built 18650 Li-ion battery cells.

A record high figure-of-merit has been achieved in new thermoelectric materials for waste heat recovery. A smart battery management system has been demonstrated on ISEM's fully-electric vehicle. Our method for generalised self-assembly of scalable two-dimensional metal oxide nanosheets has shown outstanding potential for a wide range of future applications. A demonstration of the photonic Aharonov-Bohm effect presents new possibilities to control and manipulate photons. For the first time in Australia, an advanced scanning tunneling microscope was used to fabricate and test a novel 2D material – silicene.

Our staff members have further improved their profiles and gained international recognition, as evidenced by the large number of awards and appointments as Honorary Professor, and Members of Advisory and Editorial Boards, which strongly contributes to raising UOW's worldwide reputation. Seven staff members (Chao Zhang, Alexey Pan, Shulei Chou, Md Shahriar Hossain, Zhen Li, Zi Qi Sun, and Wei Kong Pang) were promoted to Senior Professor, Professor, Senior Researcher, and Level B researchers, respectively. Our team consists of two distinguished professors, three senior professors, three

professors, five associate professors and five senior fellows, including three Future Fellows, one QEII fellow, and four DECRA fellows. This phenomenal achievement places ISEM among the most competitive research teams in materials science in the world. This is evident from the high ranking of UOW at the 6th position in Australia (88th in the world) in materials science by the US News ranking.

We have continued our success in attracting competitive research grants: three ARC Discovery grants, one ARC Future and one ARC DECRA Fellowship were awarded to ISEM in 2014, with total ISEM funding for 2014 once again exceeding $4M. This is a fantastic achievement considering present pressures and the research funding climate.

Our postgraduate students have made very impressive progress in 2014, with 14 PhD students graduating. Three of our PhD students won highly competitive Chinese overseas private student scholarship awards, one won Auto CRC conference prize and seven were awarded ISEM prizes. ISEM has attracted 11 Chinese Scholarship Committee (CSC) PhD students, two ANSTO scholarships, and two half scholarships from industry. This can be translated into $970,000 worth of scholarship grants for three years that originate from external sources. By the end of 2014, ISEM had 106 PhD graduates, who have been actively pursuing their further careers all around the globe.

In 2014 we published a record 206 papers, exceeding any previous year, not only by numbers, but also quality. ISEM has contributed over 28% of UOW's total self-exclusive citations with these publications. Citations per faculty member are 11 times the UOW average, and more than 20 papers were published or accepted in journals with impact factors (IF) greater than 10.

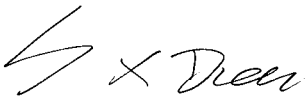
In July 2014, as a part of ISEM's 20th anniversary celebration, we have organised the 5th Australia-China Symposium of Materials Science and the 5th Australia-China Conference of Science, Technology and Education. This event has attracted many distinguished scientists from both Australia and China, as well as from Korea, Japan, and Europe. The conference was very successful and served the purpose of enhancing networking and access to world-class research by our HDR students, once again raising UOW's reputation.

I would like to express my sincere gratitude to our Honorary Professors for their significant contribution to ISEM and its output. In 2014 we hosted 15 visiting fellows, who were mostly supported by their government and their university. 60% of ISEM publications in 2014 include contributions from the honorary professors, visiting fellows, and collaborators. We have been extremely proactive within our joint research centre with Bei Hang University. This collaboration has been very fruitful, resulting in a large number of high quality journal publications, some of which were selected as cover pages.

The above achievements are attributed to the strategies we implemented, including promoting ISEM-Asia engagement, strengthening networking at all levels, taking advantage of interdisciplinary expertise from top institutions, and enhancing HDR training by exploring all the possible sources of candidates and funding. Our practice demonstrated that the exciting goal for UOW of joining the top 1% of world universities set up by the Vice Chancellor, Prof. Wellings, can be achieved.

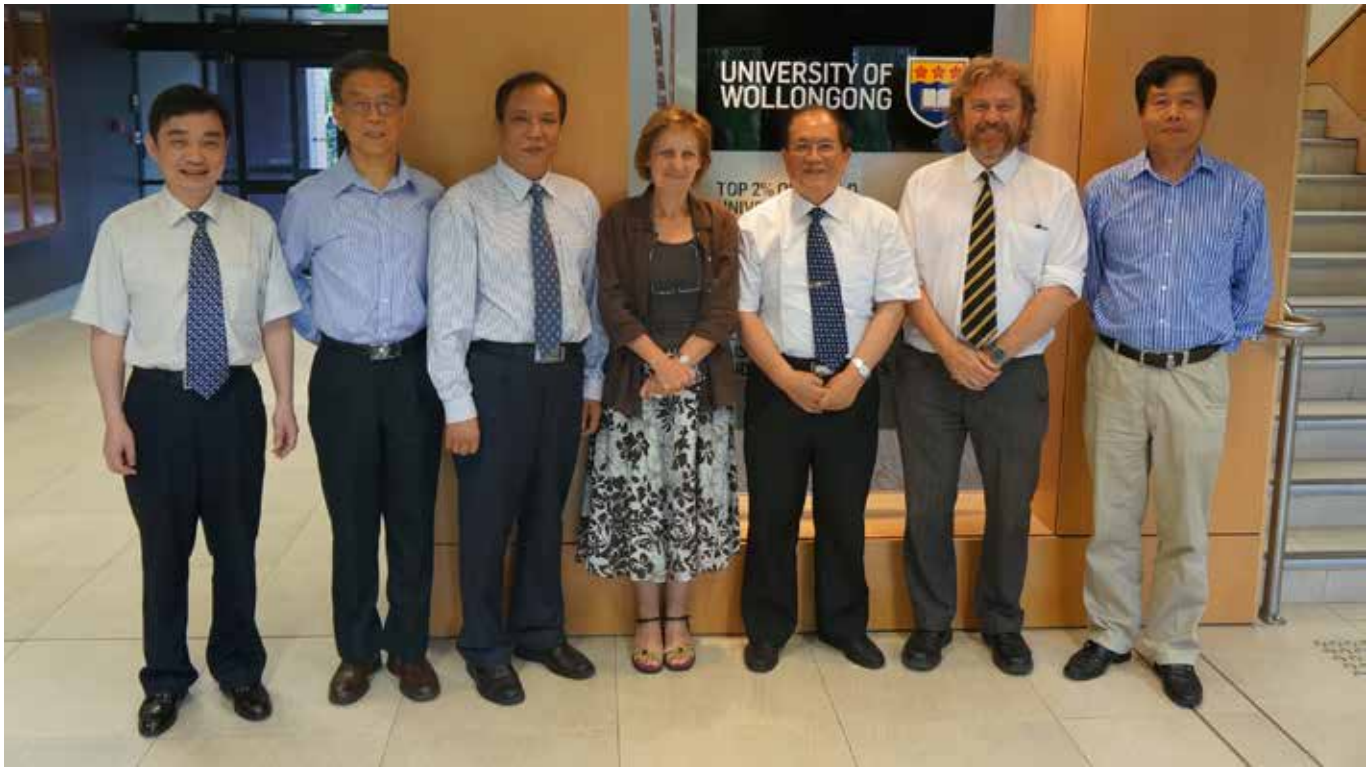
I would like to take this opportunity to acknowledge the support from the executives of the University and Faculties, the Student Research Centre, the Research Services Office, and the administrative staff and technical staff at the Australian Institute of Innovative Materials (AIIM). I would particularly like to thank our researchers, HDR students, visiting staff, Honorary Professors, and collaborators for their dedication and contribution to ISEM. I am confident that ISEM will continue its success and will strongly contribute to UOW's wellbeing and reputation in 2015.

Sincerely yours,



PROF. SHI XUE DOU

DIRECTOR, INSTITUTE FOR SUPERCONDUCTING AND ELECTRONIC MATERIALS

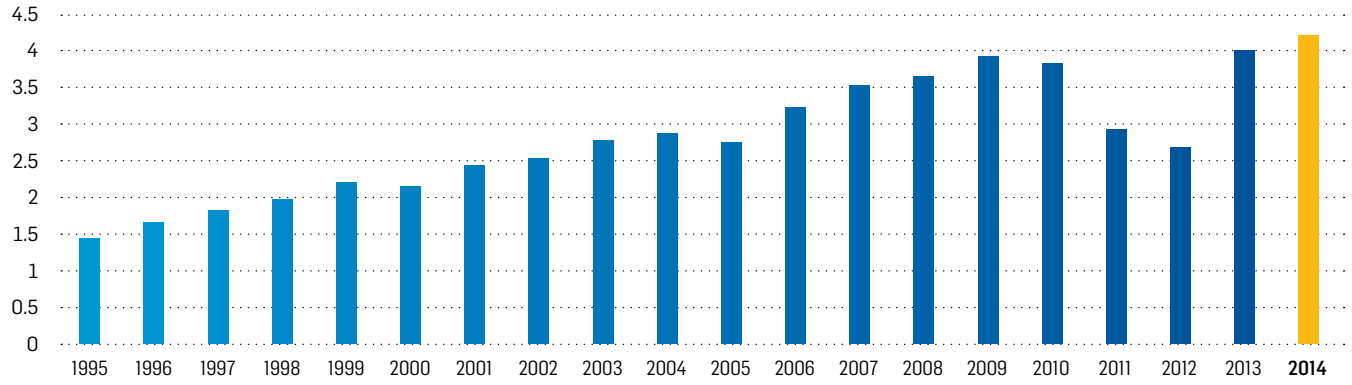


Collaborative visit to the University of Wollongong (Prof. Ning Ye, Prof. Shi Xue Dou, Prof. Maochun Hong, Prof. Judy Raper, Prof. Jiyang Wang, Prof. Will Price, Prof. Xiaolin Wang)

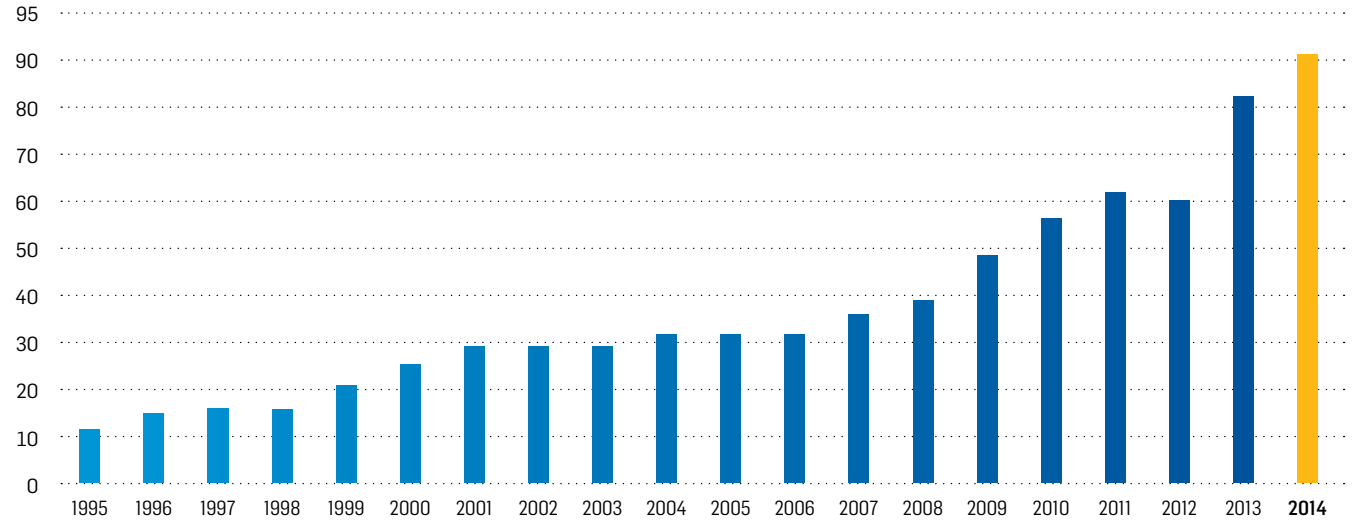
Australian Academic delegates attended 65th anniversary celebrations of People Republic of China (Prof. Yi Bing Cheng, Prof. Ai Bing Yu, Prof. Shi Xue Dou, Prof. Max Lu, Dr. Gang Wei, and Prof. Jun Wang)

ISEM AT A GLANCE

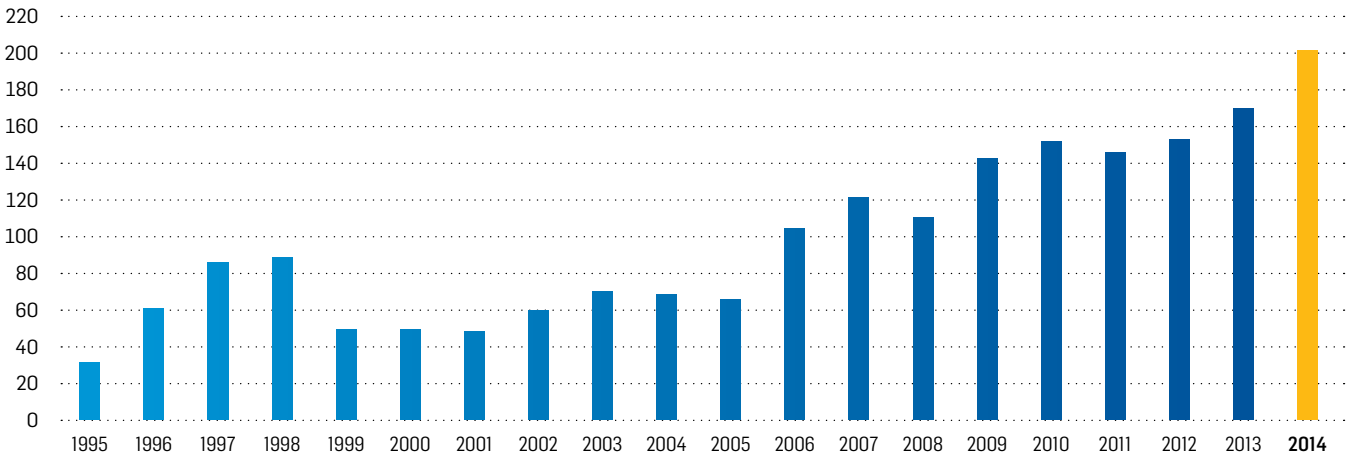
Research Funding, $M

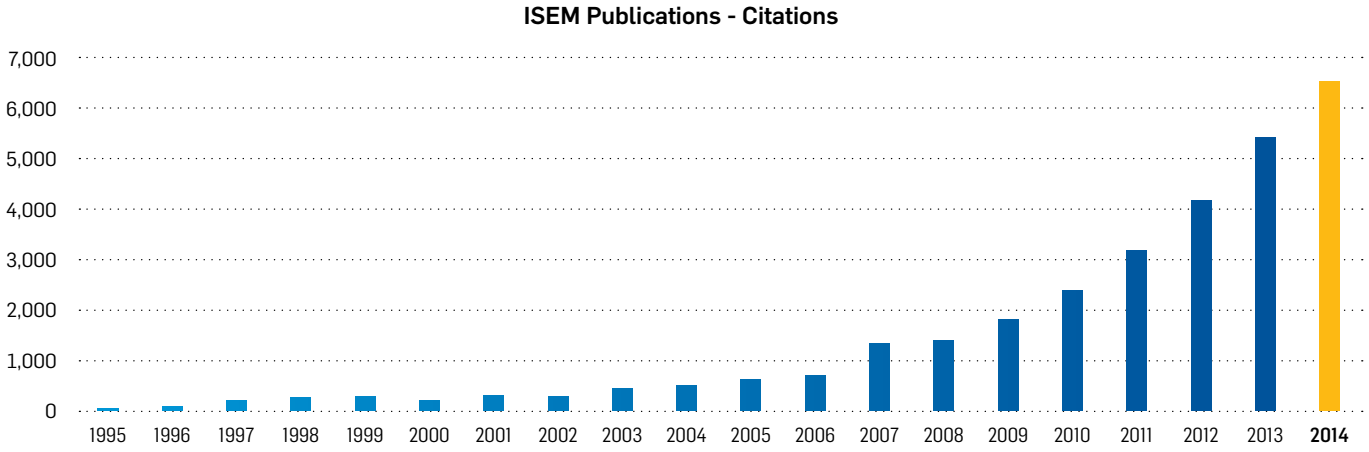


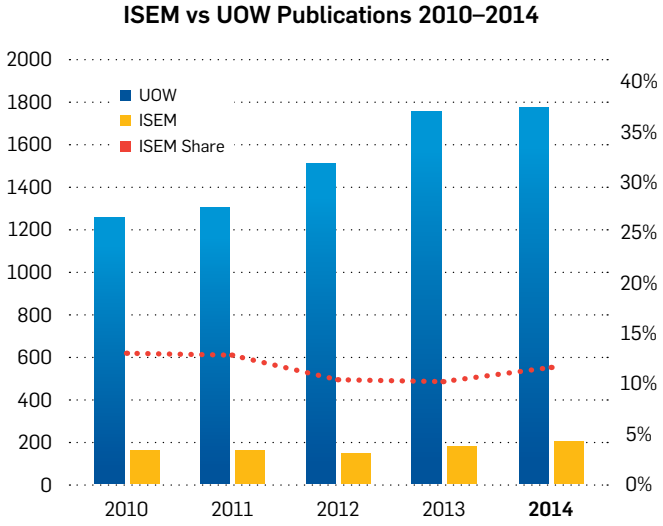
ISEM Students



ISEM Publications







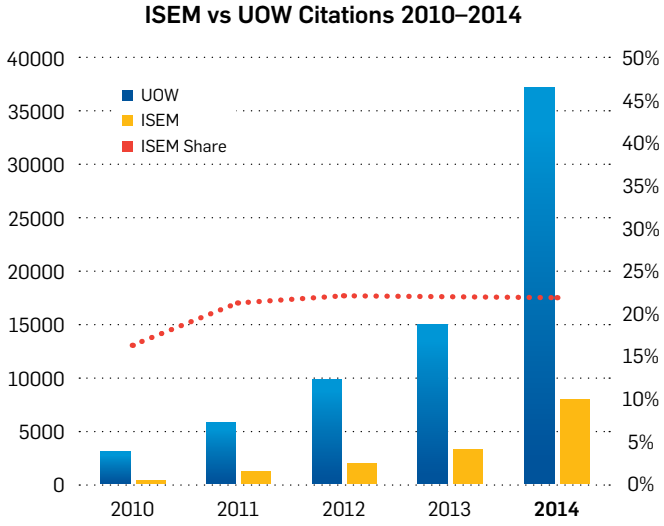


Table 1: 2014 publication citation data for ISEM and UOW (206 papers vs. 1824)

Date	Self-exclusive citation			Citation/paper		h-index		# of top 20 most cited papers	
	ISEM	UOW	% ISEM/UOW	ISEM	UOW	ISEM	UOW	ISEM	% ISEM/UOW
16/1	204	806	**25.3**	1.24	0.6	6	8	10	**50**
430/1	229	881	**26.0**	1.36	0.65	7	9	10	**50**
13/2	262	964	**27.2**	1.52	0.69	8	9	11	**55**
27/2	294	1085	**27.2**	1.66	0.75	8	9	11	**55**
20/3	363	1309	**27.7**	2.00	0.86	9	11	10	**50**
17/4	482	1662	**29.0**	2.48	1.05	11	13	11	**55**
29/5	615	2207	**27.9**	3.15	1.34	12	15	8	**40**
5/6	641	2259	**28.4**	3.28	1.37	13	15	9	**45**
20/6	695	2449	**28.4**	3.53	1.46	13	16	10	**50**

MANAGEMENT

MANAGEMENT COMMITTEE

Chairperson:	Prof. Judy Raper	Deputy Vice Chancellor (Research), UOW
	Prof. Shi Xue Dou	Director, ISEM
	Prof. Will Price	Executive Director, AIIM
	Prof. Chris Cook	Dean, Faculty of Engineering and Information Science, UOW
	Prof. Xiaolin Wang	Associate Director, ISEM
	Prof. Hua Kun Liu	Research Co-Coordinator, ISEM
	Dr. Germanas Peleckis	Assistant Director, ISEM

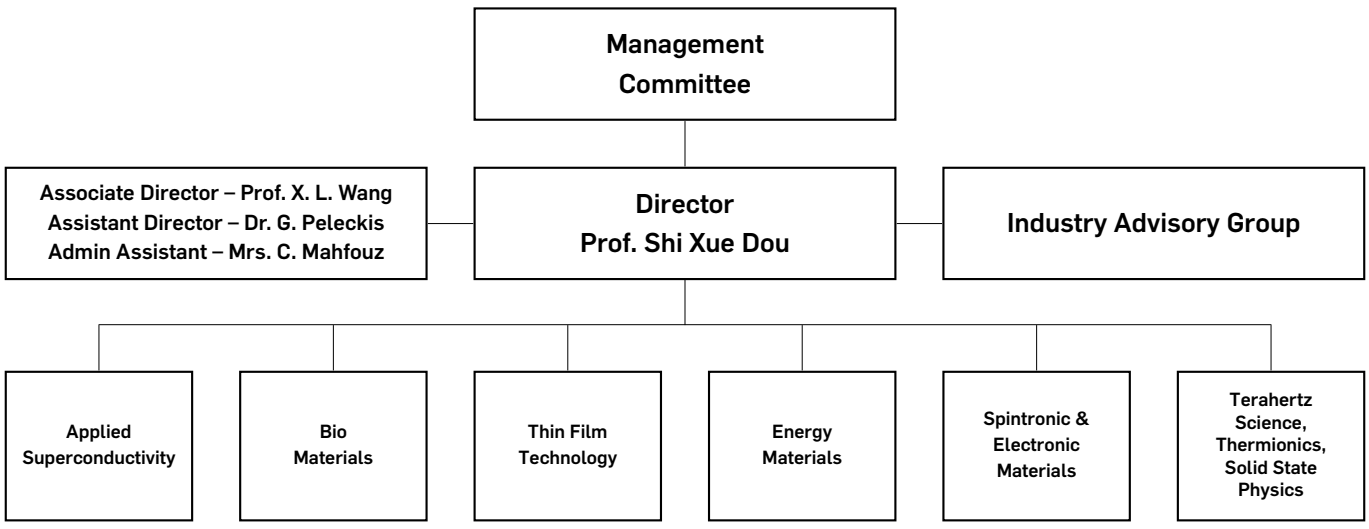
INDUSTRY ADVISORY COMMITTEE

Mr. B. Lynch	CEO, Valley International Ltd, Newcastle Australia
Mr. M. Sahari	CEO of Malaysian Automotive Institute, Malaysia
Mr. Y. C. Li	President of Hong Cheng Electric Power Co Ltd, Anshan, P.R. China
Mr. J. F. Wu	Chairman of the Board, DLG Battery Co Ltd, Shanghai, P. R. China
Mr. M. Tomsic	Managing Director, Hyper Tech Research Ltd, Ohio, USA
Dr. X. F. Gao	General Manager, DLG Co. Ltd, Shenzhen, P. R. China
Mr. T. Guina	Managing Director, Guina R&D, QLD, Australia
Mr. A. Kittel	Managing Director, Redarc Electronics, Adelaide, SA, Australia
Mr. J. Brown	Managing Director, Charge Point Australia, NSW, Australia
Dr. Y. Sharma	Chief Technological Officer, Galaxy Resources Ltd
Mr. J. Y. Xu	Chief Executive Officer, Ningbo Jian 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 Sciences
Prof P. J. Zhang	President of Bao Steel Research Institute
Prof. R. Taylor	Adjunct Professor, Queensland University of Technology, Australia
Prof. P. Robinson	Chair, Cast CRC Ltd

ORGANISATIONAL CHART



PERSONNEL

DIRECTOR
Distinguished Prof. Shi Xue Dou (PhD, DSc, FTSE)

ASSOCIATE DIRECTOR
Senior Prof. Xiaolin Wang (BSc, MSc, PhD)

ASSISTANT DIRECTOR
Dr. Germanas Peleckis (BCh, MSc, PhD)

SENIOR PROGRAM COORDINATORS
Senior Prof. Xiaolin Wang (BSc, MSc, PhD)
Senior Prof. Chao Zhang (BSc, PhD, MA, MPhil, FAIP)
Prof. Hua Kun Liu (Dipl. for PGS, FTSE)
Prof. Alexey Pan (MSc, PhD)
A/Prof. Josip Horvat (BSc, PhD, FAIP)
Dr. Kosta Konstantinov (BSc, MSc, PhD)

ARC FELLOWS
Senior Prof. Zaiping Guo (BSc, MSc, PhD, ARC QE-II Fellow)
A/Prof. Jung Ho Kim (BSc, MSc, PhD, ARC Future Fellow)
A/Prof. Zhenxiang Cheng (BSc, MSc, PhD, ARC Future Fellow)
Dr. Shulei Chou, (BSc, MSc, PhD, ARC Postdoctoral Fellow)
Dr. Xun Xu (BSc, MSc, PhD, ARC Postdoctoral Fellow (Industry))
Dr. Ziqi Sun (BSc, MSc, PhD, ARC Postdoctoral Fellow)
Dr. Sima Aminorroaya-Yamini (BSc, MSc, PhD, ARC DECRA Fellow)
Dr. Zhenguo Huang (BSc, MSc, PhD, ARC DECRA Fellow)
Dr. Md Shahriar Hossain (BSc, PhD, ARC DECRA Fellow)
Dr. Zongqing Ma (BSc, PhD, ARC DECRA Fellow)

RESEARCH STAFF
Dr. Tania Silver (BSc, PhD)
Dr. Dongqi Shi (BSC, MSc, PhD)
A/Prof. Jiazhao Wang (BSc, MSc, PhD)
Dr. Zhen Li (BSC, MSC, PhD)
Dr. Zhi Li (BSc, MSc, PhD)
Dr. Jianli Wang (BSc, MSC, PhD)
Dr. Wai Kong Yeoh (BSc, MSC, PhD)
Dr. Ting Liao (BSc, MSC, PhD)
Dr. Peng Zhang (BSc, MSC, PhD)
Dr. Yi Du (BSc, MSC, PhD)
Dr. Khay Wai See (BSc, MSC, PhD)
Dr. Dawei Su (BSc, MSC, PhD)
Dr. Soo Min Hwang (BSc, MSC, PhD)
Dr. Hany Bastawrous (BSc, MSC, PhD)
Dr. Wei Kong Pang (BSc, MSC, PhD)
Dr. Qiao Sun (BSc, MSC, PhD)

FACULTY STAFF
Prof. Chris Cook, Executive Dean of EIS (BSc, PhD, FIEAust)
Dr. Carey Freeth (MSc, PhD, MAIP)
Prof. Roger Lewis, Associate Dean of EIS (BSc (Hons), PhD, FAIP, FRMS)
Dr. En Bang Li
Senior Prof. Chao Zhang (BSc, PhD, MA, MPhil, FAIP)
A/Prof. Rodney Vickers (MSc, PhD, MAIP)
Dr. Zhixin Chen (BSc, MSC, PhD)
Dr. Yue Zhao (MSc, PhD)

