INSTITUTE *for* SUPERCONDUCTING *and* ELECTRONIC MATERIALS

UNIVERSITY OF WOLLONGONG AUSTRALIA

isem.uow.edu.au

Institute for Superconducting and Electronic Materials

ANNUAL REPORT 2017

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Director's Report

Dear all,

In 2017 ISEM has continued its stellar performance across all major impact areas including securing competitive funding, high quality publications, staff development, and training of high calibre postgraduate students. For your information, I would like to briefly highlight some of our achievements.

Our researchers and students have achieved many breakthroughs across a range of topics including but not limited to battery materials, renewable energy technology, superconductivity, topological insulators, electronic materials, battery management systems (BMS), thermoelectric materials, low dimensional materials, and biomaterials. Many great developments in these research areas have been published in international journals of highest quality and already been cited and followed by many research groups. We have continued our research promotion through hosting workshops, conferences, and meetings. For example, an exceptionally successful "Next Generation Batteries" has attracted a large number of world renowned scientists with selected papers being published in special issues of Advanced Materials and Advanced Energy Materials.

Our continuing research excellence is strongly supported by extraordinary publication data. In 2017, ISEM published 368 papers, which accounted for 14.6% of total University of Wollongong papers published that year and a phenomenal increase in publication outcomes as compared to 2016, i.e. 35% increase. The average journal impact factor for our publications reached 8.02 compared to 2.61 in 2010 and 6.47 in 2016. It is important to note that generally journals published in the field of physics have lower IF as compared to those in materials engineering or science, thus I am confident in saying that our publication impact is even stronger than what the numbers say. We have published staggering 73 papers in journals with IF>10, compared to just one such publication in 2010. In 2017, our publications contributed 50% of the Weighted Fraction Counts (WFC) in Nature Index Rank to UOW (9.53/18.90) and 45% of top 1% of highly cited publications from UOW between 2013 and 2016 (42/94). Our publication record for 2017 shows continuous expansion of collaborative research efforts with National and International partners - 93.8% of our publications in 2017 have had at least one external collaborator, a further increase from 2016 with 89.4% of such publications. ISEM's 2017 publications reflect broad research themes including energy storage materials, superconductors, spintronic/topological materials, electro/photo-catalysts, optics/photonics, biomaterials, piezo-electrical, ferroelectric/multiferroic, magnetic and thermoelectric materials and nano-materials/porous materials for applications.

This year ISEM has yet again been successful in attracting competitive funding from the Australian Research Council for projects commencing in 2018. Members of ISEM have secured three DECRA Fellowships, one Discovery Project, and one LIEF grant. The total funding received for 5 projects is $1,765,000 for ISEM. Notably, ISEM has contributed 33% of UOW total in the past three ARC funding rounds. We have also secured a number of industry funded projects, such as Coal Services Council funded project for electrification of mining vehicles. In addition to current financial support ISEM has secured further $300,000 to continue development of petrol free systems for underground vehicles.