VISITING STAFF
Dr. Xiaodong Guo
A/Prof. Yemin Hu
A/Prof. Boafeng Wang
A/Prof. Zhiping Lin
Dr. Xiao Lu
Dr. Jianmin Ma
Prof. Enling Li
Prof. Yuanhe Tang
Dr. Qingping Ding
A/Prof. Dongliang Tian
Dr. Nu Wang
Dr. Mislav Mustapic
A/Prof. Siti Rohana Majid
Dr. Guoxing Li
Dr. Jang-Hee Yoon
A/Prof. Zhian Zhang
Prof. Jieqiang Wang
Prof. Lifang Jiao
Dr. Zhigang Gai
Prof. Kesong Liu
Dr. Stefan Eilers
Dr. Jianping Yang

ADMINISTRATION OFFICERS
Mrs. Crystal Mahfouz
Mrs. Narelle Badger

HONORARY PROFESSORS AND FELLOWS
Prof. Edward Collings, Ohio State University
Prof. Lei Jiang, Fellow of Chinese Academy of Science, Institute of Chemistry CAS
Prof. Tom Johansen, Oslo University
Prof. Shane Kennedy, Deputy Director of Bragg Institute, ANSTO
Prof. Zhong Fan Liu, Peking Uinversity, Fellow of CAS
Prof. Kostya Ostrikov, Future Fellow (FT-3), CSIRO
Prof. Chang Ming Li, Fellow of the Royal Society of Chemistry, Southwest University

Dr. Scott Needham, Intven Ltd
Prof. Guoxiu Wang, Future Fellow (FT-3) University of Technology, Sydney
Prof. Dongyuan Zhao, Fellow of CAS, Fudan University
Prof. Yi Xie, University of Science & Technology of China, Fellow of CAS

LIST OF ISEM ARC RESEARCH FELLOWS SINCE 1994 (Total 54)

ARC AUSTRALIAN POSTDOCTORAL FELLOWS

Y. C. Guo (1998)
X. L. Wang (2002)
A. V. Pan (2004)
G. X. Wang (2003)
S. Zhong (1998)
J. Z. Wang (2003)
Z. P. Guo (2004)
Y. Zhao (2005)
D. Q. Shi (2006)
S. H. Zhou (2005)
C. H. Jiang (2007)
J. H. Kim (2008)
X. B. Yu (2008)
W. K. Yeoh (2009, Univ of Sydney)
G. Peleckis (2010)
Z. Q. Sun (2010)
X. Xu (2010)
S. L. Chou (2010)
Z. G. Huang (2012)
W. X. Li (2012)

ARC DISCOVERY EARLY CAREER RESEARCH AWARDEES

H. Liu (2013, UTS)
Z. G. Huang (2012)
S. Aminorroaya-Yamini (2013)
M. S. A. Hossain (2013)
Z. Q. Ma (2014)
Z. Q. Sun (2015)
Z. Liu (2015)

ARC AUSTRALIAN RESEARCH FELLOWS

A. V. Pan (2008)

ARC QUEEN ELIZABETH II FELLOWS

X. L. Wang (2005)
G. X. Wang (2007)
Z. P. Guo (2010)

ARC FUTURE FELLOWS

Z. X. Cheng, FT-1 (2009)
J. H. Kim, FT-1 (2011)
G. X. Wang, FT-3 (2012, UTS)
X. L. Wang, FT-3 (2013)
S. J. Zhang, FT-2 (2014)

ARC SENIOR RESEARCH FELLOWS

S. X. Dou (1993)
H. K. Liu (1994)
D. L. Shi (1995)

AUSTRALIAN PROFESSORIAL FELLOWS

H. K. Liu (1999)
S. X. Dou (2002)
H. K. Liu (2003)
H. K. Liu (2006)
S. X. Dou (2007)

ARC INTERNATIONAL RESEARCH FELLOWSHIPS

V. Roussec (France, 1997)
T. Hughes (UK, 1999)
J. H. Ahn (S. Korea, 2000)
E. H. Brandt (Germany, 2001)
J. Y. Lee (S. Korea, 2001)
P. Majevski (Germany, 2002)
J. M. Yoo (S. Korea, 2006)
F. Liu (USA, 2008)
T. Johansen (Norway, 2009)
G. Hong (Korea, 2009)

Meeting with Hong Cheng Electric Power Ltd (Mr. Zhihong Ma, Mr. Yong Cheng Li, Prof. Shi Xue Dou, Prof. Hua Kun Liu)

Graduation ceremony - the award of the Honorary Doctor to Prof. Jing Hai Li (Deputy Chancellor Dr Stephen Anderson OAM, Professor Shi Xue Dou, Deputy Vice-Chancellor (Research) Professor Judy Raper, Vice President of the Chinese Academy of Sciences Professor Jing Hai Li, and Vice-Chancellor Professor Paul Wellings CBE)

POSTGRADUATE STUDENTS

CURRENT

PhD	Thesis Title	Supervisors
Mr. Amar Al-Keisy	Hydrogen production by the photoelectrolysis of water using nanocrystalline semiconductors in the form of electrodes, colloids, powders and thin films	Dr. Yi Du, Prof. Shi Xue Dou
Mr. Mustafa Al-Qurainy	Synthesis, study structural, and electrical properties of doped BaCaCuO based thin film superconductors	Prof. Alexey Pan
Ms. Shaymaa Hadi Khudhair Al-Rubaye	Preparation of new ceramic-matrix nanocomposite and studying its properties	A/Prof. Zhenxiang Cheng, Prof. Shi Xue Dou
Ms. Kathrin Bogusz	Engineering and study of multifunctional biocompatible nanoceramics	Dr. Kosta Konstantinov, Prof. Hua Kun Liu, Dr. Moeava Tehei
Mr. Colin Bleasdale	Electromagnetic properties of superconducting films and multilayers	Prof. Roger Lewis, Prof. Chao Zhang
Mr. Dean Cardillo	Multifunctional metal oxide nanoparticles for biomedical applications	Dr. Kosta Konstantinov
Mr. Qinjun Chen	Electrical and optical properties of functional thermoelectrical materials	Prof. Xiaolin Wang, Prof. Chao Zhang, Prof. Roger Lewis
Ms. Azrin Chowdhury	Synthesis of nanoceramics for supercapacitors	Dr. David Wexler, Dr. Kosta Konstantinov
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
Ms. Xinqi Chen	Engineer thermoelectric nanostructures for energy conversion	Dr. Zhen Li, Prof. Shi Xue Dou
Mr. Yuhai Dou	Nano materials for energy storage	Dr Ziqi Sun, Prof. Shi Xue Dou
Mr. Van Huan Duong	Adaptive and robust algorithm for lithium-ion's states estimation for application in electric vehicles	Dr. Khay Wai See, Prof. Shi Xue Dou
Mr. Muhamad Faiz	Nanomaterials for biosensors	Prof. Shi Xue Dou, Dr. Jianli Wang
Mr. Chunsheng Fang	Functional nano materials for energy storage and conversion	A/Prof. Zhenxiang Cheng
Mr. Sergey Fedoseev	Investigation of superconducting thin films and multilayered structures for electronic applications	Prof. Alexey Pan, Prof. Shi Xue Dou
Mr. Haifeng Feng	Exploration of novel nanomaterials for visible light photocatalysis	Dr. Yi Du, Prof. Shi Xue Dou, Dr. Xun Xu
Mr. Xiao Feng	Synthesis of high quality BN graphene	Dr. Zhenguo Huang
Mr. Xavier Reales Ferreres	Efficient energy recovery in light and heavy vehicles	Dr. Sima Aminorroaya-Yamini, Prof. Shi Xue Dou
Ms. Xuanwen Gao	Development of inorganic-conducting polymer composites and ionic liquid-based electrolytes for rechargeable lithium batteries	A/Prof. Jiazhao Wang, Prof. Hua Kun Liu
Mr. Chao Han	Advanced nanostructured metal chalcogenide based thermoelectric materials	Dr. Zhen Li, Prof. Shi Xue Dou
Mr. Fang Hong	Spin manipulation by electrical field	Prof. Xiaolin Wang, A/Prof. Zhenxiang Cheng
Ms. Gao Hong	Synthesis and electrochemical properties of WO_3 nanocomposite	Prof. Zaiping Guo, A/Prof. Jun Chen
Mr. Jian Hong	Energy storage materials	Dr. Zhenguo Huang, Prof. Hua Kun Liu, Prof. Zaiping Guo
Mr. Eoin Hodge	Design, build and test fault current limiter using MgB_2 coils	Dr. Jeff Moscrop, Prof. Shi Xue Dou, Dr. Frank Darmann
Mr. Mohammad Ihsan	Li-based polymer electrolyte for solid state battery	Prof. Hua Kun Liu, Prof. Zaiping Guo
Mr. Monirul Islam	High performance supercapacitors	Dr. Kosta Konstantinov, Prof. Shi Xue Dou
Mr. Sheik Md. Kazi Nazrul Islam	Treatment of waste water: photocatalytic efficiency of semiconductor materials to decompose dye ingredients	Prof. Xiaolin Wang
Mr. Abolfazl Jalalian	Lead-free Piezoelectric materials	Prof. Shi Xue Dou, Prof. Xiaolin Wang
Mr. Majharul Khan	Synthesis and characterisation of BN	Prof. Hua Kun Liu, Dr. Zhenguo Huang

PhD	Thesis Title	Supervisors
Mr. Tomas Katkus	Thermoelectric modules for high temperature power generation	Dr. Germanas Peleckis, Prof. Xiaolin Wang
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 of new materials for Li-S batteries	A/Prof. Jiazhao Wang, Prof. Shi Xue Dou
Mr. Jonathan Knott	Electromagnetic design of MgB_2 coil for fault current limiter	Prof. Shi Xue Dou, Dr. Jeff Moscrop, A/ Prof. Josip Horvat
Mr. Philip Lavers	Electronic structure of perovskite and related materials	Prof. Shi Xue Dou
Mrs. Xin Liang	Study on sulfur cathode materials for high performance lithium/sulfur batteries	Dr. Jiazhao Wang, Dr. Kosta Konstantinov, Prof. Hua kun Liu
Ms. Weijie Li	Nano materials for Li ion battery	Dr. Shulei Chou, Prof. Shi Xue Dou, A/Prof. Jung Ho Kim
Ms. Sha Li	Bio-compatible materials for batteries	Prof. Hua Kun Liu, Prof. Zaiping Guo, Prof. Gordon Wallace
Ms. Dan Li	Three-dimensional porous electrode materials for lithium ion batteries	Prof. Zaiping Guo, Prof. Hua Kun Liu
Ms. Jianjian Lin	Nanomaterials for catalyst	A/Prof. Jung Ho Kim, Dr. Zi Qi Sun, Prof. Shi Xue Dou
Mr. Kai Chin Lim	Battery management and packaging system for application in electric vehicles	Dr. KhayWai See, Prof. Shi Xue Dou
Ms. Lili Liu	Development of new materials for Li-air batteries	A/Prof. Jiazhao Wang, Prof. Hua Kun Liu, A/Prof. Jun Chen
Ms. Qiannan Liu	Development of porous materials for applications	Dr. Ziqi Sun, Prof. Shi Xue Dou
Mr. Wenbin Luo	Advanced materials for lithium-air batteries	Prof. Hua Kun Liu, Dr. Shulei Chou
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	A/Prof. Jung Ho Kim, Prof. Shi Xue Dou, Dr. Shariar Hossain
Ms. Faizun Nesa	Investigating the change in structural, magnetic and electric properties of tin doped metal oxide	Prof. Shi Xue Dou, Prof. Shane Kennedy, Dr. Jianli Wang
Mr. Yuede Pan	Nanostructured electrode materials for lithium ion batteries	Prof. Shi Xue Dou, Dr. Shulei Chou
Mr. Dipakkumar Jayantibhai Patel	Design and fabrication of prototype solid nitrogen cooled MgB_2 based persistent magnet for MRI application	A/Prof. Jung Ho Kim, Dr. Shariar Hossain, Dr. KhayWai See
Ms. Elise Pogson	The medical applications of terahertz	Prof. Roger Lewis, Dr. Peter Metcalfe
Mr. Spencer Porter	Perovskite titanium and niobium oxide nitrides: synthesis and characterisation	Dr. Zhenguo Huang, Prof. Shi Xue Dou
Mr. Hong Qing	Materials for Li-S battery	Prof. Zaiping Guo
Ms. Ranjusha Rajagopalan	Cathode electrode materials for Li ion battery	Prof. Hua Kun Liu, Prof. Shi Xue Dou
Mr. Boyang Ruan	Exploring boron-containing hydrides for hydrogen storage	A/Prof. Jiazhao Wang, Prof. Hua Kun Liu, Dr. Shulei Chou
Mr. Chandrasekar Mayandi Subramaniyam	Development of advanced electrodes and electrolytes for lithium-ion battery applications	Prof. Hua Kun Liu, Prof. Shi Xue Dou
Mr. Joao Rafael Lourenco Santos	Efficient energy recovery in light and heavy vehicles	Dr. Sima Aminorroaya-Yamini, Prof. Shi Xue Dou, Dr. Germanas Peleckis
Mr. Julian Steele	Optical characterisation of semiconductors	Prof. Roger Lewis, A/Prof. Josip Horvat
Mr. Babar Shabir	Design of new superconductors	Prof. Xiaolin Wang, Prof. Shi Xue Dou
Ms. Yi Shi	Graphene composite materials for lithium ion batteries	A/Prof. Jiazhao Wang, Prof. Hua Kun Liu, A/Prof. Huijun Li
Ms. Asyd Tawfiq	Dielectric response of graphene under electromagnetic radiation.	A/Prof. Jiazhao Wang, Prof. Chao Zhang
Mr. Zhixin Tai	Fields of lithium ion batteries for electrical vehicles	Prof. Hua Kun Liu, Prof. Shi Xue Dou
Ms. Li Wang	Design and development of p-block visible light photocatalysis	Dr. Yi Du, Prof. Shi Xue Dou, Dr. Xun Xu
Ms. Yunxiao Wang	Nanomaterials for lithium ion batteries	Prof. Shi Xue Dou, Dr. Shulei Chou, Prof. Hua Kun Liu

PhD	Thesis Title	Supervisors
Mr. Jun Wang	All solid state lithium ion batteries	Prof. Hua Kun Liu, A/Prof. Jiazhao Wang
Mr. Hongqiang Wang	Three-dimensional nanostructures as electrode materials for lithium ion batteries	Prof. Zaiping Guo
Mr. Frederick Wells	Analysis of the magnetic properties of superconductors by magneto-optical imaging and video	Prof. Alexey Pan
Mr. Feng Xiao	Synthesis of high quality BN graphene	Dr. Zhenguo Huang, A/Prof. Huijun Li
Mr. Feixiang Xiang	Energy materials	Prof. Xiaolin Wang, Prof. Shi Xue Dou
Mr. Jinyan Xiong	Advanced nanostructures for energy application	Dr. Zhen Li, Prof. Shi Xue Dou
Ms. Zheyin Yu	The design and synthesis of new cathode materials for high performance batteries	A/Prof. Zhenxiang Cheng, Prof. Xiaolin Wang, Prof. Shi Xue Dou
Mr. Zhenwei Yu	Development of thermoelectric composites for high temperature power generation	Prof. Xiaolin Wang
Mr. Frank Fei Yun	Electronic band structures and gas sensing properties of single layer materials using first principles calculation and experimental methods	Prof. Xiaolin Wang
Mr. Lei Zhang	Novel Si based composite materials as anodes for Li-ion batteries	Prof. Kua Kun Liu, Prof. Shi Xue Dou
Ms. Lijuan Zhang	High-performance thermoelectric materials for waste heat recovery	Dr. Zhen Li, Prof. Shi Xue Dou, Dr. Jianli Wang
Mr. Zidong Zhang	Metal-ceramic composites	Prof. Xiaolin Wang
Mr. Zhijia Zhang	Development of advanced materials for rechargeable lithium batteries	A/Prof. Jiazhao Wang, Dr. Shulei Chou, A/Prof. Huijun Li
Ms. Lanling Zhao	Study on growth and properties of $FeSe_x$ and related superconductive crystals	Prof. Xiaolin Wang, Dr. Zhenxiang Cheng
Mr. Yang Zheng	Selectivity facet exposed transition metal oxide nanostructures as advanced materials for energy storage applications	Prof. Zaiping Guo
Mr TengFei Zhou	Na-ion battery	Prof. Zaiping Guo
Mr. Chengbo Zhu	Spin wave and spin density wave in magnetic materials	Prof. Xiaolin Wang, Prof. Shi Xue Dou
Mr. Jincheng Zhuang	Low-temperature scanning tunneling microscopy study on Fe-based superconductors	Prof. Shi Xue Dou, Dr. Yi Du
Mr. Shaohua Zhang	High-performance oxide-based thermoelectric nano-materials	Dr. Zhen Li, Prof. Shi Xue Dou

Master's	Thesis Title	Supervisors
Mr. Shaon Barua	Computational modeling of magnesium diboride based superconducting generator for wind turbine	Dr. Shariar Hossain
Mr. Yuchen Chen	Study of new class of materials: topological insulators	Prof. Xiaolin Wang
Mr. Jonathan George	Study of vortex dynamics	Prof. Alexey Pan
Ms. Israa Mefter Hashim	Corrosion evaluation of Al-based alloys	Prof. Zaiping Guo
Mr. Nai-Sheng Hsu	Drug delivery multifunctional systems based on nanoceramic particles for cancer treatment	Dr. Kosta Konstantinov
Mr. Kan Huang	One-dimensional anode materials for sodium ion batteries	Prof. Zaiping Guo
Mr. David Oakden	Magnetotransport properties of superlattices and multilayers	Prof. Alexey Pan
Mr. Vaughan Patterson	Band gap study of lead chalcogenide alloys	Dr. Sima Aminorroaya-Yamini
Mr. Matthew Sale	Large throughput analysis of crystal structures for identification of promising Li-ion battery materials.	A/Prof. Jiazhao Wang, Dr. Shulei Chou, Dr. Maxim Avdeev
Ms. Yangfei Xu	Silicon-based anode materials for Li-ion batteries	Dr. Shulei Chou, Dr. David Wexler
Ms. Qiuran Yang	Nano/composite anode materials for Li-ion batteries	Dr. Shulei Chou

COMPLETIONS

PhD Graduates

Name	PhD Thesis Title	Awarded	Position	Appointed
S.H. Aboutalebi	Processing graphene oxide and carbon nanotubes: routes to self-assembly of designed architectures for energy storage applications	2014		
Y.S. Ang	Many-body effect in massless Dirac fermions	2014		
D. Beaven	FPGA architecture for numerical computations	2014		
A. Chidembo	Advanced graphene-metal oxide nanostructured composites for supercapacitors	2014	Research Fellow at IPRI	2014
A. Chowdhury	Synthesis of nano-ceramics for supercapacitors	2014		
L. Feng	Simulation of crystal, electronic and magnetic structures, and gas adsorption of two dimensional materials	2014		
A. Jalalian	Lead free piezoelectric materials	2014		
J.G. Kim	Ti-based nanostructured materials for lithium-ion batteries	2014	Postdoc at KETI	2014
L.M. Lepodise	THz spectroscopic studies of materials using the FTIR technique: Experiment and simulation	2014	lecturer at Botswana International University of Science and Technology	2014
L. Li	Nanostructured anode materials with high capacity for rechargeable energy storage	2014	Lecturer at Nanjing University of Technology	
V. Malgras	Lead sulfide colloidal quantum dots: passivation and optoelectronic characterisation for photovoltaic device applications	2014	Postdoc fellow at NIMS	2014
M. Shahbazi	Study of iron pnictide superconductors	2014		
J. Xu	Advanced materials for lithium-ion batteries and sodium-ion batteries	2014	Associate fellow of Case-western reserve University	2014
Z. Yue	Transport properties of topological insulators Sb_2Te_3 and Bi_2Te_3 crystals and films	2014	Postdoc fellow at Swinburne University of Technology	2014
C. Zhong	Graphene materials for Li-ion batteries	2014	Staff at SETRO	2014
F. Bijarbooneh	Improved nano-structures in hydrolysis-derived titanium dioxide particles for dye sensitized solar cell applications	2013	Research Fellow, IPRI, UOW	
K. S. De Silva	Improving superconducting properties of MgB_2 by chemical doping using graphene as C source	2013	Associate fellow at UTS	2013
F. Bijarbooneh	Improved nano-structures in hydrolysis-derived titanium dioxide particles for dye sensitized solar cell applications	2013	Research Fellow, IPRI, UOW	2013
K. S. De Silva	Improving superconducting properties of MgB_2 by chemical doping using graphene as C source	2013	Research Fellow, University of Technology Sydney	2013
Q. Li	Research on superconducting films and buffer layers for electronic applications	2013	Associate Fellow, ISEM, UOW	2013
L. Lu	Electrolytes for rechargeable batteries	2013		
M. Mustapic	Enhancement of MgB_2 superconductor by magnetic nanoparticle doping	2013	Visiting Fellow, ISEM, UOW	2013
L. Noerochim	Improving the capacity and safety of lithium ion battery	2013	Senior Lecturer	
K. Radhanpura	Semiconductor materials and structures for the efficient generation of terahertz radiation	2013	Research Fellow, UOW	2013
M. Salari	Application of nanostructural titania in supercapacitors	2013	Research Fellow, IPRI, UOW	2013

Name	PhD Thesis Title	Awarded	Position	Appointed
P. Shamba	Novel magnetocaloric materials for room temperature magnetic refrigeration	2013		
K. H. Seng	Advanced nanomaterials for lithium ion batteries	2013	Auto CRC Research Fellow, ISEM, UOW	2013
			Real estate manager, Malaysia	2014
C. Zhong	Three-dimensional nano-materials for lithium-ion batteries	2013	Senior Manager	2013
C.F. Zhang	Advanced electrode materials for lithium ion batteries	2013	Prof at He Fei University	2015
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. Maeda	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

Name	PhD Thesis Title	Awarded	Position	Appointed
L. Wang	Chemical solution deposition for YBCO superconducting films and Sm_2O_3 buffer layers on single crystal and biaxially textured metallic substrates	2011	Senior Engineer at Siemens in Shanghai	2012
P. Zhang	Synthesis and characterization of nanostructured electrodes for lithium-ion batteries	2011	Research fellow at Griffith University	2012
S. L. Chou	Nanostructured / composite materials for rechargeable Li-ion battery and supercapacitor	2010	ARC Postdoctoral Fellow, ISEM, University of Wollongong	2010
W. X. Li	Carbohydrate doping effect on the superconductivities and microstructure of MgB_2 superconductor	2010	Eastern Scholar Professor at Shanghai University	2010
			Research Fellow, University of Western Sydney	2012
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
			Research Fellow, ISEM, University of Wollongong	2013
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	2009
			Humboldt Research Fellow, Max-Planck Institute, Germany	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
			Assistant Professor, Department of Mechanical Engineering, Shiraz Faculty of Technical Engineering, University of Technical and Vocational, Shiraz, Iran.	2013
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	2008
			Patent Officer, Australian Patent Office, Canberra	2013

Name	PhD Thesis Title	Awarded	Position	Appointed
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	2008
S. H. Ng	Nanostructured materials for electrodes in lithium-ion batteries	2008	Postdoctoral Fellow, Electrochemistry Laboratory, Paul Scherrer Institute, Switzerland	2008
			Technical Customer Support Manager, Asia Pacific, Changzhou Timcal Graphite Corp. Ltd, Shanghai, China	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	2008
			UOW VC Fellow, University of Wollongong	2011
			ARC DECRA Fellow, University of Wollongong	2012
S. A. Needham	Development of advanced electrode materials for lithium-ion batteries	2007	Commercialization Manager, University of Wollongong	2007
			Commercialization Manager, Intven Ltd., Australia	2009
G. Peleckis	Studies on diluted oxide magnetic semiconductors for spin electronic applications	2007	Research Fellow, ISEM, University of Wollongong	2007
			ARC APD Fellow, ISEM, University of Wollongong	2010
			Assistant Director, ISEM, University of Wollongong	2010
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	Associate Research Fellow, ISEM, University of Wollongong	2006
S. H. Pilehrood	Electronic properties of semiconductor nanostructures under intense terahertz radiation	2006		
W. K. Yeoh	Control of nanostructure for enhancing superconductor performance through chemical doping	2006	Research Fellow, Cambridge University, U.K.	2007
Y. Zhao	Fabrication and characterization of superconducting PLD MgB_2 thin films	2006	APD Fellow ISEM, University of Wollongong	2006
			Lecturer, University of Wollongong	2008

Name	PhD Thesis Title	Awarded	Position	Appointed
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
			Physics instructor at Cape Breton University, Nova Scotia, Canada	2013
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	2004
			Research Staff, ANSTO	2006
B. Lough	Investigations into thermionic cooling for domestic refrigeration	2004	Quantitative Analyst, ABN AMRO, UK	2005
D. Milliken	Uranium doping of silver sheathed bismuth-strontium-calcium-copper-oxide superconducting tapes for increased critical current density through enhanced flux pinning	2004	Knowledge Transfer Partnership Associate, University of Leeds and AVX Ltd	2005
S. Soltanian	Development of superconducting magnesium diboride conductors	2004	Pro-Vice Chancellor, Kurdistan University, Iran	2005
C. Wang	Cathodic materials for nickel-metal hydride batteries	2004	Research Fellow, IPRI, University of Wollongong	2004
S. H. Zhou	Processing and characterization of MgB_2 superconductors	2004	APD Fellow, ISEM, University of Wollongong	2005
			Research Associate, ISEM, University of Wollongong	2009
Z. P. Guo	Investigation on cathode materials for lithium-ion batteries	2003	APD Fellow, ISEM, University of Wollongong	2003
			Lecturer, University of Wollongong	2007
			QE II Fellow, ISEM, University of Wollongong	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	2002
			APD Fellow, ISEM, University of Wollongong	2007
			Research Fellow, ISEM, University of Wollongong	2010
J. Wang	Development of a novel plate making processing technique for manufacturing valve-regulated lead-acid batteries	2003	Research Fellow, IPRI, University of Wollongong	2003
			APD Fellow, ISEM, University of Wollongong	2004
			Research Fellow, ISEM	2007
R. Baker	Zeeman and piezo-spectroscopy of antimony and aluminium in germanium	2001	Professional Officer, University of Wollongong	2003
X. K. Fu	Fabrication and characterization of Bi-2223 current lead	2002	Research Fellow, Texas A&M University, USA	2002
			Research Fellow, University of Waterloo, Canada	2005

Name	PhD Thesis Title	Awarded	Position	Appointed
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	2001
			ARC QEII Fellow, ISEM, University of Wollongong	2006
			Professor, University of Technology, Sydney	2010
			ARC Future Fellow Level 3, University of Technology, Sydney	2012
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	2000
			ARC APD Fellow, ISEM, University of Wollongong	2002
			ARC QEII Fellow, ISEM, UOW	2005
			Professor, ISEM, University of Wollongong	2008
			ARC Future Fellow Level 3, ISEM, University of Wollongong	2013
R. Zeng	Processing and characterization of Bi-2223/Ag superconducting tapes	2000	Research Fellow, ISEM, University of Wollongong	2000
J. Chen	High energy storage material for rechargeable nickel-metal hydride batteries	1999	NEDO Fellow, Osaka National Research Institute	1999
			Professor, Nankai University, PR China	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	1997
			Electrochemist, Energizer Co, USA	2000
R. J. Heron	Far-infrared studies of semiconductors in large magnetic fields	1998	Postdoctoral Fellow, SUNY, Buffalo, USA	1997
			Research Fellow, Janis Research Company Inc., USA	2000
M. Ionescu	Growth and characterization of Bi-2212 crystals and improvement of Bi-2212/Ag superconducting tapes	1998	Assistant Director, ISEM, University of Wollongong	1997
			Senior Research Scientist, ANSTO	2004
J. X. Jin	$(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10+x}$/Ag high T_c superconductors and their applications in an electrical fault current limiter and an electronic high voltage generator	1998	Research Fellow, ISEM, University of Wollongong	1997

Name	PhD Thesis Title	Awarded	Position	Appointed
			ARC, APD Fellow, ISEM, University of Wollongong	2000
			Professor, University of Electronic Engineering, PR China	2003
M. Lerch	Optical & electrical studies of resonant tunnelling heterostructure	1998	Lecturer, School of Engineering Physics, University of Wollongong	2006
S. Stewart	Thermodynamic and dielectric properties in modulated two-dimensional electronic systems	1998	ARC APD Fellow	1998
			Teacher	1999
			Associate Professor	2002
W. G. Wang	Fabrication and improvement of silver sheathed $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10}$ tapes By powder-in-tube technique	1998	R&D Manager, Nordic Superconductor Tech. Denmark	1997
			Associate Director, Ningbo Materials Institute, Chinese Academy of Sciences, PR China	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	1997
			CEO, Leadcel Dynamic Energy Ltd, PR China	2002
			CEO, Guangzhou Delong Energy Tech Ltd., PR China	2003
			Research Fellow, ISEM, University of Wollongong	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	1997
			Professor, Chemistry Department, University of Western Ontario	2002
N. Vo	Design and characterization of HTS coils	1997	Research Fellow, Los Alamos Nat. Lab, USA	1998
			Research Staff, Intermagnetics General Co., USA	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	2000
			Ass. Research Professor, Tohoku University, Sendai, Japan	1997
			Ass. Professor, University of Waterloo, Canada	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	1997
			Research Scientist, Argonne National Lab., USA	1999

Name	PhD Thesis Title	Awarded	Position	Appointed
			Senior Engineer, Lucent, USA	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	1997
			ARC Postdoctoral Fellow, ISEM, University of Wollongong	1998
			Senior IT Specialist, ITS, University of Wollongong	2002
A. Bourdillion	Microstructure, phase characterization and texture processing of HTS	1992	Senior Engineer, Hewlett Packard, Singapore	1993
			Hewlett Packard, USA	2000
M. Apperley	The fabrication of high T_c superconductor wire	1992	Chief Technologist, Australian Superconductors	1993
			Business Development Manager, University of Sydney	2004

Masters Course Graduates

Masters Name	Thesis Title	Awarded	Position	Appointed
F. Yun	Energy Materials	2014		
R. Hargreaves	Ultrafast demagnetization as a terahertz source	2014		
H. Baiej	Superconducting thin films	2013		
A. Chowdhury	Synthesis of nanoceramics for supercapacitors	2013	PhD Candidate, ISEM, University of Wollongong	2013
X. Wang	Study of energy materials	2013		
I. Sultana	Biodegradable 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, University of Wollongong	2011
C. Zhong	Development of new electrode materials for lithium ion batteries	2010	PhD Candidate, ISEM, University of Wollongong	2011
L. Lu	Enhancement of connectivity and flux pinning in MgB_2 superconducting bulk and wires	2009	PhD Candidate, ISEM, University of Wollongong	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, Australian National University	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	2000
			Research Fellow, Argonne National Lab., USA	2003
J. Z. Wang	Investigations on anode materials for rechargeable lithium-ion batteries	1999	PhD Candidate, ISEM, University of Wollongong	2000

Masters Name	Thesis Title	Awarded	Position	Appointed
			Research Fellow, ISEM, University of Wollongong	2003
F. Chen	The influence of selenium on lead-calcium-tin-aluminium	1998	PhD Candidate, University of Sydney, Australia	1999
G. Yang	Effect of element substitution on superconductivity	1997	Research Fellow, University of Melbourne	2000
N. Zahir	A new method for production and study of electrical properties of carbon foam	1996	PhD Candidate, Queensland University	1997
J. X. Jin	$(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10+x}$/Ag high T_c superconductors and their applications in an electrical fault current limiter and an electronic high voltage generator	1994	PhD Candidate, ISEM, University of Wollongong	1997
			ARC APD Fellow, ISEM, University of Wollongong	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
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ARC PROJECT PROGRESS REPORTS

DISCOVERY PROJECTS

PROJECT ID: DP120100095

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

Project Title: Nanostructure engineered iron-based pnictide superconductors

Observation of single-phased double superconducting domes in the $FeSe_xTe_{1-x}$ thin films: A complete phase diagram and its corresponding physical properties are essential prerequisites to understand the underlying mechanism of iron-based superconductivity. For the structurally simplest 11 (FeSeTe) system, earlier attempts using bulk samples have not been able to do so due to the fabrication difficulties. Here, thin $FeSe_xTe_{1-x}$ films with the Se content covering the full range ($0 \le x \le 1$) were fabricated by using pulsed laser deposition method. Crystal structure analysis shows that all films retain the tetragonal structure in room temperature. Significantly, the highest superconducting transition temperature (T_C = 20 K) occurs in the newly discovered domain, i.e. $0.6 \le x \le 0.8$. The single-phased superconducting dome for the full Se doping range is the first of its kind in iron chalcogenide superconductors. Our results present a new avenue to explore novel physics as well as to optimize superconductors.

Enhancement of transition temperature in $FeSe_{0.5}Te_{0.5}$ thin film via iron vacancies: The influence of Fe vacancy on superconductivity is still unclear, because available literature data on Fe deficiency is contradictory from study to study. The effects of iron deficiency in epitaxial $Fe_xSe_{0.5}Te_{0.5}$ thin films ($0.8 \le x \le 1$) on superconductivity and electronic properties were studied. A significant enhancement of the superconducting transition temperature (T_C) up to 21 K was observed in the most Fe deficient film (x = 0.8). Based on the observed and simulated structural variation results, we proposed that there is a high possibility that Fe vacancy phase can be formed in the $Fe_xSe_{0.5}Te_{0.5}$ films. The enhancement of TC was basically due to the lattice strain effect induced by the coexistence of different Fe vacancy orders, which was evident from the broad transition temperature and out-of-plane disorder. Fe vacancy phase altered the charge carrier population by introducing electron charge carriers, while Fe deficient film showed more metallic behavior than the defect-free film. Our study not only provided important evidence for the critical role of Fe in the superconductivity, but also showed that Fe vacancy ordered film could be formed by tuning the Fe content.

Vortex dynamics of ion irradiated iron based superconductor: We investigated the influence of defects induced by light-ion (C^{4+})-irradiation on transition temperature, T_c, the irreversibility field, H_{irr}, the upper critical field, H_{c2}, and the pinning potential, Uo, in $BaFe_{1.9}Ni_{0.1}As_2$ superconducting single crystal, and resolved the vortex phase diagram for the sample before and after irradiation. Our results suggested that light C^{4+} ion irradiation is an effective method for the enhancement of Jc in Fe superconductors compared to heavy ion irradiation and neutron irradiation. In addition, the glass transition that is introduced based on a modified model for the vortex-glass transition can be applied to both the pristine and C^{4+}-irradiated $BaFe_{1.9}Ni_{0.1}As_2$ single crystal. For temperatures below the superconducting transition temperature, a scaling of all measured resistivity $\rho(B,T)$ and of the pinning potential U0(B,T) in magnetic fields up to 13 T with the critical exponents = 2.6 ± 0.41 was obtained.

Publications:

1. J. C. Zhuang, W. K. Yeoh, X. Y. Cui, J. H. Kim, D. Q. Shi, Z. X. Shi, S. P. Ringer, X. L. Wang, and S. X. Dou, "Enhancement of transition temperature in $Fe_xSe_{0.5}Te_{0.5}$ film via iron vacancies", *Applied Physics Letters* 104, 262601 (2014)

2. Q. H. Chen, D. Q. Shi, W. X. Li, B. Y. Zhu, V. V. Moshchalkov, and S. X. Dou, "Configuration-induced vortex motion in type-II superconducting films with periodic magnetic dot arrays", *Superconductor Science & Technology* 27, 65004 (2014)

3. S. R. Ghorbani, G. Farshidnia, X. L. Wang, S. X. Dou, "Flux pinning mechanism in SiC and nano-C doped MgB2: evidence for transformation from delta T-c to delta l pinning", *Superconductor Science & Technology*, 27, 12; (2014)

4. H. S. Kim, S. S. Oh, H. S. Ha, D. Youm, S. H. Moon, J. H. Kim, S. X. Dou, Y. U. Heo, S. H. Wee, and A. Goyal, "Ultra-high performance, high-temperature superconducting wires via cost-effective, scalable, co-evaporation process", *Scientific Reports* 4, 4744 (2014)

PROJECT ID: DP130102699

CIs/PIs: Z. Li, G. M. Lu

Project Title: Nanostructure engineering of semiconductor nanowires for high performance thermoelectrics

This project aims to develop high-performance thermoelectric nanomaterials through advanced fabrication and engineering of their dimension, morphology, composition and crystal structure. It has been well progressing. A comprehensive literature review on state-of-the-art in thermoelectric materials has been completed, which was highlighted and selected as journal front cover (*Chin. Sci. Bull.*, 2014, *59*, 2073). A number of potential thermoelectric materials was selected, especially copper chalcogenides because they show unique phonon-liquid electron-crystal properties. Various copper chalcogenide nanostructures were prepared by our novel methods (two patent applications have been submitted and under processing). Firstly, uniform surfactant-free copper selenide ($Cu_{2-x}Se$) nanowires were prepared via an aqueous

route. The effects of reaction parameters on the formation of nanowires were comprehensively investigated. The resultant $Cu_{2-x}Se$ nanowires were sintered into pellet and tested for thermoelectric application in comparison with commercial Cu_2Se powder. Both synthetic and commercial samples have a similar performance and their figures of merit are 0.29 and 0.38 at 750 K, respectively (*J. Colloid & Interface*, 2015, *442*, 140). Second, $Cu_{2-x}S$ and $Cu_{2-x}Se$ nanotubes with a hierarchical architecture were successfully synthesized at room temperature through the reaction of Cu nanowires with S or Se powder in the presence of thiol ligands under the catalysis of NaOH (*Chem.-A Euro J*., 2015, *21*, 1055). Cu NWs served as sacrificial templates during the formation of the nanotubes. NaOH played a role in deprotonating –SH groups of thiol ligands and helped dissolving of chalcogen precursors. This article was selected as a hot article and back cover of the journal due to the novelty and significance of our method. Recently, this method has been extended to prepare copper chalcogenide nanostructures from commercial copper powder and chalcogen powder at room temperature in a large scale (Submitted to *ACS Appl. Mater. Interfaces*). Third, large-scale ternary CuAgSe nanoparticles were successfully synthesized via a robust environmentally friendly aqueous method at room temperature, which were sintered into pellets and show an interesting temperature-dependent transport property accompanied by a phase transition, i.e. they exhibit metallic characteristics below 60 K, n-type semiconductor behavior in the range of 60 K to 480 K, and p-type semiconducting behavior above 480 K. The pellet displays a ZT of 0.42 at 323 K and 0.9 at 623 K, and exhibits excellent cycling stability. The temperature-dependent n-p transition and the excellent stability of CuAgSe enable it to simultaneously serve as an n-type and p-type (at different temperatures) thermoelectric candidate for conversion of heat into electricity (*J. Am. Chem. Soc.*, 2014, *136*, 17626). Cu_2O-based heterostructured nanowires were also prepared at room temperature (*ACS Appl. Mater. Interfaces*., 2014, *6*, 15716).

Publications:

1. C. Han, Q. Sun, Z. X. Cheng., J. L. Wang, Z. Li, G. Q. Lu, S. X. Dou, *Journal of the American Chemical Society* 136, 17626 (2014).

2. C. Han, Z. Li, S. X. Dou, *Chinese Science Bulletin* 59, 2073 (2014). (Front cover)

3. X. Q. Chen, Z. Li, J. P. Yang, Q. Sun, S. X. Dou, *Journal of Colloids & Interfaces* 442, 140 (2015).

4. X. Q. Chen, Z. Li, Y. Bai, Q. Sun, L. Z. Wang, S. X. Dou, *Chemistry – A European Journal* 21, 1055 (2015).

5. J. Y. Xiong, Z. Li, J. Chen, S. Q. Zhang, L. Z. Wang, S. X. Dou, *ACS Applied Materials & Interfaces* 6, 15716 (2014).

6. C. Han, Z. Li, W. J. Li, S. L. Chou, S. X. Dou, J*ournal of Materials Chemistry A* 2, 11683 (2014).

7. Z. Li, Q. Sun, Y. Zhu, B. Tan, Z. P. Xu, S. X. Dou, *Journal of Materials Chemistry B* 2, 2793 (2014).

PROJECT ID: DP130102956

CIs/PIs: X. L. Wang, C. Zhang, R. A. Lewis, Q. K. Xue, A. Hoffmann, F. Klose

Project Title: Electron and spin transport in topological insulators

This project officially commenced in July 2013. The following results have been obtained under the full or partial support of this project in 2014:

1) We theoretically studied the frequency-dependent current response of the bulk state of topological insulator HgTe/CdTe quantum well. The optical conductivity is mainly due to the inter-band process at high frequencies. The result suggests that the transport scattering rate has an opposite frequency dependence in the low and high temperature regime. We found that the different frequency dependence is due to the interplay of the carrier-impurity scattering and carrier population near the Fermi surface.

2) We investigate the energy loss rate (ELR) of a charged particle in a HgTe/(HgTe, CdTe) quantum well. The scattering of a charged particle by the bulk insulating states dominates the diffusion rate in this type of topological insulator is. It is found that the ELR characteristics due to the intraband excitation have linear energy dependence while those due to interband excitation depend on the energy exponentially. An interesting quantitative result is that for a large range of the incident energy, the mean inelastic scattering rate is around a few terahertz.

3) We have reported that Superconductor-topological insulator-superconductor Josephson junctions have been fabricated in order to study the width dependence of the critical current, normal state resistance and flux periodicity of the critical current modulation in an external field. Previous literature reports suggest anomalous scaling in topological junctions due to the presence of Majorana bound states. However, for most realized devices, one would expect that trivial 2-periodic Andreev levels dominate transport. We also observe anomalous scaling behavior of junction parameters, but the scaling can be well explained by mere geometric effects, such as the parallel bulk conductivity shunt and flux focusing.

4) Ferromagnetism in graphene is fascinating, but it is still a big challenge for practical applications due to the weak magnetization. In order to enhance the magnetization, here, we design plasma-enabled graphene nanopetals with ultra-long defective edges of up to 105 m/g, ultra-dense lattice vacancies, and hydrogen chemisorptions. The designed graphene nanopetals display robust ferromagnetism with large

saturation magnetization of up to 2 emu/g at 5K and 1.2 emu/g at room temperatures. This work identifies the plasma-enabled graphene nanopetals as a promising candidate for graphene-based magnetic devices.

5) Topological Kondo insulators have been attracting great attention from the condensed-matter physics community due to their fascinating topological and strongly correlated properties. We reported angle-dependent c-axis magnetoresistance (MR) oscillations in a Kondo insulator, SmB_6 single crystal, in a magnetic field of up to 13 T rotated in the ab-plane. Four-fold symmetric MR oscillations are first observed above 8 K, which result from the four-fold (C4) degeneracy of the bulk Fermi surface of SmB_6. With decreasing temperature down to 2.3 K, the C4 symmetry of the MR oscillations gradually weakens and C2 symmetry appears. This demonstrates a crossover from three-dimensional bulk states to two-dimensional surface states and implies the possible emergence of topological nematic states. Our experimental observations shed new light on the metallic surface states and nematic states in the Kondo insulator SmB_6.

Publications:

1. Q. J. Chen, M. Sanderson, J. C. Cao, and C. Zhang, "Dynamic conductivity of the bulk states of n-type HgTe/CdTe quantum well topological insulator", *Applied Physics Letters* 105, 202110 (2014).

2. C. G. Molenaar, D. P. Leusink, X. L. Wang, and A. Brinkman, "Geometric dependence of Nb-Bi_2Te_3-Nb topological Josephson junction transport parameters", *Superconductor Science & Technology* 27, 1040031 (2014).

3. Z. J. Yue, D. H. Seo, K. Ostrikov, and X. L. Wang, "Defects induced ferromagnetism in plasma-enabled graphene nanopetals", *Applied Physics Letters* 104, 092417 (2014).

4. Z. J. Yue, X. L. Wang et al., "Crossover of magnetoresistance from fourfold to twofold symmetry in SmB_6 single crystal, a topological Kondo insulator", *Journal of the Physical Society of Japan*, Accepted for publication on Feb. 12, 2015.

PROJECT ID: DP140100401

CIs/PIs: J. Z. Wang, J. Chen, S. L. Chou, H. K. Liu, H. S. Zhou, X. L. Wang

Project Title: Lithium-ion air batteries with non-flammable ionic liquid–based electrolytes: a platform for safety in lithium-air batteries

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

1) CNTs@MnO electrocatalyst

A composite of CNTs@MnO has been synthesized by a facile approach, in which the CNTs form a continuous conductive network connecting the electrocatalyst MnO nanoparticles together to facilitate good electrochemical performance. The electrocatalyst MnO shows favourable rechargeability, and good phase and morphology stability in lithium oxygen batteries. Excellent cycling performance is also demonstrated, in which the terminal voltage is higher than 2.4 V after 100 cycles at 0.4 mA cm^2, with 1000 mAh g^{-1} capacity. Therefore, this hybrid material is promising for use as a cathode material for lithium oxygen batteries.

2) Graphene@g-C_3N_4 Composite

We first report a metal-free, free-standing macroporous graphene@graphitic carbon nitride (g-C_3N_4) composite air cathode, in which the g-C_3N_4 nanosheets can act as efficient electrocatalysts, and themacroporous graphene nanosheets can provide space for Li_2O_2 to deposit and also promote the electron transfer. The electrochemical results on the graphene@ g-C_3N_4 composite air electrode show a 0.48 V lower charging plateau and a 0.13 V higher discharging plateau than those of pure graphene air electrode, with a discharge capacity of nearly 17300mAh g^{-1}. Excellent cycling performance, with terminal voltage higher than 2.4 V after 105 cycles at 1000 mA h g^{-1} capacity, can also be achieved. Therefore, this hybrid material is a promising candidate for use as a high energy, long-cycle-life, and low-cost cathode material for lithium oxygen batteries.

3) Core-shell Co/CoO Integrated on 3D Nitrogen Doped Graphene

Cobalt/cobalt oxide core-shell nanoparticles integrated on nitrogen-doped graphene three-dimensional (3D) architecture were synthesized through a feasible hydrothermal method following by heat treatment. The synthesized electrocatalysts show comparable electrocatalytic oxygen reduction performance with Pt/C, but with excellent methanol resistance and better durability. The superb electrocatalytic performance towards the ORR is attributed to the excellent electron and charge transfer properties of the unique core-shell structures, the 3D structure of the supporting material, and the synergistic enhancement from the nitrogen-metal-carbon interactions in the electrocatalyst. We anticipate that this synthetic method could be further extended to other types of transition-metal core-shell nanostructure synthesis and would be beneficial in developing low-cost, economically feasible, and environmentally friendly electrocatalysts for Li-air batteries.

4) Pd -N-doped carbon nanofibers

The Pd nanoparticles were decorated onto the porous N-doped carbon nanofibers (PNC), which derives from KOH treated polypyrrole nanofibers. The composite cathode material with 25.49 wt.% Pd delivers a discharge and charge capacity of 10080 and 9404.5 mAh g^{-1}, respectively, which are the highest

value compared with the Pd, PNC, and the other composite cathodes at the current density of 100 mA g^{-1} from 2.35 to 4.35 V. For the cycling performance at the current density of 100 mA g^{-1} with a cur-off capacity of 1000 mAh g^{-1}, the composite cathode material with 25.49 wt.% Pd exhibits less terminal voltage changes within 50 cycles than that of the PNC cathode. It is presumed that the synergetic effect between Pd and PNC is the key reason for the improved electrocatalytic performances. PNC with large surface area and good electrical conductivity could serve as a suitable matrix, and the N dopping and optimal Pd nanoparticles loading could be helpful to enhance the electrocatalytic performances during the charge-discharge process in LOBs.

Publications

1. W. B. Luo, S. L. Chou, J. Z. Wang, Y. C. Zhai, H. K. Liu, "A facile approach to synthesize stable CNTs@MnO electrocatalyst for high energy lithium oxygen batteries", *Scientific Reports* 5, 8012 (2014). (IF: 5.078)

2. W. B. Luo, S.L. Chou, J. Z. Wang, Y. C. Zhai, H.K. Liu, "A metal-free, free-standing, macroporous graphene@g-C_3N_4 composite air electrode for high energy lithium oxygen batteries", *Small*, doi:10.1002/smll.201403535. (IF: 7.514)

PROJECT ID: DP140101501

CIs/PIs: C. Zhang, X. L. Wang, R. A. Lewis, Q. Bao, J. Horvat

Project Title: Novel terahertz photonics and plasmonics in high mobility low-dimensional electronic systems (HMLDES)

We have made following progress in the first year of the project.

1. We calculated in nonlinear electrical current in high mobility two dimensional semiconductors with Rashba spin-orbit coupling. The step-like nonlinear optical response in the terahertz regime has been detected. The result shows the system can be used in application of terahertz detectors.

2. For the above high mobility system, we investigated the quantum ratchet effect due to scattering. We have shown that a non-symmetric scattering potential on the opposite sides of the twodimensional electron gas give rise to the non-cancelling ac current through the structure. The result provides a mechanism to generate a directional dc current in a system subject to a uniform electromagnetic radiation.

3. We have shown that in a two-dimensional semiconductor with Rashba spin-orbit coupling (R2DEG), the real-spin chiral-like tunnelling of electrons at normal incidence simultaneously exhibits features of massless Dirac fermion and massive Dirac Fermion. The parabolic branch of opposite spin in R2DEG crosses at a Dirac-like point and has a band turning point. These features generate transport properties not found in usual two-dimensional electron gas.

4. We investigated the generation of terahertz radiation from surface plasmon in graphene grown on a periodic dielectric substrate in the linear response regime. The result suggests that the graphene-SPP-based terahertz emitter can be developed. The radiation intensity of such emitters can be much stronger than that from a dielectric surface.

5. We investigated geometrical and electronic symmetries in a GaN/AlGaN two-dimensional electron gas terahertz detector, both resonant excitation of cavity plasmon modes and non-resonant self-mixing of terahertz waves, concluding a single detector may utilize both effects.

6. We have found that strong LO-phonon-hole plasmon coupling in nominally undoped GaAsBi (a variable bandgap terahertz emitter/detector) is evidenced in Raman scattering experiments.

Publications:

1. Y. Ang, Z. Ma and C. Zhang, "Quantum ratchet in two-dimensional semiconductors with Rashba spin-orbit interaction", *Scientific Reports* 5: 7872 | DOI: 10.1038/srep078726 (2015).

2. S. Liu, C. Zhang, M. Hu, X. Chen, P. Zhang, S. Gong, T. Zhao, and R. Zhong, "Coherent and tunable terahertz radiation from graphene surface plasmon polaritons excited by an electron beam", *Applied Physics Letters* 104, 201104 (2014).

3. Y. Ang, J. C. Cao, and C. Zhang, "Nonlinear optical conductivity of two-dimensional semiconductors with Rashba spin-orbit coupling in terahertz regime", *The European Physical Journal B* 87, 28 (2014).

4. Y. Ang, Z. Ma and C. Zhang, "Chiral tunneling of electrons in two-dimensional semiconductors with Rashba spin-orbit coupling", *Scientific Reports* 4, 3780; DOI:10.1038/srep03780 (2014).

5. J. D. Sun, H. Qin, R. A. Lewis et al., "The effect of symmetry on resonant and nonresonant photoresponses in a field-effect terahertz detector", *Applied Physics Letters* 106, 031119 (2015).

6. J. A. Steele, R. A. Lewis, et al., "Raman scattering reveals strong LO-phonon-hole-plasmon coupling in nominally undoped GaAsBi: optical determination of carrier concentration", *Optics Express* 22, 11680 (2014).

PROJECT ID: DP140102581

CIs/PIs: S. X. Dou, Y. Du, X. Xu, G. Peleckis, S. Scott, J. H. Ye, W. C. Hao, K. S. Liu, P. Cheng

Project Title: Design and exploration of novel p-block materials for visible light photocatalysis

Project aims and progress

The aims of this project are to design and explore p-block materials that consist of only p-block elements for visible light photocatalysis, and to develop a comprehensive understanding of the effects of electronic structure and microstructure on their photocatalytic characteristics at the atomic level by addressing key scientific issues such as charge transport and trapping dynamics, the adsorbed state, the effects of promoters, and especially, the photocatalytically active sites. This is an important scientific frontier and has great prospects for photocatalytic application, with additional benefits that include hydrogen production, pollutant elimination and carbon sequestration.

Since 03/2014, a series of p-block compounds have been theoretically designed following band structure engineering strategy in this project. (1) Visible-light-driven bismuth-based photocatalysts including $Bi_{24}O_{31}Cl_{10}$ and $Bi_{24}O_{31}Br_{10}$ have been explored and synthesized. They demonstrate photoactivity in photocatalytic hydrogen production and organics degradation. Their photocatalytic performances are even better than some commercialized transition metal oxide photocatalysts. (2) The new p-block single-atom-thick materials, silicene, was designed and successfully fabricated for the first time in Australia. Its electronic structure and chemical activity were feasibly modulated by precise oxygen doping in MBE-STM system at UOW. This study is a solid foundation for electronic structure engineering by chemical doping in p-block photocatalysts. (3) A new approach was developed to control surface wettability of materials in PIs' groups, which will be further investigated based on the p-block photocatalysts in 2015. All these results have been published in high-impact journals as listed below.

Achievements

10 journal articles have been published or accepted: 1 Chemical Review (IF 45.661), 1 ACS Nano (IF 12.033), 1 Adv. Funct. Mater. (cover page, IF 10.400), 1 ACS Catalysis (IF 7.572), 3 Sci. Rep. (IF 5.078), 1 Phys. Rev. B (R) (IF 3.664), 2 IEEE conference proceedings.

1. J. C. Zhuang *et al*, "Investigation of electron-phonon coupling in epitaxial silicene by *in situ* Raman spectroscopy", *Physical Review B* 91, 161409(R) (2015).

2. J. Shang *et al*, "Bismuth oxybromide with reasonable photocatalytic reduction activity under visible light", *ACS Catalysis* 4, 954 (2014).

3. L. Wang *et al*, "A dye-sensitized visible light photocatalyst-$Bi_{24}O_{31}Cl_{10}$", *Scientific Reports* 4, 7384 (2014).

4. Y. Du *et al*, "Tuning the band gap in silicene by oxidation", *ACS Nano* 8, 10019 (2014).

5. X. Xu *et al*, "Effect of oxygen adsorption on the surface state of epitaxial silicene on Ag(111)", *Scientific Reports* 4, 7543 (2014).

6. K. S. Liu *et al*, "Bio-inspired titanium dioxide materials with special wettability and their applications", *Chemical Review* 114, 10044 (2014).

7. X. Jin *et al*, "Bio-inspired multifunctional metallic foams through the fusion of different biological solutions", *Advanced Functional Materials* 24, 2721 (2014).

8. J. C. Zhuang *et al*, "Observation of single-phased double superconducting domes in the $FeSe_xTe_{1-x}$ thin films", *Scientific Reports* 4, 7543 (2014).

9. S. Eilers *et al*, "Pb thin films on Si(111): local density of states and defects", *IEEE conference series, Nanoscience and Nanotechnology*, 54 (2014).

10. X. Xu *et al*, "Epitaxial growth mechanism of silicene on Ag(111)", *IEEE conference series, Nanoscience and Nanotechnology*, 28 (2014).

ARC FUTURE FELLOWSHIPS

PROJECT ID: FT110100170

CIs/PIs: J. H. Kim

Project Title: Development of solid nitrogen cooled MgB_2 magnet for persistent-mode operation

Summary: Since the discovery of superconductivity in MgB_2 materials at around 40 K in year 2001, wire or tape conductor development has advanced to the stage where MgB_2 superconducting conductor in kilometre-length in commercially available. A variety of applications have been proposed in making use of the new conductors. In this project, I made some progress in the construction and test of an MgB_2 superconducting magnet. This project aims to demonstrate the feasibility and practicality of low-cost MRI magnet system. As the performance/price ratio of MgB_2 becomes competitive to LTS, a wide operating temperature range of MgB_2, much wider than that possible with LTS, should make MgB_2 conductor of choice for magnets now dominated by LTS. Instead of operation in the liquid helium temperature range, we are developing a cryogenic system that combines solid nitrogen and cryocooler to maintain the working temperature of an MgB_2 magnet. Such a magnet will not depend on helium supply and the presence of solid nitrogen in the cold body enables the magnet (in

persistent mode operation) to keep its operating field intact even during a short period of electric power disruption.

Outcomes: We are engaged in the development of prototype SN_2 cooled MgB_2 based persistent magnet for MRI application. Recently, we have reported our success in the development of new highly consistent persistent-joining technique concept for unreacted monofilament MgB_2 conductors. Despite the consistently in the joints performance, the current fading after joining was about 35 %. To enhance joint performance further, we have modified our joining technique and fabricated superconducting joints. These joints achieved almost 96% of current retention at 20 K, 3.5 T after joining. Furthermore, we have also fabricated conduction cooled SN_2 cooling chamber to test various components of persistent-magnet. The detail test and analysis results of the MgB_2 persistent-joints, closed-loop coil, solenoid coil and racetrack coil in SN_2 environment at various temperatures, and detail microstructural analysis to unveil features responsible for joints performance will be presented.

Publications:

1. J. H. Kim, S. Y. Choi, "Carbon doping induced imperfections on MgB_2 superconducting wire", *Journal of Analytical Science and Technology*, DOI 10.1186/s40543-015-0048-3

2. M. Shahabuddin, N. S. Alzayed, S. J. Oh, S. Y. Choi, M. Maeda, M. S. Shah, A. Motaman, Md S. A. Hossain, J. H. Kim, "Percolative nature of current transport in polycrystalline MgB_2 wires", *Solid State Communications* 181, 20 (2014).

3. M. Shahabuddin, N. S. Alzayed, S. J. Oh, S. Y. Choi, M. Maeda, S. Hata, Y. Shimada, Md S. A. Hossain, J. H. Kim, "Microstructural and crystallographic imperfections on MgB_2 superconducting wire and their correlation with the critical current density", *AIP Advances* 4, 017113 (2014).

4. D. Patel, M. Maeda, S. Y. Choi, S. J. Kim, M. Shahabuddin, J. M. Parakandy, Md S. A. Hossain, J. H. Kim, "Multiwalled carbon nanotube-derived superior electrical, mechanical, and thermal properties in MgB_2 wires", *Scripta Materialia* 88, 13 (2014).

ARC DECRA FELLOWSHIPS

PROJECT ID: DE120101496

CIs/PIs: Z. G. Huang

Project Title: Diammoniate of diborane for hydrogen storage

Important breakthroughs in the syntheses of several B, N, H containing compounds have been made during this period. Two patents have been filed and six papers published, with another three submitted. CI Huang gave an Invited Talk at the International Symposium on Metal-Hydrogen System (MH2014) and Keynote Lecturer at the 15th International Meeting on Boron Chemistry (2015, Prague) on the progress for this project. Some of the key achievements are listed below.

1) A simple and easy synthesis of diammoniate of diborane has been developed. It was found that this compound is stable only at very low temperatures (< -10˚C) in organic solvents, which makes it unsuitable for liquid-phase hydrogen storage.

2) A new synthesis of ammonia-monochloroborane (NH_3BH_2Cl) has been developed. Compared to ammonia borane, NH_3BH_2Cl gives off H2 at lower temperatures, with no NH_3 or $B_3N_3H_6$ detected. HCl was observed at higher temperatures.

3) A new synthesis of unsolvated NaB_3H_8 that avoids mercury has been developed, and a patent on this new synthesis has been filed. It is with fair confidence that this method can be called the best since the discovery of NaB_3H_8 > 70 years ago in terms of safety, scalability, and cost.

4) A new method for synthesizing BH_3 complexes has been developed and a patent filed. Compared with all the known methods, this one uses very cheap chemicals such as $FeCl_3$ and has very high yield. Since BH_3 complexes are widely used in organic synthesis, this new synthesis is expected to be of high value to the chemical industry.

5) A much-improved understanding of NaB_3H_8 hydrolysis has indicated that this system can offer high capacity while maintaining liquid phase during hydrolysis.

6) The synthesis of sodium aminodiboranate $Na(H_3B\text{-}NH_2\text{-}BH_3)$ has been improved, and a comprehensive study has been carried out to investigate its thermal decomposition under controlled conditions. It can release about 2 equiv. H_2 in two steps, which is equal to about 5.98 wt %. The decomposition products contain NaBH4 and amorphous highly condensed polyborazylene.

7) Guanidinium octahydrotriborate with 13.8 wt % H has been successfully synthesized. This compound has a melting point < -10 ˚C and gives off 12.9 or 11.2 wt.% high purity hydrogen with or without solvent at 100 or 83.5 ˚C, respectively. Compared with solid octahydrotriborates, the much-improved H_2 purity can be ascribed to the more effective combination of H^+ (in the guanidinium cation) and H^- (in the octahydrotriborate anion) in the liquid state.

Publications:

1. P. Chen, W. Chen, Z. Huang, Patent: CN201410492154.7.

PROJECT ID: DE130101247

CIs/PIs: M. S. A. Hossain

Project Title: Rational design of new generation magnesium diboride superconducting rotor coil suitable for offshore low cost wind turbine generator

The main aim of this project is to develop and optimize a low cost and high performance magnesium diboride wires for the manufacturing of rotor coil suitable for wind turbine generator. The work according to the other objectives is continuing to achieve the goals of the proposed project. Here, a detailed power-law relationship (m), $n \propto Jc^m$, has been presented systematically. Structural defects can affect the index m. Large n-values >30 are reported here to make it possible to operate an MgB_2-based magnet in persistent mode at 20 K. Other work has shown detailed study on pinning mechanism in MgB_2 wires with different additives. Powder in tube MgB_2 based cables were fabricated and tested to be used in racetrack coil.

Personnel: One PhD student is also contributing to the 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, all the 2D/3D electromagnetic, mechanical design software was bought. The wet chamber for the transport measurement of racetrack coil has been ordered. The racetrack winding machine is selected and ready for the purchase order.

Progress: Project progress over this period has been in-line with the original objectives and if anything, slightly ahead of the original planned milestones. The wires have been tested and ordered customized wires to Hyper Tech according to our design and specification. Very cheap nano sized amorphous boron source have been found and tested the powder for this wires. This wire has been wound in a racetrack winding machine and tested and the results are in progress for publication.

Publications:

1. M. S. A Hossain, A. Motaman, S. Barua et al., "The roles of CHPD: superior critical current density and n-value obtained in binary in situ MgB_2 cables", *Superconductor Science & Technology* 27, 095016 (2014).

2. M. S. A. Hossain, A. A. Gazder, S. Barua et al., "Development of high current capacity mono- and 18-filament in situ MgB_2 cables by varying the twist pitch", *IEEE Transactions on Applied Superconductivity* 24, 6200304 (2014).

3. M. Mustapic, J. Horvat, M. S. A. Hossain et al., "Novel synthesis of superparamagnetic Ni-Co-B nanoparticles and their effect on superconductor properties of MgB_2", *Acta Materialia* 70, 298 (2014).

PROJECT ID: DE130100310

CIs/PIs: S. Aminorroaya-Yamini

Project Title: Nano-engineered, cost-effective Pb chalcogenides will boost the thermoelectric performance of mid-range temperature thermoelectric materials

Progress: The project progress over this period is in-line with the original objectives. The spinodally decomposed composition of $PbTe_{0.3}S_{0.62}$ has been fabricated to n-type alloys. The zT of 0.75 was achieved at 800 K with a predicted zT of ~0.85 at 750 K from the single parabolic band model. The experimental results were compared with estimates from the parallel and series models for heterogeneous composites of single phase PbTe and PbS. The significantly low thermal conductivity was proposed to be attributed to the phonon scattering on solute atoms and interfaces. This is aligned with one of the main aims of the project: *"Develop and design advanced nanostructured, cost effective, Pb-Chalcogenides bulk thermoelectric materials through varying the metallurgical procedure parameters".*

The solubility of sodium, the most efficient p-type dopant, in PbTe is studied to address the poor mechanical properties of these materials in thermoelectric generator devices. We have measured its maximum solubility for the first time. This supports one of the main objectives of this project: *"investigate dopant solubilities (n-type and p-type) in alloys and understand their effects on formation and solubility of precipitates in the matrix"* A high thermoelectric efficiency of ~1.6 was achieved in a p-type single phase quaternary alloy that is superior to ternary and binary systems alloys. This indicated for the first time that the single phase quaternary Pb chalcogenides are promising thermoelectric materials. Thermoelectric performance of an n-type nanostructured quaternary $(PbTe)_{0.75}(PbSe)_{0.1}(PbS)_{0.15}$ was studied. The reduction in the lattice thermal conductivity owing to nanostructuring was found to be compensated by reduced mobility. This results in a zT of ~ 1.1 similar to the single phase alloys. These outcomes address the main objective of the project: *"Explore and study the electronic structure, transport properties, and effective mechanisms involved in electronic transport properties of both n-type and p-type* $PbTe_{(1-x-y)}Se_xS_y$*".*

Nanostructured quaternary Pb-chalcogenides were fabricated through PbS alloying, beyond its solubility limit in the ternary $PbSe_xTe_{(1-x)}$ alloy. She demonstrated a high zT of ~1.4 over a wide temperature range in a p-type $PbS_{0.25}Se_{0.1}Te_{0.65}$ nanocomposite. This value is comparable to the efficiency of PbTe, even though 35 at% of the Te atoms are replaced by abundant elements of Se and S. She has also achieved a zT of ~2 in a p-type $(PbTe)_{0.65}(PbS)_{0.25}(PbSe)_{0.1}$ multiphase compound by optimising the dopant concentration. This is the highest reported efficiency value for Pb-chalcogenides with tellurium concentration less than 90% and support one of the

main objectives of the project: *"tune the electronic structure and transport properties of Pb-chalcogenides by substitution of Se and S for Te and develop optimize the alloy composition to achieve the highest zT".*

Publications:

1. S. Aminorroaya, D. H. Wang, Z. Gibbs, Y. Z. Pei, S. X. Dou, G. J. Snyder, *AIP Advances* 5, 053601 (2015).

2. S. Aminorroaya, H. Wang, Z. Gibbs, Y. Z. Pei, D. Mitchell, S. X. Dou, G. J. Snyder, *Acta Materialia* 80, 365 (2014).

3. S Aminorroaya, H. Wang, D. Ginting, D. Mitchell, S. X. Dou, G. J. Snyder, *ACS Applied Materials & Interfaces* 6, 11476 (2014).

4. S. H. Aboutalebi, R. Jalili, D. Esrafilzadeh, M. Salari, Z. Gholamvand, S. Aminorroaya Yamini, K. Konstantinov, R. Shepherd, J. Chen, S. Moulton, P. Innis, A. Minett, J. Razal, G. Wallace, *ACS Nano* 8, 2456 (2014).

5. S. Aminorroaya Yamini, H. Wang, Z. Gibbs, Y. Z. Pei, S. X. Dou, G. J. Snyder, *Physical Chemistry Chemical Physics* 16, 1835 (2014).

6. S Aminorroaya, A. Z. Williams, D. Attard, S. X. Dou, G. J. Snyder, *Science of Advanced Materials* 6, 1453 (2014).

PROJECT ID: DE140101333

CIs/PIs: Z. Q. Ma

Project Title: Microstructure design of second generation MgB_2 superconducting wires for enhancement of critical current density

1) The sintering process of IMD MgB_2 wires using different Mg rods and B powders were systemically studied by DSC and XRD. It was found that nano-sized carbon coated amorphous boron precursor is more active than normal amorphous boron and thus more easily react with Mg during sintering process. Consequently, using this kind of carbon coated amorphous boron as precursor in IMD technique can enhance formation of MgB_2 layers in wires. We also found that usage of Cu coated Mg rod as raw materials in IMD technique can significantly accelerate the diffusion of Mg and thus enhance the formation of MgB_2 layers. As a result, the high-quality IMD wires with larger diameter can be fabricated successfully at temperature as low as 600˚C through usage of Cu coated Mg rods as raw materials instead of traditional Mg rod. The engineering critical current density of these prepared wires is higher than various IMD MgB_2 wires prepared by sintering at high temperature (675˚C and 700˚C) in other groups. Moreover, after sintering, a thin Mg-Cu alloy layer was observed only surrounding the hole in our IMD wires. Compared to IMD wires without Cu coating, this thin alloy layer might serve as the supporter and enhance the mechanical properties of IMD MgB_2 wires and allow these wires more easily twisted without destroying their superconducting layer.

2) Collaborating with colleagues in ISEM and ISEM's external partner, Hyper Tech Research Inc and Tianjin University, We have prepared several kinds of high-quality MgB_2 bulks and MgB_2 wires using carbon-coated amorphous boron powder as precursor. The superconducting properties (such as Tc, magnetic Jc, and transport Jc) of these samples were measured using PPMS and standard four-probe method. Their microstructure was also observed in detail by optical microscopy, SEM and TEM. The results indicate that significant enhancement of critical current density (J_c) was obtained in the MgB_2bulks, PIT MgB_2wires and IMD MgB_2 wires using carbon-coated boron as precursor compared to other carbon-based chemical doped MgB_2 samples. Combined with microstructure analysis, it is found that the reason behind the improved high field J_c is that the refined MgB_2 grains and homogeneous carbon distribution in the carbon-coated samples.

ARC LINKAGE PROJECTS

PROJECT ID: LP120100173

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

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

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.

Personnel: One PhD student is also contributing to the 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, a so-called two axial rolling machine, was designed and attached to the wire drawing facility for the fabrication of isotropic square wires suitable for pressing the wire surface without any stress concentration.

Progress: Project progress over this period was 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 wires. Very cheap nano sized amorphous boron source was identified with subsequent fabrication and tests of superconducting wires. The mono-filamentary MgB_2 wires were fabricated and analysed using the combined effect of localised internal magnesium diffusion (LIMD) and cold compaction processes. The advanced microstructure analysis with high resolution TEM and SEM of these samples is now under progress.

We have also investigated the magnetization loss in MgB_2 superconducting wire using numerical calculations based on the finite element method. Various superconducting properties of MgB_2 wire such as nonlinearity and the field dependence of the critical current were considered in the numerical formulation. An analysis of magnetization loss was carried out as a function of the external magnetic field for a wide range of operating temperatures. The numerical results were compared with conventional theories and were found to be in relatively good agreement. An alternate approach based on a normalization method using critical current data was also employed as a simple method for predicting magnetization loss. The effectiveness of the simple equation for predicting loss was verified by comparisons of both values for various temperatures.

PROJECT ID: LP120200432

CIs/PIs: S. L. Chou, J. Z. Wang, H. K. Liu, D. Wexler

Project Title: Development of novel composite anode materials combined with new binders for high energy, high power and long life lithium-ion batteries

This research project was delayed due to the fact that the final agreement between industry Partners and the University of Wollongong was signed in the end of 2012. The project was only officially started in January 2013. 2 PhD students (Ms Weijie Li and Ms Yunxiao Wang) joined our Institute and spend 50% of their time to work on this project in January 2013. One research Associate (Dr. Qi Li) was started work on this project in April 2013. 1 PhD scholarship will be offer from this project on 1 April 2015.

The achievements and outcomes are summarised as follows:

1) Writing a review for the effect of binder on the performance of Li-ion battery and sodium ion battery

The binder effect on the performance of Lithium ion battery and sodium ion battery was reviewed. Many review papers recently published only focused on the active materials. Although binders take a small part of electrode composition, they play an important role on effecting the cycling stability and rate capability for Li-ion battery and Sodium ion battery. The advantages of transition from PVDF to aqueous binders are cheap, green, and easy for electrode fabrication. Anode materials of Li-ion battery such as Si-based, Sn-based, transitional metal oxides showed enhanced cycling life when using aqueous binders.

2) Si/amorphous carbon composite anode materials

From energy and environmental consideration, an industrial waste product, coal tar pitch (CTP), is used as the carbon source for Si/amorphous carbon (AC) composite. We exploited a facile sintering method to largely scale up Si/ amorphous carbon nanocomposite. The composites with 20 wt.% silicon with PVdF binder exhibited stable lithium storage ability for prolonged cycling. The composite anode delivered a capacity of 400.3 mAh g^{-1} with a high capacity retention of 71.3% after 1000 cycles. Various methods are used to investigate the reason for the outstanding cyclability. The results indicate that the silicon nanoparticles are wrapped by amorphous SiO_x and AC in Si/AC composite. This uniform structure is very favorable to lithium storage, the SiO_x and AC layers can supply sufficient conductivity and strong elasticity to suppress the stress resulting from the reaction of Si with Li during charge/ discharge process

3) $Sn_{4+x}P_3$@(Sn-P) composite

we prepared $Sn_{4+x}P_3$@(Sn-P) composite in large quantities by direct low-speed ball milling of the P and Sn powders and studied its electrochemical performance as anode material for sodium-ion batteries. The results demonstrated that the $Sn_{4+x}P_3$@(Sn-P) electrode using CMC binder delivered an initial discharge capacity of 1030 mA h g^{-1} and a reversible charge capacity of 892 mA h g^{-1}, at the current density of 100 mA g^{-1}. The addition of 5% FEC to the electrolyte can improve the cycling stability of the $Sn_{4+x}P_3$@(Sn-P) electrode, delivering a stable capacity of 465 mA h g^{-1}, with capacity retention of 92.6%, at the current density of 100 mA g^{-1} over 100 cycles. Moreover, the $Sn_{4+x}P_3$ electrode exhibited superior high rate capability, with a stable capacity of 165 mA h g^{-1} at the 10 C rate (5000 mA g^{-1}). All the results indicate that $Sn_{4+x}P_3$@(Sn-P) would be a promising anode material candidate for sodium-ion batteries with low cost, long cycling stability, and relatively good rate capability.

4) Sn/graphene composite with new binders

A structured Sn/ reduced graphene oxide (RGO) nanocomposite has been synthesized with Sn nanoparticles (~5 nm) anchored on RGO framework. It has been successfully applied as an anode material in Li-ion batteries. The electrode delivers a reversible capacity of 530 mA h g^{-1} with an outstanding capacity retention of 81.3 % over 150 cycles. Moreover, it possess a relatively good rate capability, exhibiting a capacity retention of 25.8 % at high rate (1000 mA h g^{-1}). With its combined advantages of low cost and environmental benignity, the Sn/RGO nanocomposite would be a promising anode for

Li-ion batteries.

Publications:

1. S. L. Chou, J. Z. Wang, H. K. Liu and S. X. Dou, *Physical Chemistry Chemical Physics* 16, 20347 (2014).

2. W. J. Li, S. L. Chou, J. Z. Wang, J. H. Kim, H. K. Liu, S. X. Dou, *Advanced Materials* 26, 4037 (2014).

3. Y. X. Wang, K. H. Seng, S. L. Chou, J. Z. Wang, Z. Guo, D. Wexler, H. K. Liu, S. X. Dou, *Chemical Communications* 50, 10730 (2014).

PROJECT ID: LP120200289

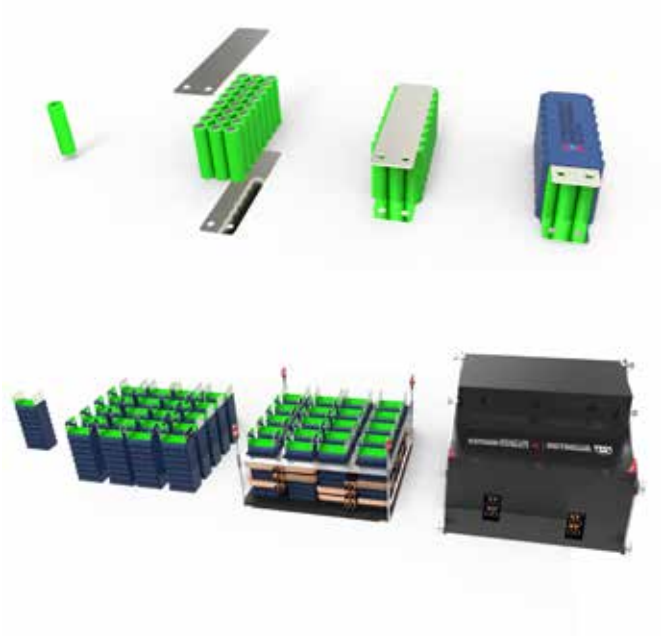
CIs/PIs: S. X. Dou, S. Li, W. X. Li, C. Zhang, S. Aminorroaya-Yamini

Project Title: New generation high efficiency thermoelectric materials and modules for waste heat recovery in steelworks

Background: Growing energy demands, concerns over climate change, and depletion of fossil fuel resources have led to a concerted effort to develop sustainable technologies for the efficient use and recovery of energy. Direct conversion of emitted waste heat (> 60% of produced energy) into electricity using thermoelectric materials and devices is among such technologies. This projects aims to develop and fabricate advanced thermoelectric materials and use them as building blocks to develop high-efficiency thermoelectric energy conversion devices. The devices made from advanced thermoelectric materials are expected to be robust and highly stable in harsh atmospheric environments, in particular, steel making factories. The collaboration with industry partner, Baosteel, will accelerate the uptake of this green technology, significantly reducing energy consumption and carbon dioxide emissions.

Progress: The project was progressing according to the schedule without any significant delays. A comprehensive literature review was completed, which allowed us to understand the current state-of-the-art in this research field. The emphasis of the review was put onto current high performance thermoelectric materials (Chin. Sci. Bulletin, CSB2013-0751). A number of potential thermoelectric materials was selected and prepared. Firstly, an n-type $PbTe_{0.38}S_{0.62}$ alloy was fabricated. The achieved nanostructured compound showed high figure of merit (ZT) of 0.75 at ~ 800 K. Secondly, the solubility of sodium as the most efficient p-type dopant for PbTe was studied to address the traditionally overlooked question, the actual role of sodium inclusions in the PbTe matrix. We have determined the maximum solubility of dopant and found that the Na solubility plays a critical role in maintaining suitable mechanical stability of the compound necessary for thermoelectric generator applications. We have also prepared Ga-doped $Ca_3Co_4O_9$ which has great potential for high temperature thermoelectric power generation due to its excellent stability at elevated temperatures. We have investigated the growth mechanisms of pure and Bi doped $Ca_3Co_4O_9$ thermoelectric oxide thin films. We showed that the thin film formation is mostly governed by an island growth mechasnism. Recently, we developed a hydrothermal approach to prepare tuneable $Cu_{2-x}Se$ ($0<x<1$) nanowires, and measured their ZT to be 2.1 at 620 °C. The value is 30% higher than that of commercial Cu_2Se powder, and is to date the highest reported for copper selenides.

Personnel: Dr. Wenxian Li moved to the University of Western Sydney and Dr. Zhen Li has taken over his position and has been working on the project. Two PhD students were enrolled and were partially contributing to the project. Dr. Sima Aminorroaya Yamini is co-supervising one of the PhD students to develop robust thermoelectric materials for high temperature applications.



A full scale battery pack made of batteries fabricated using ISEM battery manufacturing line.

CURRENT AND ONGOING RESEARCH PROJECTS

ARC DISCOVERY PROJECTS

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

Years Funded:	2010	2011	2012	2013	2014
	$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.

NANOSTRUCTURE ENGINEERED IRON-BASED SUPERCONDUCTORS

Years Funded:	2012	2013	2014
	$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.

ELECTRON AND SPIN TRANSPORT IN TOPOLOGICAL INSULATORS

Years Funded:	2013	2014	2015
	$120,000	$150,000	$140,000
Total Funding:	$410,000		
Project ID:	DP130102956		
Chief Investigators:	X. L. Wang, C. Zhang, R. A. Lewis,		
Partner Investigator:	Q. K. Xue, A. Hoffmann, F. Klose		

Project Summary: This project brings together experts with complementary skills to study newly discovered topological insulators that conduct electricity on their surface but not inside. The project will explore potential applications of this new class of materials in novel electronics, optics, spintronics, superconducting and quantum information technologies.

NANOSTRUCTURE ENGINEERING OF SEMICONDUCTOR NANOWIRES FOR HIGH PERFORMANCE THERMOELECTRICS

Years Funded:	2013	2014	2015
	$110,000	$100,000	$100,000
Total Funding:	$310,000		
Project ID:	DP130102699		
Chief Investigators:	Z. Li, G. M. Lu		
Partner Investigator:			

Project Summary: This project aims to develop high-performance thermoelectric semiconductor nanowires for recovery of waste

heat from automotive exhausts and industrial processes. The successful development of such technology would help save energy, reduce carbon emissions and create enormous economical and environmental benefits for Australia and the world.

NOVEL TERAHERTZ ELECTRONICS, PHOTONICS AND PLASMONICS IN HIGH- MOBILITY, LOW-DIMENSIONAL ELECTRONIC SYSTEMS (HMLDES)

Years Funded:	2014	2015	2016
	$130,000	$140,000	$140,000
Total Funding:	$410,000		
Project ID:	DP140101501		
Chief Investigators:	C. Zhang, X. L. Wang, R. A. Lewis, Q. L. Bao, J. Horvat		
Partner Investigator:			

Project Summary: High-mobility, low-dimensional electronic systems (HMLDES) are of importance in developing the next generation of electronics, photonics and plasmonics. This is due to their very rapid response time and their strong coupling with the electromagnetic field. This project will investigate the electronic and optical properties of HMLDES in the terahertz frequency regime in a search for a new mechanisms leading to terahertz emission and detection. This fundamental research on charge dynamics, plasmonics and non-linear optical processes in HMLDES will link electronics and optics, paving the way for new HMLDES-based terahertz electronic, photonic and plasmonic devices that will significantly expand terahertz technology to the benefit of all Australians.

LITHIUM-ION AIR BATTERIES WITH NON-FLAMMABLE IONIC LIQUID–BASED ELECTROLYTES

Years Funded:	2014	2015	2016
	$55,000	$140,000	$155,000
Total Funding:	$350,000		
Project ID:	DP140100401		
Chief Investigators:	**J. Z. Wang, J. Chen, S. L. Chou, H. K. Liu, H. S. Zhou, X. L. Wang**		
Partner Investigator:			

Project Summary: The aim of this project is to develop rechargeable lithium-ion air batteries based on novel advanced materials and non-flammable ionic-liquid-based electrolytes for use in electric vehicles. The success of this project would make a significant contribution to improving the safety of typical lithium-air batteries. The expected outcomes include: establishing novel lithium-ion air battery electrochemical systems using selected advanced electrode materials and electrolytes which are developed in this proposal; and, understanding the degradation mechanisms of electrode materials in the novel lithium-ion air battery systems with different advanced characterisation methods.

DESIGN AND EXPLORATION OF NOVEL P-BLOCK MATERIALS FOR SOLAR ENERGY CONVERSION

Years Funded:	2014	2015	2016
	$215,000	$145,000	$160,000
Total Funding:	$520,000		
Project ID:	DP1402581		
Chief Investigators:	S. X. Dou, Y. Du, X. Xu, G. Peleckis, J. Scott, J. H. Ye, W. C. Hao, K. S. Liu, P. Cheng		
Partner Investigator:			

Project Summary: This project aims to design and explore novel visible light p-block photocatalysts through in depth surface studies of materials at an atomic level. A new strategy of band structure engineering and in-situ investigation of atomiclevel photocatalytic dynamics will be the key elements in this research which is expected to yield several novel visible light photocatalysts. The outcome of the project will be the understanding of processes and mechanisms underlying the photocatalysis and building the foundation of usable, stable, and durable visible-light photocatalytic applications.

FUTURE FELLOWSHIPS

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

Years Funded:	2011	2012	2013	2014	2015
	$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.

ELECTRONIC TOPOLOGICAL MATERIALS

Years Funded:	2013	2014	2015	2016	2017
	$124,000	$247,000	$246,000	$246,000	$124,000
Total Funding:	$987,000				
Project ID:	FT130100778				
Chief Investigators:	X. L. Wang				

Project Summary: Discovery of new classes of materials with new functionalities or significantly improved performance has always been the driving force for the advance of modern science and technology, and the improvement of our daily lives. This project aims to discover a number of innovative materials, based on new strategies of materials design, discover their novel functionalities and novel quantum effects, and elucidate their underlying physics. It is expected that these novel materials will provide a new platform for superconductivity, magnetism, spintronics, optical and multi-disciplinary sciences, and lead to future generations of advanced multifunctional electronic devices.

LEAD-FREE BISMUTH BASED DIELECTRIC MATERIALS FOR ENERGY STORAGE

Years Funded:	2014	2015	2016	2017	2018
	$111,000	$222,000	$222,000	$222,000	$111,000
Total Funding:	$888,000				
Project ID:	FT140100698				
Chief Investigator:	S. J. Zhang				

Project Summary: Electrical energy generation from renewable sources, such as solar, wind and geothermal, provide enormous potential for meeting future energy demands. However, the ability to store and control this energy for miniaturisation and modularisation in applications requiring a wide temperature usage range is a limiting factor that needs to be addressed. This project aims to develop new bismuth-based lead-free dielectric materials for improving the storage density of high temperature multilayer ceramic capacitors for sustainable applications in the energy and vehicle industries, where high temperature stability and high volumetric efficiency are crucial.

DECRA FELLOWSHIPS

DIAMMONIATE OF DIBORANE FOR HYDROGEN STORAGE

Years Funded:	2012	2013	2014
	$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.

RATIONAL DESIGN OF A NEW GENERATION MAGNESIUM DIBORIDE SUPERCONDUCTING ROTOR COIL SUITABLE FOR OFFSHORE LOW-COST WIND TURBINE GENERATORS

Years Funded:	2013	2014	2015
	$125,000	$125,000	$125,000
Total Funding:	$375,000		
Project ID:	DE130101247		
Chief Investigators:	M. S. A. Hossain		

Project Summary: New developments in wind power technologies provide opportunities in the next decade to deliver renewable energy. The present and future low cost magnesium diboride superconducting technology, coupled with renewable energy sources, has the potential to provide a long-term solution to the energy crisis and global warming threat.

NANO-ENGINEERED, COST-EFFECTIVE LEAD CHALCOGENIDES TO BOOST THE PERFORMANCE OF MID-RANGE TEMPERATURE THERMOELECTRIC MATERIALS

Years Funded:	2013	2014	2015
	$125,000	$125,000	$125,000
Total Funding:	$375,000		
Project ID:	DE130100310		
Chief Investigators:	S. Aminorroaya-Yamini		

Project Summary: This project presents high performance, cost-effective lead-based thermoelectric materials for mid-range temperature thermoelectric generators. The development of these materials for waste heat recovery and solar thermoelectric generators will bring tremendous economic benefits and can have a profound impact on clean alternative energy sources.

MICROSTRUCTURE DESIGN OF SECOND GENERATION MgB_2 SUPERCONDUCTING WIRES FOR ENHANCEMENT OF CRITICAL CURRENT DENSITY

Years Funded:	2014	2015	2016
	$130,000	$124,000	$124,000
Total Funding:	$377,000		
Project ID:	DE140101333		
Chief Investigators:	Z. Q. Ma		

Project Summary: Magnesium diboride (MgB_2) superconducting wires have outstanding potential for a diverse range of commercial applications. However, the critical current density in MgB_2 wires is still comparatively low, which represents the biggest obstacle in terms of their practical applications. This project will further enhance the critical current density in second generation MgB2 wires prepared by an optimised internal magnesium diffusion process through addressing fundamental issues and designing appropriate microstructure. The research outcomes will be extremely beneficial to fundamental research and to the potential application of MgB_2 superconductors. High performing, low-cost second generation MgB2 wires are also expected to be developed in this project.

ARC LINKAGE PROJECTS

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
ARC Fund:	$90,000	$90,000	$90,000
Industry Fund:	$60,000	$60,000	$60,000
Total Funding:	$450,000		
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
ARC Fund:	$45,000	$90,000	$90,000	$45,000
Inmdustry Fund:	$20,000	$40,000	$40,000	$20,000
Total Funding:	$390,000			
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
	$60,000	$120,000	$110,000	$80,000	$30,000
Industry Fund:	$70,000	$120,000	$110,000	$80,000	$30,000
Total Funding:	$810,000				
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.

AUTO CRC PROJECTS

LITHIUM AIR BATTERY FOR ELECTRIC VEHICLES

Years Funded:	2013	2014	2015
	$160,000	$160,000	$160,000
Total Funding:	$480,000		
Project ID:	1-108		
Chief Investigators:	S. X. Dou, G. X. Wang		
Industry Partner:			

Project Summary: Lithium air batteries have a theoretical density of 11,680 Wh/kg and practically can reach 1700 Wh/kg which is an order of magnitude higher than state-of-the-art LIBs. However, the major challenges of electrochemical stability of both the electrolyte and the cathode must be addressed. This research will seek dramatic improvement of up to an order of magnitude in energy density through a proff-of-concept battery using lithium air technology.

DESIGN AND PROTOTYPE OF ON-VEHICLE BATTERY MANAGEMENT SYSTEM FOR ELECTRIC VEHICLES

Years Funded:	2013	2014	2015
	$78,000	$78,000	$78,000
Total Funding:	$234,000		
Project ID:	1-110		
Chief Investigators:	S. X. Dou, Z. P. Guo		
Industry Partner:	Red Arc Co. Ltd.		

Project Summary: The aim of this project is to develop a battery management system (BMS) for monitoring, balancing, protecting, and optimizing battery modules and pack, as well as hybrid battery/ supercapacitor pack to achieve smart charge, optimal performance and cycle life, and high safety.

ISEM learning labs experience: electrical vehicles

DEVELOPMENT OF ADVANCED ELECTRODE AND ELECTROLYTES FOR LIB

Years Funded:	2013	2014	2015
	$479,000	$479,000	$480,000
Total Funding:	$1,438,000		
Project ID:	1-111		
Chief Investigators:	S. X. Dou, G. X. Wang, H. K. Liu		
Industry Partner:	Malaysia Automotive Institute (MAI)		

Project Summary: The proposed research program is aimed at achieving major advances in the development of next generation, high energy and high power cathode materials for lithium ion batteries (LIB) with reduced cost and improved safety. The project will concentrate on development of breakthrough scale-up cathode materials; development of liquid/organic ionic or polymer electrolytes with high conductivity and safety; fabricate, test, and evaluate large-size prototypes.

BATTERY CHARGE, MECHANICAL AND THERMAL MANAGEMENT SYSTEM DEVELOPMENT

Years Funded:	2013	2014	2015
	$356,000	$356,000	$356,000
Total Funding:	$1,068,000		
Project ID:	1-112		
Chief Investigators:	S. X. Dou, K. W. See		
Industry Partner:	Malaysia Automotive Institute (MAI)		

Project Summary: The focus of this project is to identify and resolve gaps and weaknesses in EV systems. The project is expected to deliver a fully integrated battery management system module with effective monitoring, charging and balancing capability; reliable and robust mechanical system; a complete vehicle electrification system that is compact, low-cost, easily packaged, and compatible with mass production line for Malaysian automotive industry.

LITHIUM ION BATTERY MODULE PACKAGING AND TESTING

Years Funded:	2013	2014	2015
	$208,000	$208,000	$208,000
Total Funding:	$624,000		
Project ID:	1-113		
Chief Investigators:	S. X. Dou, K. W. See		
Industry Partner:	Malaysia Automotive Institute (MAI)		

Project Summary: The battery packs used as rechargeable electrical storage system in electric vehicles are large and complex. Controlled release of the battery's energy provides useful electrical power in the form of current and voltage. However, uncontrolled release of this energy can result in dangerous situations such as release of toxic materials, fire, and high pressure events. These can be best prevented by a properly designed and validated electronic safety and monitoring system. The project will focus on design and development of fully integrated electric vehicle battery packaging system and development of reliable testing platform for electric vehicle battery pack system.

THERMOELECTRICS – EFFICIENT ENERGY RECOVERY IN LIGHT AND HEAVY VEHICLES

Years Funded:	2013	2014	2015
	$154,000	$154,000	$154,000
Total Funding:	$464,000		
Project ID:	1-203		
Chief Investigators:	S. X. Dou, S. Aminorroaya-Yamini, Z. Li, G. Peleckis		
Industry Partner:	Baosteel Company		

Project Summary: The project is targeted in three major directions, i.e. materials, device engineering, and device fabrication with the ultimate goal of the project to achieve high Carnot efficiency for energy conversion from waste heat and at least 2% reduction of fuel consumption in automobiles. This will be achieved through development of novel nano-particle based highly dense thermoelectric materials and design and engineering of new generation thermoelectric modules.

THE STUDY OF CARBON BASED BATTERY MATERIALS FOR LI ION BATTERY

Years Funded:	2013	2014	2015
	$33,000	$33,000	$33,000
Total Funding:	$99,000		
Project ID:	4-102		
Chief Investigators:	H. K. Liu, S. X. Dou		
Industry Partner:	Auto CRC		

SULPHUR-CARBON COMPOSITE CATHODE MATERIAL FOR LI-S BATTERY

Years Funded:	2013	2014	2015
	$33,000	$33,000	$33,000
Total Funding:	$99,000		
Project ID:	4-103		
Chief Investigators:	J. Z. Wang, S. X. Dou		
Industry Partner:	Auto CRC		

CONDUCTING POLYMER COATED GRAPHENE OXIDE NANOCOMPOSITES FOR SUPERCAPACITOR APPLICATION

Years Funded:	2013	2014	2015
	$33,000	$33,000	$33,000
Total Funding:	$99,000		
Project ID:	4-104		
Chief Investigators:	K. Konstantinov, S. X. Dou		
Industry Partner:	Auto CRC		

FABRICATION & CHARACTERISATION OF GRAPHENE & GRAPHENE OXIDE COMPOSITES FOR APPLICATION IN SUPERCAPACITORS & LI-ION BATTERIES

Years Funded:	2013	2014	2015
	$33,000	$33,000	$33,000
Total Funding:	$99,000		
Project ID:	4-105		
Chief Investigators:	Z. P. Guo, S. X. Dou		
Industry Partner:	Auto CRC		

URC SMALL GRANTS, AIIM GOLD GRANTS & ARC NEAR-MISS GRANTS 2014

MULTIFERROIC HETEROSTRUCTURES FOR HIGH DENSITY AND LOW ENERGY DISSIPATION SOLID-STATE MEMORY APPLICATION

Total Funding: $12,000
Chief Investigators: Z. X. Cheng

EXPANDING THE SEARCH FOR HYDROGEN STORAGE MATERIALS

Total Funding: $11,000
Chief Investigators: Z. G. Huang

DEVELOPMENT OF BATTERY MANAGEMENT SYSTEM FOR LITHIUM-ION BATTERY TECHNOLOGY FOR ELECTRIC VEHICLES APPLICATION

Total Funding: $10,000
Chief Investigators: K. W. See

MAGNETICALLY TRIGGERED MECHANOSELECTIVE CHANNELS FOR LIPOSOMAL DRUG DELIVERY

Total Funding: $18,000
Chief Investigators: M. S. A. Hossain

TEXTURE-INDUCED ENHANCEMENT OF PHYSICAL RESPONSE IN MELT-SPUN RIBBONS AND THIN FILMS OF INTERMETALLIC COMPOUNDS

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

STRUCTURAL AND CHEMICAL SURFACE CHARACTERISATION OF FUNCTIONALISED THERANOSTIC CORE/SHELL CERAMIC NANOSTRUCTURES FOR CANCER THERAPY

Total Funding: $10,000
Chief Investigators: K. Konstantinov

EPITAXIAL GROWTH, SCANNING TUNNELLING MICROSCOPY AND RAMAN SPECTROSCOPY STUDIES ON SILICENE

Total Funding: $14,800
Chief Investigators: Y. Du

ENGINEERING DOPANT DISTRIBUTIONS IN COMPOSITE SEMICONDUCTORS – A NEW STRATEGY TO DESIGN HIGH PERFORMANCE THERMOELECTRIC MATERIALS

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

DEVELOPMENT OF LOW RADIOACTIVE BORON-11 ISOTOPE ($Mg^{11}B_2$) SUPERCONDUCTING POLOIDAL FIELD MAGNET COIL SUITABLE FOR TOKAMAK-TYPE FUSION REACTORS

Total Funding: $8,500
Chief Investigators: M. S. A. Hossain

ARCHITECTURE DESIGN OF METAL OXIDE NANOSTRUCTURES FOR HIGH-PERFORMANCE BAND A ULTRAVIOLET DETECTORS

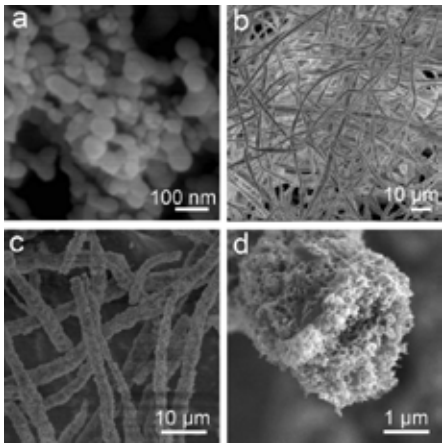
Total Funding: $8,500
Chief Investigators: Z. Q. Sun

NOVEL ANODE MATERIALS FOR SODIUM BATTERY TO STORE RENEWABLE ENERGY

Total Funding: $8,000
Chief Investigators: S. L. Chou

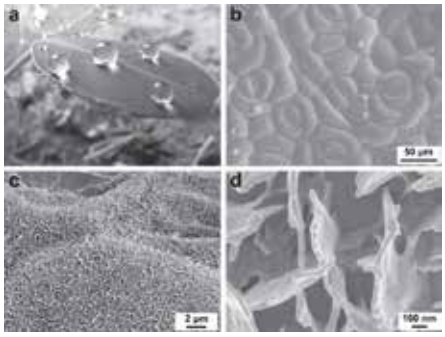
SELECTED ABSTRACTS

MASS PRODUCTION OF THREE-DIMENSIONAL HIERARCHICAL MICROFIBERS CONSTRUCTED FROM SILICON-CARBON CORE-SHELL ARCHITECTURES WITH HIGH-PERFORMANCE LITHIUM STORAGE



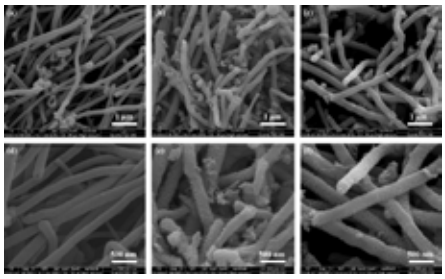
In this work, a facile approach is reported to mass produce highly porous fibers constructed from silicon–carbon core–shell structures. The C–Si microfibers are prepared using a modified electrospinning deposition method (ESD), and subsequent calcination of the carbon shells. Benefited from the step of vacuum drying, the unnecessary solvent left in the precursor will volatilize, resulting in the uniform three-dimensional hierarchical microfibers constructed from silicon–carbon core–shell architectures. The uniform covering layers of carbon formed by decomposition of polymer contribute to the improvement of conductivity and alleviation of volume change. The pores in the microfibers are helpful for the diffusion of electrolyte. When evaluated as an anode material for lithium-ion batteries, the C–Si microfibers exhibit improved reversibility and cycling performance compared with the commercial Si nanoparticles. A high capacity of 860 mAh g^{-1} can be retained after 200 cycles at a current rate of 0.3 C. The rate capability of the C–Si microfibers is also improved. The special structure is believed to offer better structural stability upon prolonged cycling and to improve the conductivity of the material. This simple strategy using the modified ESD method could also be applied to prepare other porous energy materials. (C. F. Zhang et al., *Carbon* 72, 169 (2014))

PEANUT LEAF INSPIRED MULTIFUNCTIONAL SURFACES



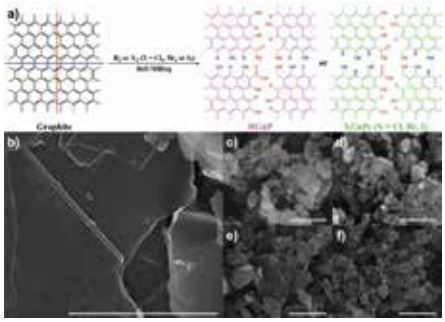
Nature has long served as a source of inspiration for scientists and engineers to design and construct multifunctional artifi cial materials. The lotus and the peanut are two typical plants living in the aquatic and the arid (or semiarid) habitats, respectively, which have evolved different optimized solutions to survive. For the lotus leaf, an air layer is formed between its surface and water, exhibiting a discontinuous three-phase contact line, which resulted in the low adhesive superhydrophobic self-cleaning effect to avoid the leaf decomposition. In contrast to the lotus leaf, the peanut leaf shows highadhesive superhydrophobicity, arising from the formation of the quasi-continuous and discontinuous three-phase contact line at the microscale and nanoscale, respectively, which provides a new avenue for the fabrication of high adhesive superhydrophobic materials. Further, this high adhesive and superhydrophobic peanut leaf is proved to be effi cient in fog capture. Inspired by the peanut leaf, multifunctional surfaces with structural similarity to the natural peanut leaf are prepared, exhibiting simultaneous superhydrophobicity and high adhesion towards water. (S. Yang et al., *Small* 10, 294 (2014))

IMPROVED CYCLABILITY OF LITHIUM-SULFUR BATTERY CATHODE USING ENCAPSULATED SULPHUR IN HOLLOW CARBON NANOFIBER@NITROGEN-DOPED POROUS CARBON CORE-SHELL COMPOSITE



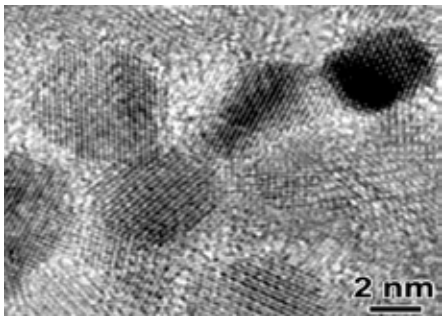
Hollow carbon nanofiber@nitrogen-doped porous carbon (HCNF@NPC) core–shell composite, which was carbonized from HCNF@polyaniline, was prepared as an improved high conductive carbon matrix for encapsulating sulfur as a cathode composite material for lithium–sulfur batteries. The prepared HCNF@NPC-S composite with high sulfur content of 77.5 wt.% showed an obvious core–shell structure with an NPC layer coating on the surface of the HCNFs and sulfur homogeneously distributed in the coating layer. This material exhibited much better electrochemical performance than the HCNF-S composite, delivered initial discharge capacity of 1170 mAh g^{-1}, and maintains 590 mAh g^{-1} after 200 cycles at the current density of 837.5 mA g^{-1} (0.5 C). The significantly improved electrochemical performance of the HCNF@NPC-S composite was attributed to the synergetic effect between HCNF cores, which provided electronic conduction pathways and worked as mechanical support, and the NPC shells with relatively high surface area and pore volume, which could trap sulfur/polysulfides and provide Li^+ conductive pathways. (Q. Li et al., *Carbon* 78, 1 (2014))

EDGE-SELECTIVELY HALOGENATED GRAPHENE NANOPLATELETS (XGNPS, X = CL, BR, OR I) PREPARED BY BALL-MILLING AND USED AS ANODE MATERIALS FOR LITHIUM-ION BATTERIES



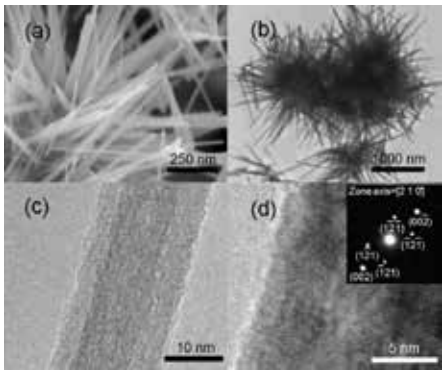
Edge-selectively halogenated graphene nanoplatelets (XGnPs, X = Cl, Br, or I) are prepared by a simple mechanochemical ball-milling method, which allows low-cost and scalable production of XGnPs as highly stable anode materials for lithium-ion batteries. (J. T. Xu et al., *Advanced Materials* 26, 7317 (2014))

NOVEL SYNTHESIS OF SUPERPARAMAGNETIC NI–CO–B NANOPARTICLES AND THEIR EFFECT ON SUPERCONDUCTOR PROPERTIES OF MgB_2



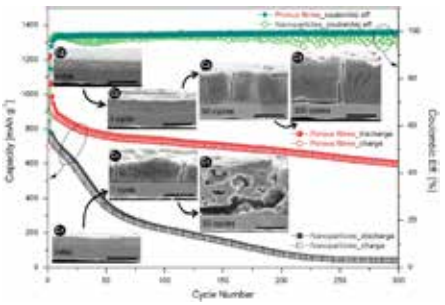
A new procedure for the preparation of amorphous Ni–Co–B nanoparticles is reported, with a detailed investigation of their morphology by X-ray diffraction and transmission electron microscopy, as well as their magnetic properties. Many factors, such as chemical composition, anisotropy, size and shape of the particles, were controlled through chemical synthesis, resulting in the control of morphological and magnetic properties of the nanoparticles. Controlling pH values with ethylenediamine and using sodium dodecyl sulfate surfactant lowered the size of the nanoparticles to below 10 nm. Such a small structure and chemical disorder in nanocrystalline materials lead to magnetic properties that are different from those in their bulk-sized counterparts. The obtained nanoparticles can be used for different purposes, from pharmaceutical applications to implementations in different materials technology. The focus of this research is the synthesis of Ni–Co–B nanoparticles in a new way and studying the reaction of Ni–Co–B nanoparticles with Mg and B precursors and their effect on MgB_2 properties. New nanostructures are formed in the reaction of Ni–Co–B nanoparticles with Mg: Mg_2Ni, Co_2Mg and possibly Mg_2Co. (M. Mustapic et al., *Acta Materialia* 70, 298 (2014))

UNCOUPLED SURFACE SPIN INDUCED EXCHANGE BIAS IN ALPHA-MnO_2 NANOWIRES



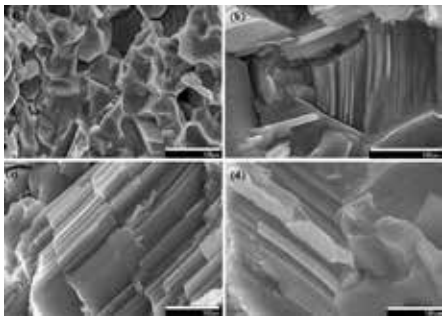
We have studied the microstructure, surface states, valence fluctuations, magnetic properties, and exchange bias effect in MnO_2 nanowires. High purity alpha-MnO_2 rectangular nanowires were synthesized by a facile hydrothermal method with microwave-assisted procedures. The microstructure analysis indicates that the nanowires grow in the [0 0 1] direction with the (2 1 0) plane as the surface. Mn^{3+} and Mn^{2+} ions are not found in the system by X-ray photoelectron spectroscopy. The effective magnetic moment of the manganese ions fits in with the theoretical and experimental values of Mn^{4+} very well. The uncoupled spins in 3d(3) orbitals of the Mn^{4+} ions in MnO_6 octahedra on the rough surface are responsible for the net magnetic moment. Spin glass behavior is observed through magnetic measurements. Furthermore, the exchange bias effect is observed for the first time in pure alpha-MnO_2 phase due to the coupling of the surface spin glass with the antiferromagnetic alpha-MnO_2 matrix. These alpha-MnO_2 nanowires, with a spin-glass-like behavior and with an exchange bias effect excited by the uncoupled surface spins, should therefore inspire further study concerning the origin, theory, and applicability of surface structure induced magnetism in nanostructures. (W. X. Li et al., *Scientific Reports* 4, 6641 (2014))

A CASE STUDY ON FIBROUS POROUS SnO_2 ANODE FOR ROBUST, HIGH-CAPACITY LITHIUM-ION BATTERIES



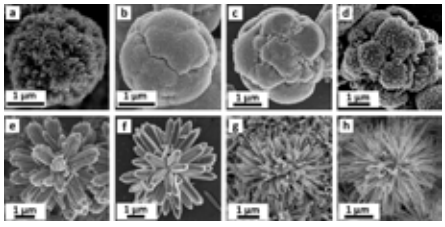
Transition metal oxides have attracted considerable interest as promising anode materials for lithium-ion batteries (LIBs) due to their high energy densities. It is necessary, however, to resolve the foremost issue for them in terms of practical applications, relating to the large volume changes during cell operation. Herein, we report a SnO_2 anode with a hierarchical fibrous porous architecture which was fabricated by electrospinning the Sn-precursor with poly (vinylpyrrolidone) and subsequent temperature-dependent pyrolysis processes, resulting in the distinctive morphology, featuring hierarchical fibrous porous structures on the microscale with numerous primary constituent nanoparticles. The porous fibres are composed of uniform polycrystalline nanoparticles (approximately 10–50 nm in size) and abundant voids in close proximity to the constituent nanoparticles. By comparing with an anode containing commercial SnO_2 nanopowder (with a size of <100 nm), we found that the porous fibrous SnO_2 anode featured superior rate capability, long-term cycling stability, and dimensional stability, which was attributed to the distinctive structural characteristics, which offered enhanced kinetics towards electrochemical reactions with lithium ions and space for alleviating the huge volume expansion during charging/discharging. These findings would pave the way for practical applications in LIBs with high capacity and long cycle life of transition metal oxide anodes that suffer from significant volume changes during cycling. (S. M. Hwang et al., *Nano Energy* 10, 53 (2014))

THE FORMATION OF NANO-LAYERED GRAINS AND THEIR ENHANCED SUPERCONDUCTING TRANSITION TEMPERATURE IN Mg-DOPED $FeSe_{0.9}$ BULKS



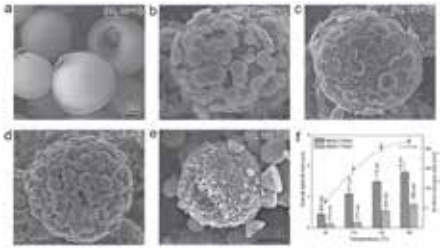
To search a proper dopant to further improve superconductivity in 11 type Fe-based superconductors makes sense to both their superconductivity mechanism and possible technological applications. In present work, Mg doped FeSe polycrystalline bulks were obtained by a two-step solid-state reaction method. Even though there are many MgSe and iron impurities existing in the Mg heavy doped FeSe bulks, they exhibit obviously increased T_c compared to undoped FeSe sample. It was found that Mg addition has little effect on the crystal lattice parameters of superconducting beta-FeSe, whereas leads to the formation of nano-layered grain structure consisted of MgSe and beta-FeSe with similar X-ray diffraction characteristics. Lots of nanostructural interfaces between FeSe and MgSe formed in this homogenous layered grain structure have significant effect on the superconducting properties and are responsible for the enhancement of T_c, as like the case of FeSe thin film on some specific substrates. Our work not only demonstrates a powerful way for raising T_c in bulk superconductors, but also provides a well-defined platform for systematic studies of the mechanism of unconventional superconductivity by considering interface effect. (F. Lan et al., *Scientific Reports* 4, 6481 (2014))

3D HIERARCHICAL RUTILE TiO_2 AND METAL-FREE ORGANIC SENSITIZER PRODUCING DYE-SENSITIZED SOLAR CELLS 8.6% CONVERSION EFFICIENCY



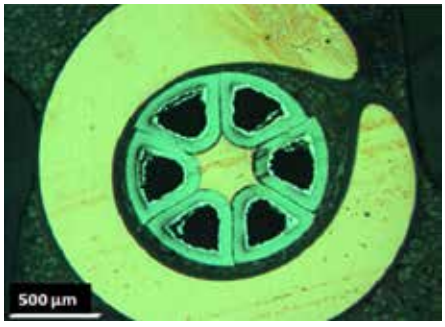
Three-dimensional (3D) hierarchical nanoscale architectures comprised of building blocks, with specifically engineered morphologies, are expected to play important roles in the fabrication of 'next generation' microelectronic and optoelectronic devices due to their high surface-to-volume ratio as well as opto-electronic properties. Herein, a series of well-defined 3D hierarchical rutile TiO_2 architectures (HRT) were successfully prepared using a facile hydrothermal method without any surfactant or template, simply by changing the concentration of hydrochloric acid used in the synthesis. The production of these materials provides, to the best of our knowledge, the first identified example of a ledgewise growth mechanism in a rutile TiO_2 structure. Also for the first time, a Dye-sensitized Solar Cell (DSC) combining a HRT is reported in conjunction with a high-extinction-coefficient metal-free organic sensitizer (D149), achieving a conversion efficiency of 5.5%, which is superior to ones employing P25 (4.5%), comparable to state-of-the-art commercial transparent titania anatase paste (5.8%). Further to this, an overall conversion efficiency 8.6% was achieved when HRT was used as the light scattering layer, a considerable improvement over the commercial transparent/reflector titania anatase paste (7.6%), a significantly smaller gap in performance than has been seen previously. (J. J. Lin et al., *Scientific Reports* 4, 5769 (2014))

FLY-EYE INSPIRED SUPERHYDROPHOBIC ANTI-FOGGING INORGANIC NANOSTRUCTURES



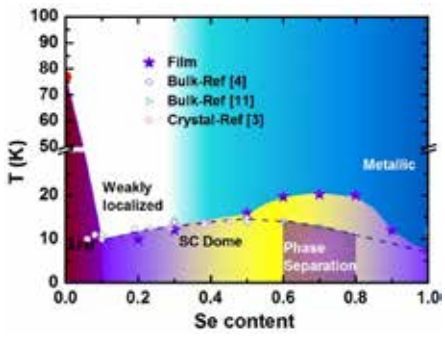
In nature, biological species have evolved optimal structures over millions of years with amazing characteristics and swift stimulus responsive capabilities, which give inspiration to researchers interested in the design of functional materials. Learning from nature takes ideas from natural species and develops novel functional materials based on these concepts, e.g ., bio-inorganic materials (biomineralization), bio-inspired multiscale structured materials (chiral morphologies), bionanomaterials (bio-nanoparticles), hybrid organic/inorganic implant materials (bonelike composites), and smart biomaterials. [1–9] Many of these smart materials have surfaces that dynamically alter their physicochemical properties in response to changes in their environmental conditions and to triggered control of interfacial properties. By mimicking the well-ordered multiscale structures of natural interfaces or surfaces, many artifi cial materials with bio-inspired functions have already been created. Herein, we propose a strategy based on rational synthesis of bio-inspired multifunctional nanostructures possessing well-defined surface properties by learning from the natural biological structures and functions of the compound eyes of the green bottle fly. (Z. Q. Sun et al., *Small* 10, 3001 (2014))

THE ROLES OF CHPD: SUPERIOR CRITICAL CURRENT DENSITY AND N-VALUE OBTAINED IN BINARY IN SITU MgB_2 CABLES



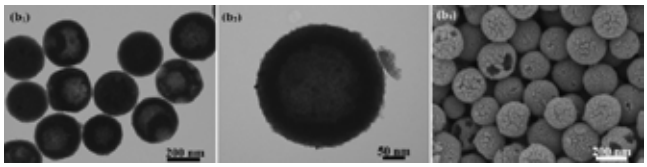
A binary magnesium diboride (MgB_2) cable has been assembled by braiding six Nb/Monel sheathed monofilament strands around a central copper stabilizer for improving the operational environment. The total critical current (I_c) of the braided cable is obtained by multiplying the I_c of six single wires, without any dissipation. In this work, various mechanical deformations, i.e., swaging, two-axial rolling, groove rolling, and cold high-pressure densification (CHPD) at 1.8 GPa have been applied to the 6-stranded cable to obtain additional densification. The highest critical current density at both 4.2 and 20 K has been achieved in this work through the CHPD treated cable due to higher filament mass density. The present results are promising in view of the cable, particularly in power applications at industrial lengths that pave the way to seeking an optimal protocol to meet a practical functionality. (M. S. A. Hossain et al., *Superconductor Science & Technology* 27, 095016 (2014))

UNABRIDGED PHASE DIAGRAM FOR SINGLE-PHASED $FeSe_xTe_{1-x}$ THIN FILMS



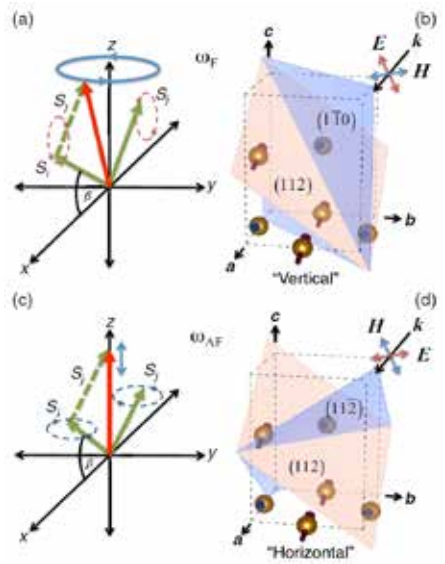
A complete phase diagram and its corresponding physical properties are essential prerequisites to understand the underlying mechanism of iron-based superconductivity. For the structurally simplest 11 (FeSeTe) system, earlier attempts using bulk samples have not been able to do so due to the fabrication difficulties. Here, thin $FeSe_xTe_{1-x}$ films with the Se content covering the full range ($0 \le x \le 1$) were fabricated by using pulsed laser deposition method. Crystal structure analysis shows that all films retain the tetragonal structure in room temperature. Significantly, the highest superconducting transition temperature (T_C = 20 K) occurs in the newly discovered domain, i.e. $0.6 \le x \le 0.8$. The single-phased superconducting dome for the full Se doping range is the first of its kind in iron chalcogenide superconductors. Our results present a new avenue to explore novel physics as well as to optimize superconductors. (J. C. Zhuang et al., *Scientific Reports* 4, 7273 (2014))

HOLLOW $MnCo_2O_4$ SUBMICROSPHERES WITH MULTILEVEL INTERIORS: FROM MESOPOROUS SPHERES TO YOLK-IN-DOUBLE-SHELL STRUCTURES



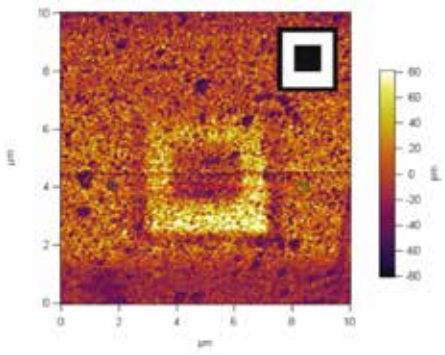
We present a general strategy to synthesize uniform $MnCo_2O_4$ submicrospheres with various hollow structures. By using MnCo-glycolate submicrospheres as the precursor with proper manipulation of ramping rates during the heating process, we have fabricated hollow $MnCo_2O_4$ submicrospheres with multilevel interiors, including mesoporous spheres, hollow spheres, yolk–shell spheres, shell-in-shell spheres, and yolk-in-double-shell spheres. Interestingly, when tested as anode materials in lithium ion batteries, the $MnCo_2O_4$ submicrospheres with a yolk–shell structure showed the best performance among these multilevel interior structures because these structures can not only supply a high contact area but also maintain a stable structure. (J. F. Li et al., *ACS Applied Materials & Interfaces* 6, 24 (2014))

COMPLEMENTARY TERAHERTZ ABSORPTION AND INELASTIC NEUTRON STUDY OF THE DYNAMIC ANISOTROPY CONTRIBUTION TO ZONE-CENTER SPIN WAVES IN A CANTED ANTIFERROMAGNET $NdFeO_3$



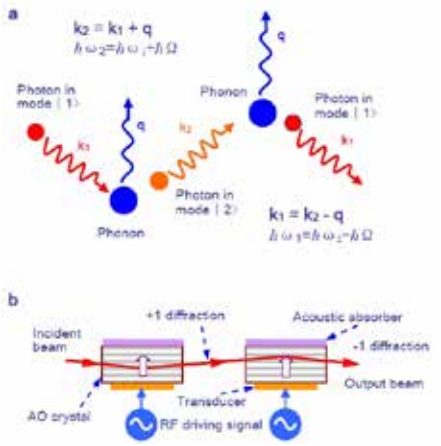
We employ a combination of pulsed- and continuous-wave polarized terahertz spectroscopy techniques to probe temperature-dependent spin waves in the antiferromagnet $NdFeO_3$. Our optical data span 1.6–467 K and reveal a conspicuous spin reorientation between 110 and 170 K, during which the lower-energy mode softens completely. Complementary inelastic neutron scattering reveals that the frequencies of the optically excited spin waves are consistent with a temperature-variable spin gap in the low-energy spin-wave dispersion of $NdFeO_3$. The result links the temperature dependence of the spin waves to a dynamic in-plane anisotropy. The magnetic anisotropy is calculated based on the results of the optical measurements. The change observed in the anisotropy energy along the a and c crystal axes suggests that the spin reorientation evident in $NdFeO_3$ is driven by temperature-dependent in-plane anisotropy. (E. Constable et al., *Physical Review* B 90, 054413 (2014))

INTERFACE STRAIN-INDUCED MULTIFERROICITY IN A $SmFeO_3$ FILM



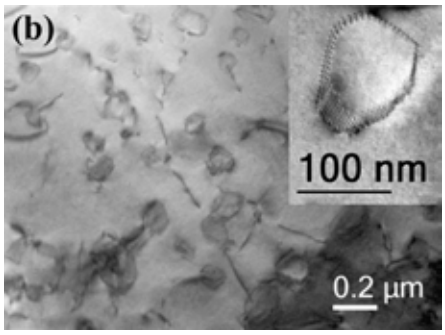
An epitaxial pseudocubic $SmFeO_3$ thin film on (100) Nb-$SrTiO_3$ was studied based on ferroelectric (FE) characterization and magnetic measurements. High-resolution transmission electron microscopy images clarify the nature of the epitaxial growth, the stress-induced structural distortion at the film/substrate interface, and the existence of two different orientation lattices. Clear grain boundaries can be seen, which could introduce an extra local distortion. Rectangular FE loops can be observed at room temperature, even by just applying a small voltage ranging from –1 to +1 V, indicative of the presence of FE polarization. Piezoelectric force microscopy images confirm the existence of FE domains and the switchable polarization. A strong ferromagnetic-like transition occurs around 185 K, which is much lower than the transition observed in the bulk sample. It is believed that the pseudocubic structure enhances FE polarization and decreases the magnetic ordering temperature, which is confirmed by the first-principles theoretical calculations. Meanwhile, the ferroelectricity in this thin film should originate from distortion and modification in the structural modules rather than from the exchange striction interaction that is found in the bulk $SmFeO_3$. (Z. X. Cheng et al., *ACS Applied Materials & Interfaces* 6, 7356 (2014))

PHOTONIC AHARONOV-BOHM EFFECT IN PHOTON-PHONON INTERACTIONS



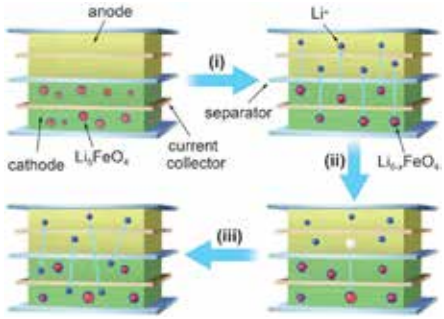
The Aharonov-Bohm effect is one of the most intriguing phenomena in both classical and quantum physics, and associates with a number of important and fundamental issues in quantum mechanics. The Aharonov-Bohm effects of charged particles have been experimentally demonstrated and found applications in various fields. Recently, attention has also focused on the Aharonov-Bohm effect for neutral particles, such as photons. Here we propose to utilize the photon-phonon interactions to demonstrate that photonic Aharonov-Bohm effects do exist for photons. By introducing nonreciprocal phases for photons, we observe experimentally a gauge potential for photons in the visible range based on the photon-phonon interactions in acousto-optic crystals, and demonstrate the photonic Aharonov-Bohm effect. The results presented here point to new possibilities to control and manipulate photons by designing an effective gauge potential. (E. B. Li et al., *Nature Communications* 5, 3225 (2014))

THERMOELECTRIC PERFORMANCE OF N-TYPE $(PbTe)_{0.75}(PbS)_{0.15}(PbSe)_{0.1}$ COMPOSITES



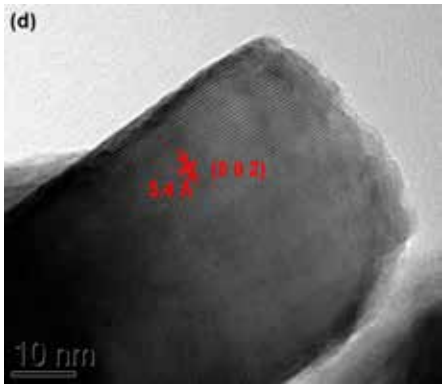
Lead chalcogenides (PbQ, Q = Te, Se, S) have proved to possess high thermoelectric efficiency for both n-type and p-type compounds. Recent success in tuning of electronic band structure, including manipulating the band gap, multiple bands, or introducing resonant states, has led to a significant improvement in the thermoelectric performance of p-type lead chalcogenides compared to the n-type ones. Here , the n - type quaternary composites of $(PbTe)_{0.75}(PbS)_{0.15}(PbSe)_{0.1}$ are studied to evaluate the effects of nanostructuring on lattice thermal conductivity, carrier mobility, and effective mass variation. The results are compared with the similar ternary systems of $(PbTe)_{1-x}(PbSe)_x$, $(PbSe)_{1-x}(PbS)_x$, and $(PbS)_{1-x}(PbTe)_x$. The reduction in the lattice thermal conductivity owing to phonon scattering at the defects and interfaces was found to be compensated by reduced carrier mobility. This results in a maximum figure of merit, zT, of ~1.1 at 800 K similar to the performance of the single phase alloys of PbTe, PbSe, and $(PbTe)_{1-x}(PbSe)_x$. (S. Aminorroaya-Yamini et al., *ACS Applied Materials & Interfaces* 6, 11476 (2014))

SCALABLE INTEGRATION OF Li_5FeO_4 TOWARDS ROBUST, HIGH-PERFORMANCE LITHIUM-ION HYBRID CAPACITORS



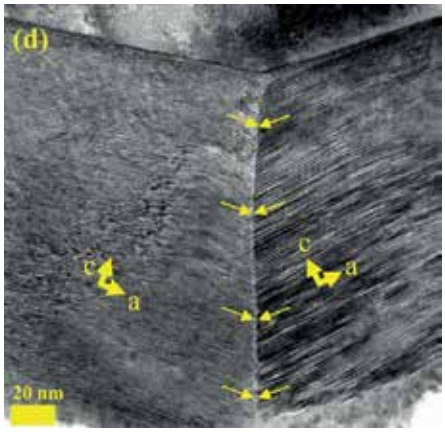
Lithium-ion hybrid capacitors have attracted great interest due to their high specific energy relative to conventional electrical double-layer capacitors. Nevertheless, the safety issue still remains a drawback for lithium-ion capacitors in practical operational environments because of the use of metallic lithium. Herein, single-phase Li_5FeO_4 with an antifluorite structure that acts as an alternative lithium source (instead of metallic lithium) is employed and its potential use for lithium-ion capacitors is verified. Abundant Li+ amounts can be extracted from Li_5FeO_4 incorporated in the positive electrode and efficiently doped into the negative electrode during the first electrochemical charging. After the first Li+ extraction, Li+ does not return to the Li_5FeO_4 host structure and is steadily involved in the electrochemical reactions of the negative electrode during subsequent cycling. Various electrochemical and structural analyses support its superior characteristics for use as a promising lithium source. This versatile approach can yield a sufficient Li+-doping efficiency of >90% and improved safety as a result of the removal of metallic lithium from the cell. (M. S. Park et al., *ChemSusChem* 7, 3138 (2014))

ELECTROSPUN P2-TYPE $Na_{2/3}(Fe_{1/2}Mn_{1/2})O_2$ HIERARCHICAL NANOFIBERS AS CATHODE MATERIAL FOR SODIUM-ION BATTERIES



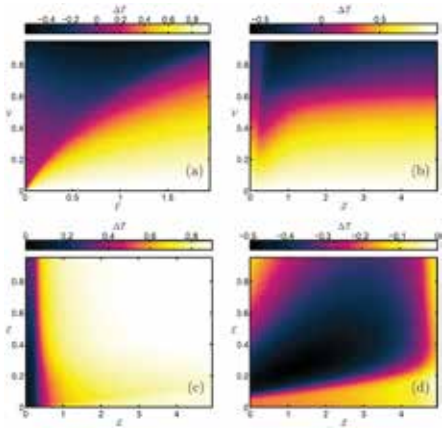
Sodium-ion batteries can be the best alternative to lithium-ion batteries, because of their similar electrochemistry, nontoxicity, and elemental abundance and the low cost of sodium. They still stand in need of better cathodes in terms of their structural and electrochemical aspects. Accordingly, the present study reports the first example of the preparation of $Na_{2/3}(Fe_{1/2}Mn_{1/2})O_2$ hierarchical nanofibers by electrospinning. The nanofibers with aggregated nanocrystallites along the fiber direction have been characterized structurally and electrochemically, resulting in enhanced cyclability when compared to nanoparticles, with initial discharge capacity of ~195 mAh g^{-1}. This is attributed to the good interconnection among the fibers, with well-guided charge transfers and better electrolyte contacts. (S. Kalluri et al., *ACS Applied Materials & Interfaces* 6, 8953 (2014))

ENHANCING PROPERTIES OF HIGH-TEMPERATURE SUPERCONDUCTING STEP-EDGE JOSEPHSON JUNCTIONS BY NANO-MULTILAYERS WITH A SMALL MISMATCH



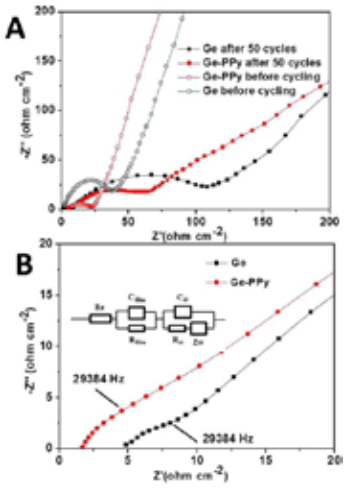
A new technology for high temperature superconducting Josephson tunnelling junctions is developed to enhance their properties for applications on-a-chip, avoiding additional fabrication complexity. Junctions with alternating nano-layers of $YBa_2Cu_3O_7$ and $NdBa_2Cu_3O_7$ superconductors with a small mismatch between their crystal lattices exhibit stronger tunneling properties due to tuning the artificial grain boundary interfaces of the junctions (A. V. Pan et al., *Advanced Materials Interfaces* 1, 1300112 (2014))

CHIRAL-LIKE TUNNELING OF ELECTRONS IN TWO-DIMENSIONAL SEMICONDUCTORS WITH RASHBA SPIN-ORBIT COUPLING



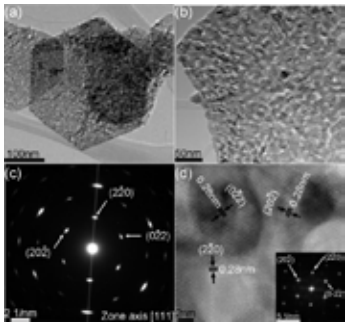
The unusual tunneling effects of massless chiral fermions (mCF) and massive chiral fermions (MCF) in a single layer graphene and bilayer graphene represent some of the most bizarre quantum transport phenomena in condensed matter system. Here we show that in a two-dimensional semiconductor with Rashba spin-orbit coupling (R2DEG), the real-spin chiral-like tunneling of electrons at normal incidence simultaneously exhibits features of mCF and MCF. The parabolic branch of opposite spin in R2DEG crosses at a Dirac-like point and has a band turning point. These features generate transport properties not found in usual twodimensional electron gas. Albeit its p Berry phase, electron backscattering is present in R2DEG. An electron mimics mCF if its energy is in the vicinity of the subband crossing point or it mimics MCF if its energy is near the subband minima. (Y. S. Ang et al., *Scientific Reports* 4, 3780 (2014))

NOVEL GERMANIUM/POLYPYRROLE COMPOSITE FOR HIGH POWER LITHIUM-ION BATTERIES



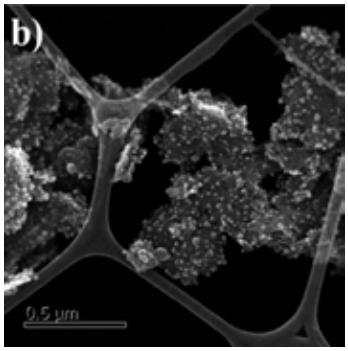
Nano-Germanium/polypyrrole composite has been synthesized by chemical reduction method in aqueous solution. The Ge nanoparticles were directly coated on the surface of the polypyrrole. The morphology and structural properties of samples were determined by X-ray diffraction, scanning electron microscopy and transmission electron microscopy. Thermogravimetric analysis was carried out to determine the polypyrrole content. The electrochemical properties of the samples have been investigated and their suitability as anode materials for the lithium-ion battery was examined. The discharge capacity of the Ge nanoparticles calculated in the Ge-polypyrrole composite is 1014 mAh g^{-1} after 50 cycles at 0.2 C rate, which is much higher than that of pristine germanium (439 mAh g^{-1}). The composite also demonstrates high specific discharge capacities at different current rates (1318, 1032, 661, and 460 mAh g^{-1} at 0.5, 1.0, 2.0, and 4.0 C, respectively). The superior electrochemical performance of Ge-polypyrrole composite could be attributed to the polypyrrole core, which provides an efficient transport pathway for electrons. SEM images of the electrodes have demonstrated that polypyrrole can also act as a conductive binder and alleviate the pulverization of electrode caused by the huge volume changes of the nanosized germanium particles during Li^+ intercalation/deintercalation. (X. W. Gao et al., *Scientific Reports* 4, 6095 (2014))

MESOCRYSTAL Co_3O_4 NANOPLATELETS AS HIGH CAPACITY ANODE MATERIALS FOR LI-ION BATTERIES



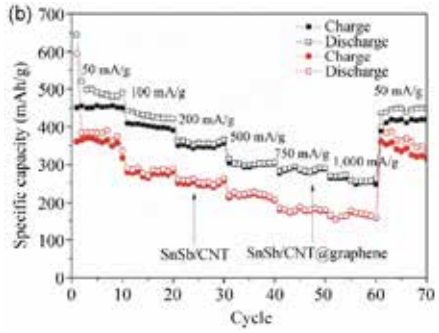
Faceted crystals with exposed highly reactive planes have attracted intensive investigations for applications. Herein, we demonstrate a general synthetic method to prepare mesocrystal Co_3O_4 with predominantly exposed {111} reactive facets by the in situ thermal decomposition from $Co(OH)_2$ nanoplatelets. The mesocrystal feature was identified by field emission scanning electron microscopy, transmission electron microscopy, selected area electron diffraction, and N_2 isotherm analyses. When applied as anode material in lithium-ion batteries, mesocrystal Co_3O_4 nanoplatelets delivered a high specific capacity and an outstanding high rate performance. The superior electrochemical performance should be ascribed to the predominantly exposed {111} active facets and highly accessible surfaces. This synthetic strategy could be extended to prepare other mesocrystal functional nanomaterials. (D. W. Su et al., *Nano Research* 7, 794 (2014))

SULFUR-GRAPHENE NANOSTRUCTURED CATHODES VIA BALL-MILLING FOR HIGH-PERFORMANCE LITHIUM-SULFUR BATTERIES



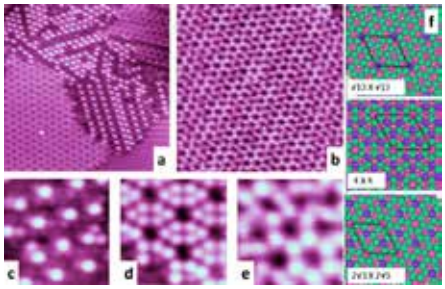
Although much progress has been made to develop high-performance lithium_sulfur batteries (LSBs), the reported physical or chemical routes to sulfur cathode materials are often multistep/complex and even involve environmentally hazardous reagents, and hence are infeasible for mass production. Here, we report a simple ball-milling technique to combine both the physical and chemical routes into a one-step process for low-cost, scalable, and eco-friendly production of graphene nanoplatelets (GnPs) edge-functionalized with sulfur (S-GnPs) as highly efficient LSB cathode materials of practical significance. LSBs based on the S-GnP cathode materials, produced by ball-milling 70 wt % sulfur and 30 wt % graphite, delivered a high initial reversible capacity of 1265.3 mAh g^{-1} at 0.1 C in the voltage range of 1.5-3.0 V with an excellent rate capability, followed by a high reversible capacity of 966.1 mAh g^{-1} at 2 C with a low capacity decay rate of 0.099% per cycle over 500 cycles, outperformed the current state-of-the-art cathode materials for LSBs. The observed excellent electrochemical performance can be attributed to a 3D "sandwich-like" structure of S-GnPs with an enhanced ionic conductivity and lithium insertion/extraction capacity during the discharge_charge process. Furthermore, a low-cost porous carbon paper pyrolyzed from common filter paper was inserted between the 0.7S-0.3GnP electrode and porous polypropylene film separator to reduce/eliminate the dissolution of physically adsorbed polysulfide into the electrolyte and subsequent cross-deposition on the anode, leading to further improved capacity and cycling stability. (J. T. Xu et al., *ACS Nano* 8, 10920 (2014))

SnSb@CARBON NANOCABLE ANCHORED ON GRAPHENE SHEETS FOR SODIUM ION BATTERIES



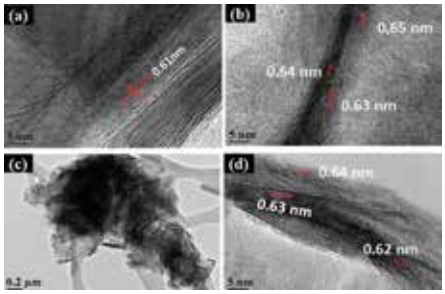
The development of materials with unique nanostructures is an effective strategy for the improvement of sodium storage in sodium ion batteries to achieve stable cycling performance and good rate capability. In this work, SnSb core/ carbon-shell nanocables directly anchored on graphene sheets (GS) were synthesized by the hydrothermal technique and chemical vapor deposition. The simultaneous carbon coating and the encapsulation of SnSb alloy is effective for alleviating the volume-change problem in sodium ion batteries. After optimizing the electrolyte for SnSb in the sodium ion batteries, the optimized coaxial SnSb/carbon nanocable/ GS (SnSb/CNT@GS) nanostructure demonstrated stable cycling capability and rate performance in 1 M $NaClO_4$ with propylene carbonate (PC) + 5% fluoroethylene carbonate (FEC). The SnSb/CNT@GS electrode can retain a capacity of 360 mAh/g for up to 100 cycles, which is 71% of the theoretical capacity. This is higher than in the other three electrolytes tested (1 M $NaClO_4$ in PC, 1 M $NaClO_4$ in PC/FEC (1:1 v/v) and 1 M $NaPF_6$ + PC), and higher than that of the sample without the addition of graphene. The good electrochemical performance can be attributed to the efficient buffering provided by the outer carbon nanocable layer and the graphene inhibiting the agglomeration of SnSb particles, as well as its high conductivity. (L. Li et al., *Nano Research* 7, 1466 (2014))

TUNING THE BAND GAP IN SILICENE BY OXIDATION



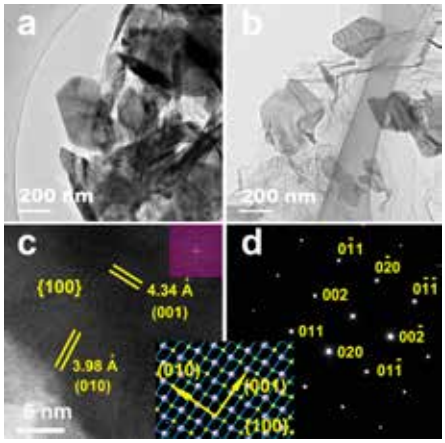
Silicene monolayers grown on Ag(111) surfaces demonstrate a band gap that is tunable by oxygen adatoms from semimetallic to semiconducting type. With the use of low-temperature scanning tunneling microscopy, we find that the adsorption configurations and amounts of oxygen adatoms on the silicene surface are critical for band gap engineering, which is dominated by different buckled structures in$\sqrt{13} \times \sqrt{13}$, 4×4, and $2\sqrt{3} \times 2\sqrt{3}$ silicene layers. The Si-O-Si bonds are the most energy-favored species formed on $\sqrt{13} \times \sqrt{13}$, 4×4, and $2\sqrt{3} \times 2\sqrt{3}$ structures under oxidation, which is verified by in situ Raman spectroscopy as well as first-principles calculations. The silicene monolayers retain their structures when fully covered by oxygen adatoms. Our work demonstrates the feasibility of tuning the band gap of silicene with oxygen adatoms, which, in turn, expands the base of available two-dimensional electronic materials for devices with properties that is hardly achieved with graphene oxide. (Y. Du et al., *ACS Nano* 8, 10019 (2014))

REVERSIBLE SODIUM STORAGE VIA CONVERSION REACTION OF A MoS_2–C COMPOSITE



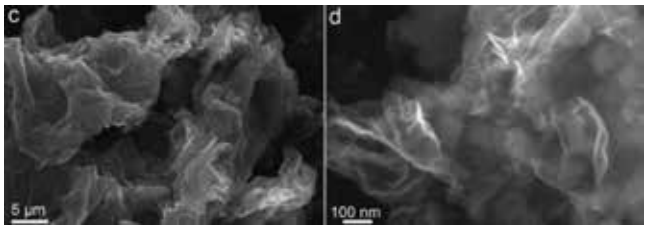
An exfoliated MoS_2–C composite (E-MoS_2–C) was prepared via simple chemical exfoliation and a hydrothermal method. The obtained E-MoS_2–C was tested as an anode material for sodium ion batteries. High capacity (~400 mA h g^{-1}) at 0.25 C (100 mAg^{-1}) was maintained over prolonged cycling life (100 cycles). Outstanding rate capability was also achieved with a capacity of 290 mA h g^{-1} at 5 C. (Y. X. Wang et al., *Chemical Communications* 50, 10730 (2014))

ENHANCED SODIUM-ION BATTERY PERFORMANCE BY STRUCTURAL PHASE TRANSITION FROM TWO-DIMENSIONAL HEXAGONAL-SnS_2 TO ORTHORHOMBIC-SnS



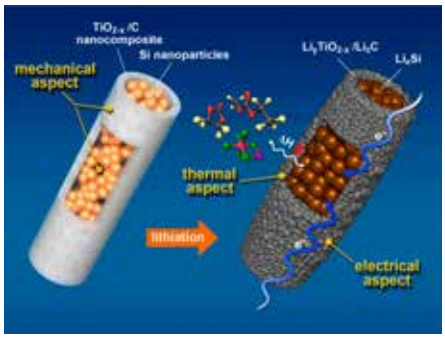
Structural phase transitions can be used to alter the properties of a material without adding any additional elements and are therefore of significant technological value. It was found that the hexagonal-SnS_2 phase can be transformed into the orthorhombic-SnS phase after an annealing step in an argon atmosphere, and the thus transformed SnS shows enhanced sodium-ion storage performance over that of the SnS_2, which is attributed to its structural advantages. Here, we provide the first report on a SnS@graphene architecture for application as a sodium-ion battery anode, which is built from two-dimensional SnS and graphene nanosheets as complementary building blocks. The as-prepared SnS@graphene hybrid nanostructured composite delivers an excellent specific capacity of 940 mAh $g^{-1}$and impressive rate capability of 492 and 308 mAh g_{-1} after 250 cycles at the current densities of 810 and 7290 mA g^{-1}, respectively. The performance was found to be much better than those of most reported anode materials for Na-ion batteries. On the basis of combined ex situ Fourier transform infrared spectroscopy, X-ray photoelectron spectroscopy, and ex situ X-ray diffraction, the formation mechanism of SnS@graphene and the synergistic Na-storage reactions of SnS in the anode are discussed in detail. The SnS experienced a two-structural-phase transformation mechanism (orthorhombic-SnS to cubic-Sn to orthorhombic-$Na_{3.75}Sn$), while the SnS_2 experienced a three-structural-phase transformation mechanism (hexagonal-SnS_2 to tetragonal-Sn to orthorhombic-$Na_{3.75}Sn$) during the sodiation process. The lesser structural changes of SnS during the conversion are expected to lead to good structural stability and excellent cycling stability in its sodium-ion battery performance. These results demonstrate that the SnS@graphene architecture offers unique characteristics suitable for high-performance energy storage application. (T. F. Zhou et al., *ACS Nano* 8, 8323 (2014))

WS2@GRAPHENE NANOCOMPOSITES AS ANODE MATERIALS FOR NA-ION BATTERIES WITH ENHANCED ELECTROCHEMICAL PERFORMANCES



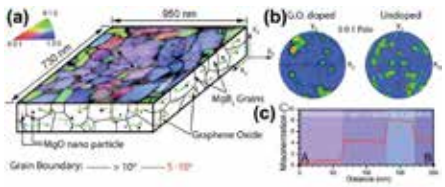
WS2@graphene nanocomposites were synthesized by a hydrothermal approach. When applied as anodes in Na-ion batteries, the WS2@graphene nanocomposite exhibited a high reversible sodium storage capacity of about 590 mA h g-1. It also demonstrated excellent high rate performance and cyclability. (D. W. Su et al., *Chemical Communications* 50, 4192 (2014))

CORE-SHELL STRUCTURED SILICON NANOPARTICLES@TiO_{2-x}/CARBON MESOPOROUS MICROFIBER COMPOSITE AS A SAFE AND HIGH-PERFORMANCE LITHIUM-ION BATTERY ANODE



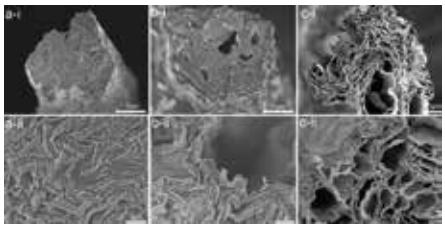
A core_shell structured Si nanoparticles@TiO_{2-x}/C mesoporous microfiber composite has been synthesized by an electrospinning method. The core_shell composite exhibits high reversible capacity, excellent rate capability, and improved cycle performance as an anode material for Li-ion batteries. Furthermore, it shows remarkable suppression of exothermic behavior, which can prevent possible thermal runaway and safety problems of the cells. The improved electrochemical and thermal properties are ascribed to the mechanically, electrically, and thermally robust shell structure of the TiO_{2-x}/C nanocomposite encapsulating the Si nanoparticles, which is suggested as a promising material architecture for a safe and reliable Si-based Li-ion battery of high energy density. (G. J. Jeong et al., *ACS Nano* 8, 2977 (2014))

ON THE ROLES OF GRAPHENE OXIDE DOPING FOR ENHANCED SUPERCURRENT IN MgB_2 BASED SUPERCONDUCTORS



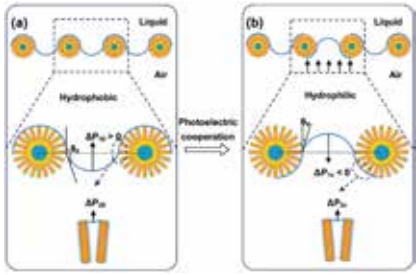
Due to their graphene-like properties after oxygen reduction, incorporation of graphene oxide (GO) sheets into correlated-electron materials offers a new pathway for tailoring their properties. Fabricating GO nanocomposites with polycrystalline MgB_2 superconductors leads to an order of magnitude enhancement of the supercurrent at 5 K/8 T and 20 K/4 T. Herein, we introduce a novel experimental approach to overcome the formidable challenge of performing quantitative microscopy and microanalysis of such composites, so as to unveil how GO doping influences the structure and hence the material properties. Atom probe microscopy and electron microscopy were used to directly image the GO within the MgB_2, and we combined these data with computational simulations to derive the property-enhancing mechanisms. Our results reveal synergetic effects of GO, namely, via localized atomic (carbon and oxygen) doping as well as texturing of the crystals, which provide both inter- and intra-granular flux pinning. This study opens up new insights into how low-dimensional nanostructures can be integrated into composites to modify the overall properties, using a methodology amenable to a wide range of applications. (W. K. Yeoh et al., *Nanoscale* 6, 6166 (2014))

HIGH-PERFORMANCE MULTIFUNCTIONAL GRAPHENE YARNS: TOWARD WEARABLE ALL-CARBON ENERGY STORAGE TEXTILES



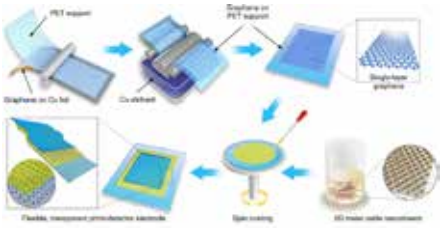
The successful commercialization of smart wearable garments is hindered by the lack of fully integrated carbon-based energy storage devices into smart wearables. Since electrodes are the active components that determine the performance of energy storage systems, it is important to rationally design and engineer hierarchical architectures atboth the nano- and macroscale that can enjoy all of the necessary requirements for a perfect electrode. Here we demonstrate a large-scale flexible fabrication of highly porous high-performance multifunctional graphene oxide (GO) and rGO fibers and yarns by taking advantage of the intrinsic soft self-assembly behavior of ultralarge graphene oxide liquid crystalline dispersions. The produced yarns, which are the only practical form of these architectures for real-life device applications, were found to bemechanically robust (Young's modulus in excess of 29 GPa) and exhibited high native electrical conductivity (2508 ± 632 S m^{-1}) and exceptionally high specific surface area (2605 m^2 g^{-1} before reduction and 2210 m^2 g^{-1} after reduction). Furthermore, the highly porous nature of these architectures enabled us to translate the superior electrochemical properties of individual graphene sheets into practical everyday use devices with complex geometrical architectures. The as-prepared final architectures exhibited an open network structure with a continuous ion transport network, resulting in unrivaled charge storage capacity (409 F g^{-1} at 1 A g^{-1}) and rate capability (56 F g^{-1} at 100 A g^{-1}) while maintaining their strong flexible nature. (S. H. Aboutalebi et al., *ACS Nano* 8, 2456 (2014))

PHOTOELECTRIC COOPERATIVE PATTERNING OF LIQUID PERMEATION ON THE MICRO/NANO HIERARCHICALLY STRUCTURED MESH FILM WITH LOW ADHESION



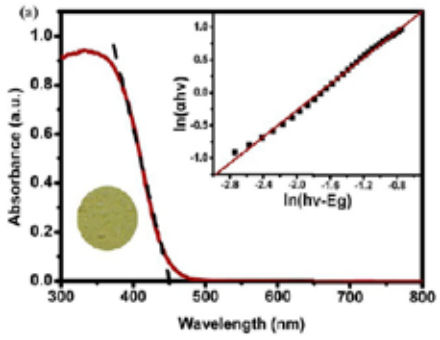
Stimuli-responsive surface wettability has been intensively studied, especially wettability controlled by photoelectric cooperation, which appears to be a trend for more effective surface wetting. In this field, the patterning of controllable surface wettability is still a challenge in the application of liquid-printing techniques because of the high adhesion and high responsive voltage, as well as low mechanical strength, of the substrate. Herein, we have demonstrated the patterning of liquid permeation controlled by photoelectric cooperative wetting on the micro/nano hierarchically structured ZnO mesh film. The special micro/nano hierarchically structured ZnO mesh is beneficial for lowering adhesion force on the mesh surface than those of the TiO_2/AAO nanopore array films previously reported for the discontinuous tri-phase contact line, in addition to precisely controlled microscale liquid movement with considerably lower threshold voltage for the hierarchical structure. Moreover, the stainless-steel mesh with different pore sizes as a substrate behaves with higher mechanical strength and lower cost, compared with the anodized Ti mesh. Thus, this work is promising for accelerating the development of patterned liquid permeation and extending the application of micro/nanofluidic system and micronanoelectronic technology. (Z. Y. Gao et al., *Nanoscale* 6, 12822 (2014))

GENERALIZED SELF-ASSEMBLY OF SCALABLE TWO-DIMENSIONAL TRANSITION METAL OXIDE NANOSHEETS



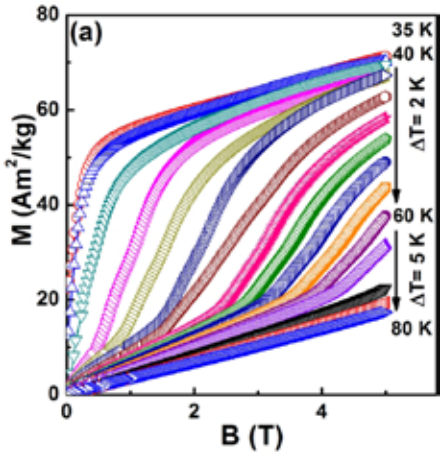
Two-dimensional (2D) transition metal oxide systems present exotic electronic properties and high specific surface areas, and also demonstrate promising applications ranging from electronics to energy storage. Yet, in contrast to other types of nanostructures, the question as to whether we could assemble 2D nanomaterials with an atomic thickness from molecules in a general way, which may give them some interesting properties such as those of graphene, still remains unresolved. Herein, we report a generalized and fundamental approach to molecular self-assembly synthesis of ultrathin 2D nanosheets of transition metal oxides by rationally employing lamellar reverse micelles. It is worth emphasizing that the synthesized crystallized ultrathin transition metal oxide nanosheets possess confined thickness, high specific surface area and chemically reactive facets, so that they could have promising applications in nanostructured electronics, photonics, sensors, and energy conversion and storage devices. (Z. Q. Sun et al., *Nature Communications* 5, 4813 (2014))

BISMUTH OXYBROMIDE WITH REASONABLE PHOTOCATALYTIC REDUCTION ACTIVITY UNDER VISIBLE LIGHT



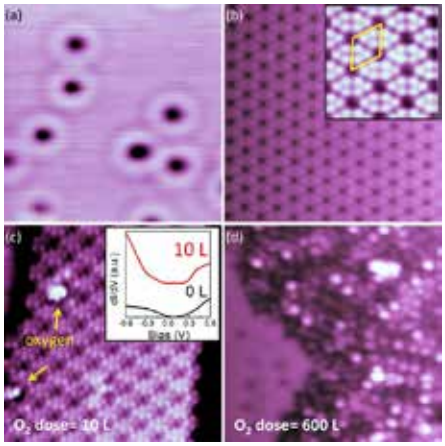
The original bismuth-based oxyhalide, known as the Sillén family, is an important photocatalyst due to its high photocatalytic oxidation activity. Here, we report a bismuth-based photocatalyst, $Bi_{24}O_{31}Br_{10}$, with reasonable reduction activity. The photoreduction capability of $Bi_{24}O_{31}Br_{10}$ in H_2 evolution from water reduction is 133.9 μmol after 40 h under visible light irradiation. $Bi_{24}O_{31}Br_{10}$ presents the highest activity among Bi_2O_3, BiOBr, and $Bi_{24}O_{31}Br_{10}$ in photocatalytic reduction of the Cr (VI) test, and Cr (VI) ions are totally removed in 40 min. The Mott-Schottky test shows the bottom of the conduction band fits the electric potential requirements for splitting water to H_2. First-principles calculations indicate the conduction band of $Bi_{24}O_{31}Br_{10}$ mainly consists of hybridized Bi 6p and Br 4s orbitals, which may contribute to the uplifting of the conduction band. (J. Shang et al., *ACS Catalysis* 4, 954 (2014))

MAGNETIC PHASE TRANSITIONS AND ENTROPY CHANGE IN LAYERED $NdMn_{1.7}Cr_{0.3}Si_2$



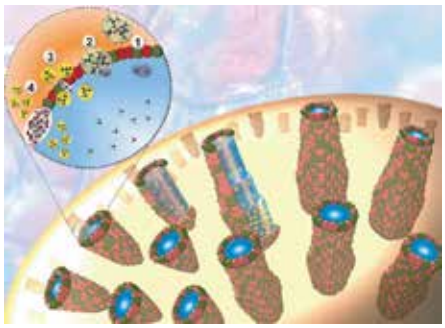
A giant magnetocaloric effect has been observed around the Curie temperature, TC ~ 42 K, in $NdMn_{1.7}Cr_{0.3}Si_2$ with no discernible thermal and magnetic hysteresis losses. Below 400 K, three magnetic phase transitions take place around 380 K, 320 K and 42 K. Detailed high resolution synchrotron and neutron powder diffraction (10-400 K) confirmed the magnetic transitions and phases as follows: TN intra ~ 380 K denotes the transition from paramagnetism to intralayer antiferromagnetism (AFl), TN inter ~ 320 K represents the transition from the AFl structure to the canted antiferromagnetic spin structure (AFmc), while TC ~ 42 K denotes the first order magnetic transition from AFmc to canted ferromagnetism (Fmc + F(Nd)) due to ordering of the Mn and Nd sub-lattices. The maximum values of the magnetic entropy change and the adiabatic temperature change, around T_C for a field change of 5 T are evaluated to be −ΔSM max ~ 15.9 J kg−1 K−1 and ΔTad max ~ 5 K, respectively. The first order magnetic transition associated with the low levels of hysteresis losses (thermal <~0.8 K; magnetic field <~0.1 T) in $NdMn_{1.7}Cr_{0.3}Si_2$ offers potential as a candidate for magnetic refrigerator applications in the temperature region below 45 K. (M. F. M. Din et al., *Applied Physics Letters* 104, 042401 (2014))

EFFECTS OF OXYGEN ADSORPTION ON THE SURFACE STATE OF EPITAXIAL SILICENE ON Ag (111)



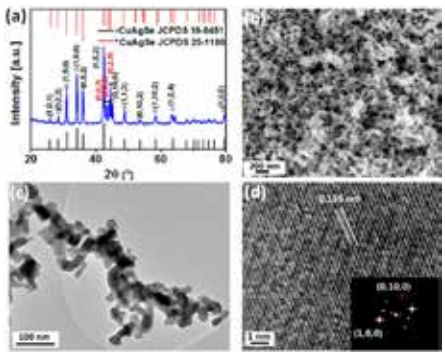
Epitaxial silicene, which is one single layer of silicon atoms packed in a honeycomb structure, demonstrates a strong interaction with the substrate that dramatically affects its electronic structure. The role of electronic coupling in the chemical reactivity between the silicene and the substrate is still unclear so far, which is of great importance for functionalization of silicene layers. Here, we report the reconstructions and hybridized electronic structures of epitaxial 4 3 4 silicene on Ag(111), which are revealed by scanning tunneling microscopy and angle-resolved photoemission spectroscopy. The hybridization between Si and Ag results in a metallic surface state, which can gradually decay due to oxygen adsorption. X-ray photoemission spectroscopy confirms the decoupling of Si-Ag bonds after oxygen treatment as well as the relatively oxygen resistance of Ag(111) surface, in contrast to 4 3 4 silicene [with respect to Ag(111)]. First-principles calculations have confirmed the evolution of the electronic structure of silicene during oxidation. It has been verified experimentally and theoretically that the high chemical activity of 4 3 4 silicene is attributable to the Si p(z) state, while the Ag(111) substrate exhibits relatively inert chemical behavior. (X. Xu et al., *Scientific Reports* 4, 7543 (2014))

CHANNELLED POROUS TiO_2 SYNTHESIZED WITH A WATER-IN-OIL MICROEMULSION



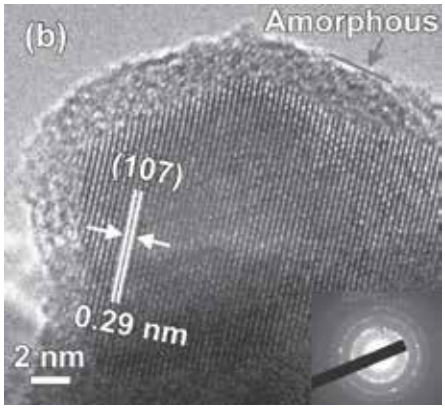
Porous titanium dioxide synthesized with a bicontinuous surfactant template is a promising method that leads to a high active surface area electrode. The template used is based on a water/isooctane/dioctyl sodium sulfosuccinate salt together with lecithin. Several parameters were varied during the synthesis to understand and optimize channel formation mechanisms. The material is patterned in stacked conical channels, widening towards the centre of the grains. The active surface area increased by 116% when the concentration of alkoxide precursors was decreased and increased by 241% when the template formation temperature was decreased to 108C. Increasing the oil phase viscosity tends to widen the pore aperture, thus decreasing the overall active surface area. Changing the phase proportions alters the microemulsion integrity and disrupts channel formation. (V. Malgras et al., *Chemistry – A European Journal* 20, 10451 (2014))

AMBIENT SCALABLE SYNTHESIS OF SURFACTANT-FREE THERMOELECTRIC CUAGSE NANOPARTICLES WITH REVERSIBLE METALLIC-N-P CONDUCTIVITY TRANSITION



Surfactant-free CuAgSe nanoparticles were successfully synthesized on a large scale within a short reaction time via a simple environmentally friendly aqueous approach under room temperature. The nanopowders obtained were consolidated into pellets for investigation of their thermoelectric properties between 3 and 623 K. The pellets show strong metallic characteristics below 60 K and turn into an n-type semiconductor with increasing temperature, accompanied by changes in the crystal structure (i.e., from the pure tetragonal phase into a mixture of tetragonal and orthorhombic phases), the electrical conductivity, the Seebeck coefficient, and the thermal conductivity, which leads to a figure of merit (ZT) of 0.42 at 323 K. The pellets show further interesting temperature-dependent transition from n-type into p-type in electrical conductivity arising from phase transition (i.e., from the mixture phases into cubic phase), evidenced by the change of the Seebeck coefficient from −28 μV/K into 226 μV/K at 467 K. The ZT value increased with increasing temperature after the phase transition and reached 0.9 at 623 K. The sintered CuAgSe pellets also display excellent stability, and there is no obvious change observed after 5 cycles of consecutive measurements. Our results demonstrate the potential of CuAgSe to simultaneously serve (at different temperatures) as both an n-type and a p-type thermoelectric material. (C. Han et al., *Journal of the American Chemical Society* 136, 17626 (2014))

$Sn_{4+x}P_3$ @ AMORPHOUS Sn-P COMPOSITES AS ANODES FOR SODIUM-ION BATTERIES WITH LOW COST, HIGH CAPACITY, LONG LIFE, AND SUPERIOR RATE CAPABILITY

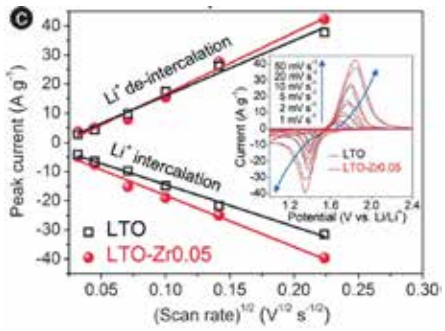


$Sn_{4+}xP_3$ @ amorphous Sn-P composites are a promising cheap anode material for sodium-ion batteries with high capacity (502 mA h g^{-1} at a current density of 100 mA g^{-1}), long cycling stability (92.6% capacity retention up to 100 cycles), and high rate capability (165 mA h g^{-1} at the 10C rate). (W. Li et al., *Advanced Materials* 26, 4037 (2014))

BIO-INSPIRED MULTIFUNCTIONAL METALLIC FOAMS THROUGH THE FUSION OF DIFFERENT BIOLOGICAL SOLUTIONS

Nature is a school for scientists and engineers. Inherent multiscale structures of biological materials exhibit multifunctional integration. In nature, the lotus, the water strider, and the fl ying bird evolved different and optimized biological solutions to survive. In this contribution, inspired by the optimized solutions from the lotus leaf with superhydrophobic self-cleaning, the water strider leg with durable and robust superhydrophobicity, and the lightweight bird bone with hollow structures, multifunctional metallic foams with multiscale structures are fabricated, demonstrating low adhesive superhydrophobic self-cleaning, striking loading capacity, and superior repellency towards different corrosive solutions. This approach provides an effective avenue to the development of water strider robots and other aquatic smart devices fl oating on water. Furthermore, the resultant multifunctional metallic foam can be used to construct an oil/water separation apparatus, exhibiting a high separation effi ciency and long-term repeatability. The presented approach should provide a promising solution for the design and construction of other multifunctional metallic foams in a large scale for practical applications in the petro-chemical fi eld. Optimized biological solutions continue to inspire and to provide design idea for the construction of multiscale structures with multifunctional integration. (X. Jin et al., *Advanced Functional Materials* 24, 2721 (2014))

Zr^{4+} DOPING IN $Li_4Ti_5O_{12}$ ANODE FOR LITHIUM-ION BATTERIES: OPEN Li^+ DIFFUSION PATHS THROUGH STRUCTURAL IMPERFECTION



One-dimensional nanomaterials have short Li^+ diffusion paths and promising structural stability, which results in a long cycle life during Li^+ insertion and extraction processes in lithium rechargeable batteries. In this study, we fabricated one-dimensional spinel $Li_4Ti_5O_{12}$ (LTO) nanofibers using an electrospinning technique and studied the Zr^{4+} doping effect on the lattice, electronic structure, and resultant electrochemical properties of Li-ion batteries (LIBs). Accommodating a small fraction of Zr^{4+} ions in the Ti^{4+} sites of the LTO structure gave rise to enhanced LIB performance, which was due to structural distortion through an increase in the average lattice constant and thereby enlarged Li+ diffusion paths rather than changes to the electronic structure. Insulating ZrO_2 nanoparticles present between the LTO grains due to the low Zr^{4+} solubility had a negative effect on the Li^+ extraction capacity, however. These results could provide key design elements for LTO anodes based on atomic level insights that can pave the way to an optimal protocol to achieve particular functionalities. (J. G. Kim et al., *ChemSusChem* 7, 1451 (2014))

CONFERENCES

BAJC ANNUAL CONFERENCE (22ND – 24TH JANUARY 2014, MELBOURNE, AUSTRALIA)

"Advanced copper chalcogenide nanostructures for thermoelectrics", Z. Li

ASIA PACIFIC CONFERENCE ON ELECTROCHEMICAL ENERGY STORAGE AND CONVERSION (5TH – 8TH FEBRUARY 2014, BRISBANE, AUSTRALIA)

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

"Synthesis of nanoporous sulfur-graphite composite for lithium/sulfur batteries via a one-step, continuous, and industry-oriented spray pyrolysis-melting method", J. Z. Wang

"Development of nanomaterials for lithium ion batteries", H. K. Liu (Keynote Speaker)

THE 14TH INTERNATIONAL SYMPOSIUM ON METAL-HYDROGEN SYSTEMS (MH2014) (20TH – 25TH JULY 2014, MANCHESTER, UNITED KINGDOM)

"Octahydrotriborates (): synthesis and hydrogen storage", Z. G. Huang (Invited Speaker)

15TH INTERNATIONAL MEETING ON BORON CHEMISTRY (24TH – 28TH AUGUST 2014, PRAGUE, CZECH REPUBLIC)

"Hydrogen storage: from, through , to ", Z. X. Cheng (Invited Speaker & Session Chair)

THE INTERNATIONAL CONFERENCE ON ELECTRONIC MATERIALS (IUMRS-ICEM2014) (10TH SEPTEMBER – 14TH JUNE 2014, TAIPEI, CHINA)

"Metal oxide nanostructures for dye-sensitized solar cells application", Z. Q. Sun

39TH INTERNATIONAL CONFERENCE ON INFRARED, MILLIMETRE AND TERAHERTZ WAVES, (SEPTEMBER 2014, TUCSON, ARIZONA, USA)

"Step-like Multi-photon Absorption In Two-di-mensional Semiconductors With Rashba Spin-orbit Coupling In Terahertz Regime" R.Vickers (Invited Speaker)

10TH IUPAC INTERNATIONAL CONFERENCE ON NOVEL MATERIALS AND THEIR SYNTHESIS (11TH – 15TH OCTOBER 2014, ZHENGZHOU, CHINA)

"Graphene composite for lithium batteries application", J. Z. Wang (Keynote speaker)

7TH INTERNATIONAL SYMPOSIUM ON ULTRAFAST PHENOMENA AND TERAHERTZ WAVES, (12TH – 14TH OCTOBER 2014, SHANGHAI, CHINA)

"Spin-orbit interaction enhanced nonlinear response in semiconductors in terahertz regime", R. Vickers (Keynote Speaker)

9TH INTERNATIONAL FORUM ON LI-ION BATTERY TECHNOLOGY & INDUSTRIAL DEVELOPMENT (24TH OCTOBER 2014, BEIJING, CHINA)

"Development of nanomaterials for energy storage applications", S. X. Dou (Plenary Speaker)

2ND INTERNATIONAL CONFERENCE OF YOUNG RESEARCHERS ON ADVANCED MATERIALS (IUMRS-ICYRAM) (24TH – 29TH OCTOBER 2014, HAIKOU, CHINA)

"Metal oxide nanostructures for advanced photovoltaic devices", Z. Q. Sun (Invited Speaker)

INTERNATIONAL FORUM ON ENERGY STORAGE TECHNOLOGY (31ST OCTOBER 2014, QING DAO, CHINA)

"Energy storage materials for commercial applications", S. X. Dou (Plenary Speaker)

ENERGY FUTURE 2014 CONFERENCE (3RD – 5TH NOVEMBER, SYDNEY, AUSTRALIA)

"Role of graphene in the composite for advanced lithium batteries", J. Z. Wang (Invited Speaker)

2014 INTERNATIONAL CONFERENCE ON ADVANCED MATERIALS AND NANOTECHNOLOGY FOR SUSTAINABLE DEVELOPMENT (ICAMN-2014) (4TH – 6TH NOVEMBER 2014, KATHMANDU, NEPAL)

"Bottom-up self-assembly ultrathin "Graphene-like" 2D metal oxide nanosheets for sustainable energy applications", Z. Q. Sun (Invited Speaker)

UOW-BUAA BILATERAL UNIVERSITY WORKSHOP (1ST DECEMBER 2014, BEIHANG UNIVERSITY, CHINA)

"Development of nanomaterials for energy applications" S. X. Dou (Plenary Speaker)

The delegates of the 5th Australia China Symposium for Materials Science conference (July 2014, Wollongong)

INVITED PRESENTATIONS AND SEMINARS AT OTHER INSTITUTIONS

S. X. DOU

"Introduction of program and progress at Institute for Superconducting and Electronic Materials"
Tian Jin Bai Li, China, 11th October 2014

"Introduction of program and progress at Institute for Superconducting and Electronic Materials"
Beijing University of Technology, China, 13th October 2014

"Brief highlights of ISEM profile relevant to energy storage research"
Anshan Liaoning, China, 16th October 2014

"Development of nanomaterials for energy applications"
Fudan University, China, 21st October 2014

"Energy materials technology for sustainable digital eco-world"
Sichuan University, China, 2nd November 2014

Z. G. HUANG

"Boron for Energy"
Swiss Federal Laboratories for Materials Science and Technology, Switzerland, 19th August 2014

"Boron-nitrogen compounds: Plenty of room to explore"
Nankai University, China, 12th December 2014

H. K. LIU

"Brief highlights of ISEM profile relevant to energy storage research"
Jinher Ltd, Ningbo, China, 24th November 2014

Z. Q. SUN

"Superior dye-sensitized solar cells achieved by rational nanostructure design"
Hubei University, Wuhan, China, 16th October 2013

"How to design metal oxide nanostructures"
Southeast University, Nanjing, China, 11th October 2013

R. VICKERS

"Terahertz absorption in graphene and graphene nanoribbons"
University of Electronic Science and Technology, China, 13th January 2014

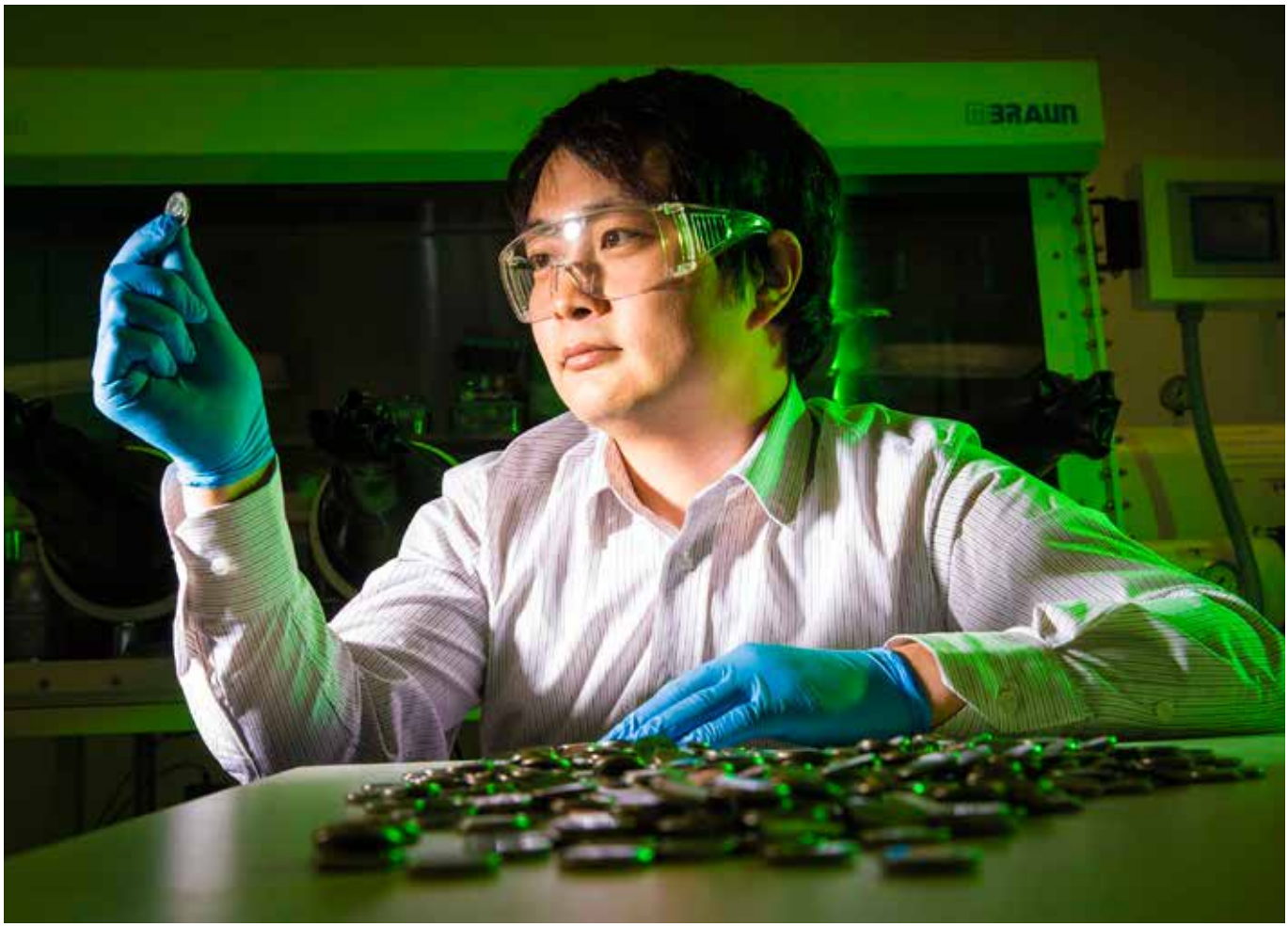
"Electromagnetically induced transparency of charge pumping in a triple quantum-dots structure"
Tokai University, Japan, 10th April 2014

"Nonlinear optical properties of graphene"
Nanjing University, China , 17th December 2014

SEMINARS BY VISITING SCIENTISTS

Date	Name	Institute	Title
20/01/14	Prof. Xianhui Chen	University of Science and Technology of China	Interfacial superconductivity in $BaFe_2As_2/CsFe_2As_2$ and novel superconductor $LiFeO_2Fe_2As_2$
21/01/14	Prof. Donglai Feng	State Key Laboratory of Surface Physics, and Department of Physics, Fudan University, China	Angle resolved photoemission spectroscopy study on FeSe films
31/01/14	Jose Oliveira	Editor-in-chief for Journal "Small" of Wiley publisher	Publishing in Wiley Materials Science Journals
04/02/14	Prof. Jun Chen	Key Laboratory of Advanced Energy Materials Chemistry (Ministry of Education), College of Chemistry; Collaborative Innovation Center of Chemical Science and Engineering, Nankai University, Tianjin, China	Nanomaterials with multi electron reactions for Li batteries
05/02/14	Dr. Arnaud Devred	Superconductor Section Leader, ITER	The way to fusion energy: challenges and status of the ITER Project
10/02/14	Prof. Zi-Feng Ma	Institute of Electrochemical & Energy Technology at Shanghai Jiao Tong University	Graphene-based electrode design and preparation for electrochemical energy storage application
11/02/14	Prof. Lei Jiang	Institute of Chemistry, Chinese Academy of Science	Bio-inspired interfacial materials with super wettability
20/02/14	Prof. David Cardwell	Department of Engineering, University of Cambridge	Recent developments in the processing of bulk, melt processed (RE)BCO superconductors for high field applications
11/03/14	Prof. Ying Dai	Shandong University, PRC	Study of electronic and photocatalytic properties of novel semiconductors
17/03/14	Prof. Maochun HONG	Director/Head of FJIRSM, Academician of CAS	Brief introduction on research activities at Fujian Institute of Research on the Structure of Matter (FJIRSM), Chinese Academy of Sciences (CAS)
17/03/14	Professor Jiyang WANG	State Key Laboratory of Crystal Materials, Shandong University, China	Progress on the research of self-frequency-doubling crystals
17/03/14	Prof. Ning YE	FJIRSM, Chinese Academy of Science	Nonlinear optical crystals with triangle structure units,
18/03/14	A/Prof Sang-Woo Kim	School of Advanced Materials Science & Engineering, SKKU Advanced Institute of Nanotechnology	Synthesis of 2D nanomaterials and novel energy harvesting applications
08/04/14	Dr. Qinfen Gu	Australian Synchrotron	Energy-related materials studies using powder diffraction at the Australian Synchrotron
10/04/14	Prof She-huang Wu	Department of Materials Engineering, Tatung University and Director, Energy Storage & Conversion Technology Research Center, Tatung University	Storage aging of commercial cells comprised with LNMC/LMO and graphite
10/04/14	Prof Chun H Wang	Director, Sir Lawrence Wackett Aerospace Research Centre, School of Aerospace, Mechanical and Manufacturing Engineering, RMIT University	Overview of the research activities within RMIT's Sir Lawrence Wackett Aerospace Research Centre and then focus on an ARC-DP project towards aligning and chaining carbon nano-sized reinforcement in fibre composites to improve damage tolerance and diagnosis.
28/05/14	Dr Salfi	Centre for Quantum Computation & Communication Technology(CQC2T), University of New South Wales	Accessing hydrogenic states of dopants in a semiconductor vacuum
07/07/14	Dr. Kirrily C. Rule	ANSTO, Sydney Australia	What makes low dimensional quantum magnets so exciting?
09/07/14	Prof. Jeffrey Reimers	School of Mathematical and Physical Sciences, University of Technology, Sydney	1. Rules controlling sulfur chemisorption to gold surfaces and gold nanoparticles 2. Why chlorophyll-a in photosystems has the fastest rate of Qx decoherence of all chlorophylls : Assignment of the Q-band spectra of Cchlorophyll 3. The effects of electron-vibration coupling in natural and artificial molecular electronic devices
11/07/14	Prof. Paul M. Koenraad	Department of Applied Physics, Eindhoven University of Technology, the Netherlands	Atomic scale analysis of semiconductor nanostructures

Date	Name	Institute	Title
05/0814	Dr. Kondo-Francois Aguey-Zinsou	School of Chemical Engineering, The University of New South Wales Sydney	Hydrogen storage technology: from a metallurgical dilemma to a chemical solution
21/08/14	Andrew Gillen	Application and Product Specialist, NETZSCH Australia Pty Ltd	Introduction to Netzsch instrumentation for advanced materials characterisation
03/09/14	Dr Rong Liu	Secondary Ion Mass Spectrometry Laboratory, Building M8, Hawkesbury Campus, University of Western Sydney	Materials and biological science
03/09/14	L.R. Sheppard	School of Computing, Engineering and Mathematics, University of Western Sydney Hawkesbury Campus	Novel TiO_2 for solar-driven water splitting
06/11/14	Prof. Ping Chen	Dalian Institute, China	Amides and amines for hydrogen storage
25/11/14	Prof. Ru-Shi Liu	Department of Chemistry, National Taiwan University, Taipei 106, Taiwan	Light conversion to light, electricity and heat: applications in solid-state lighting, energy and biomedical
27/11/14	Prof. Mukunda P Das	Department of Theoretical Physics, Research School of Physics and Engineering, The Australian National University	Novel superconductivity in multi-band materials: from bulk to nano systems
17/12/14	Prof. Dr. Todd B. Marder	Julius Maximillians University of Wuerzburg, Germany	Diethynylmetallacyclopentadienes – A new class of luminescent organometallics



Looking in to the future of batteries (Dr. S. L. Chou)

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Legend: IF is the Journal Impact Factor as provided by JCR; AI is Article Influence score as provided by Eigenfactor.org. For more information on AI metrics, please refer to the information provided at http://www.eigenfactor.org/faq.php

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PUBLICATION STATISTICS

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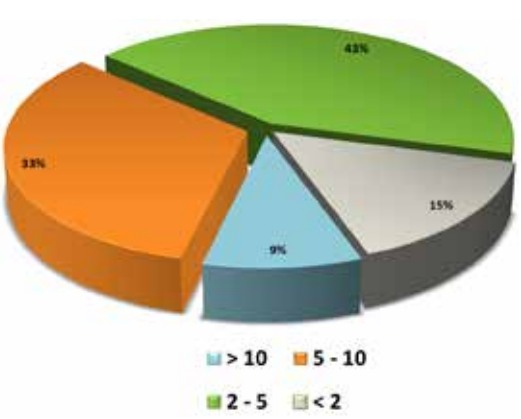

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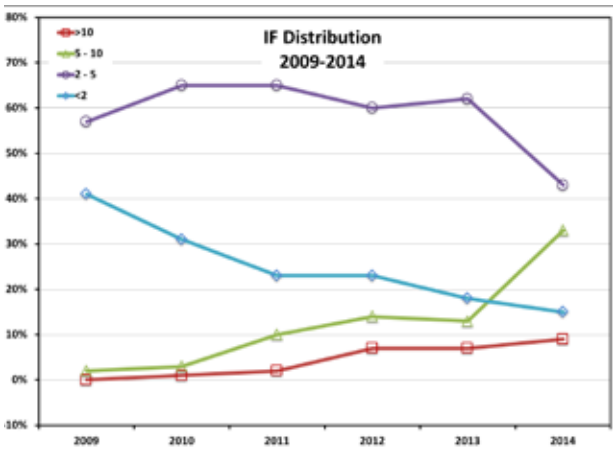

FUNDING 2014

AUSTRALIAN RESEARCH COUNCIL GRANTS

ARC DISCOVERY SCHEME GRANTS

Chief Investigators	Title	2014 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
X. L. Wang, C. Zhang, R. A. Lewis, Q. K. Xue, A. Hoffmann, F. Klose	Electron and spin transport in topological insulators	$150,000
Z. Li, M. Lu	Nanostructure engineering of semiconductor nanowires for high performance thermoelectric	$100,000
Z. P. Guo, Z. Chen, J. Dahn, J. Chen	New directions to miniaturized power sources: integrated all-solid-state rechargeable batteries	$120,000
C. Zhang, X. L. Wang, R. A. Lewis, Q. L. Bao, J. Horvat	Novel terahertz electronics, photonics and plasmonics in high- mobility, low-dimensional electronic systems (HMLDES)	$130,000
J. Z. Wang, J. Chen, S. L. Chou, H. K. Liu, H. S. Zhou, X. L. Wang	Lithium-ion air batteries with non-flammable ionic liquid–based electrolytes	$55,000
S. X. Dou, Y. Du, X. Xu, G. Peleckis, J. Scott, J. H. Ye, W. C. Hao, K. S. Liu, P. Cheng	Design and exploration of novel p-block materials for solar energy conversion	$215,000
Total		**$910,000**

ARC FUTURE FELLOWSHIPS

Chief Investigators	Title	2014 Funding
J. H. Kim	Development of a solid nitrogen cooled magnesium diboride (MgB_2) magnet for persistent-mode operation	$172,000
X. L. Wang	Electronic topological materials	$247,000
S. J. Zhang	Bismuth based lead-free dielectric materials for energy storage	$111,000
Total		**$530,000**

ARC DECRA FELLOWSHIPS

Chief Investigators	Title	2014 Funding
Z. G. Huang	Diammoniate of diborane for hydrogen storage	$125,000
M. S. A. Hossain	Rational design of a new generation magnesium diboride superconducting rotor coil suitable for offshore low-cost wind turbine generators	$125,000
S. Aminorroaya-Yamini	Nano-engineered, cost-effective lead chalcogenides to boost performance of mid-range temperature thermoelectric materials	$125,000
Z. Q. Ma	Microstructure design of second generation MgB_2 superconducting wires for enhancement of critical current density	$130,000
Total		**$505,000**

ARC LINKAGE PROJECTS

Chief Investigators	Title	2014 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	$130,000
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	$150,000
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	$220,000
Total		**$500,000**

2014 AUSTRALIAN RESEARCH COUNCIL GRANTS TOTAL: $2,445,000

AUTO CRC GRANTS

AUTO CRC PROJECTS

Chief Investigators	Title	2014 Funding
S. X. Dou, G. X. Wang	1-108: Lithium air battery for electric vehicles	$160,000
S. X. Dou, C. Zhang, S. Aminorroaya-Yamini	1-203: Thermoelectric – efficient energy recovery in light and heavy vehicles	$170,000
S. X. Dou, Z. P. Guo	1-110: Design and prototype of on-vehicle battery management system for electrical vehicles	$80,000
S. X. Dou, G. X. Wang, H. K. Liu	1-111: Development of advanced electrode and electrolytes for LIB	$373,000
S. X. Dou, K. W. See	1-112: Battery charge, mechanical and thermal management system development	$203,000
S. X. Dou, K. W. See	1-113: Lithium ion battery module packaging and testing	$216,000
Total		**$1,202,000**

AUTO CRC SCHOLARSHIPS

Chief Investigators	Title	2014 Funding
H. K. Liu, S.X. Dou	4-102: The study of carbon based battery materials	$33,000
J. Z. Wang, S.X. Dou	4-103: S-Carbon composite cathode material for Li-S battery	$33,000
K. Konstantinov, S.X. Dou	4-104: Conducting polymer coated graphene oxide nanocomposites for supercapacitor application	$33,000
Z. P. Guo, S. X. Dou	4-105: Fabrication & characterisation of graphene & graphene oxide composites for application in supercaps & Li-ion batteries	$33,000
Total		**$132,000**

2014 AUTO CRC GRANTS TOTAL: $1,334,000

OTHER GRANTS

Chief Investigators	Title	2014 Funding
L. Y. Sheng, Z. Q. Sun, T. Liao, C. Nai, S. X. Dou	Key issues in dye-sensitized solar cells and environmental durability (Shenzhen International Collaboration Grant)	$60,000
Total		**$60,000**

UOW GRANTS & ARC NEAR-MISS GRANTS

Chief Investigators	Title	2014 Funding
Z. G. Huang	Expanding the search for hydrogen storage materials	$11,000
K. W. See	Development of battery management system for lithium-ion battery technology for electric vehicles application	$10,000
Z. X. Cheng	Multiferroic heterostructures for high density and low energy dissipation solid-state memory application	$12,000
J. L. Wang	Texture-induced enhancement of physical response in melt-spun ribbons and thin films of intermetallic compounds	$11,000
M. S. A. Hossain	Magnetically triggered mechanoselective channels for liposomal drug delivery	$18,000
K. Konstantinov	Structural and chemical surface characterisation of functionalised theanostic core/shell ceramic nanostructures for cancer therapy	$10,000
Y. Du	Epitaxial growth, scanning tunnelling microscopy and Raman spectroscopy studies on silicene	$14,800
S. Aminorroaya-Yamini	Engineering dopant distributions in composite semiconductors – A new strategy to design high performance thermoelectric materials	$10,000
M. S. A. Hossain	Development of low radioactive Boron-11 isotope () superconducting poloidal field magnet coil suitable for Tokamak-type fusion reactors	$8,500
Z. Q. Sun	Architecture design of metal oxide nanostructures for high-performance band A ultraviolet detectors	$8,500
S. L. Chou	Novel anode materials for sodium battery to store renewable energy	$8,000
Total		**$121,800**

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

2014 OTHER GRANTS TOTAL: $481,800

TOTAL FUNDING 2014: $4,260,800

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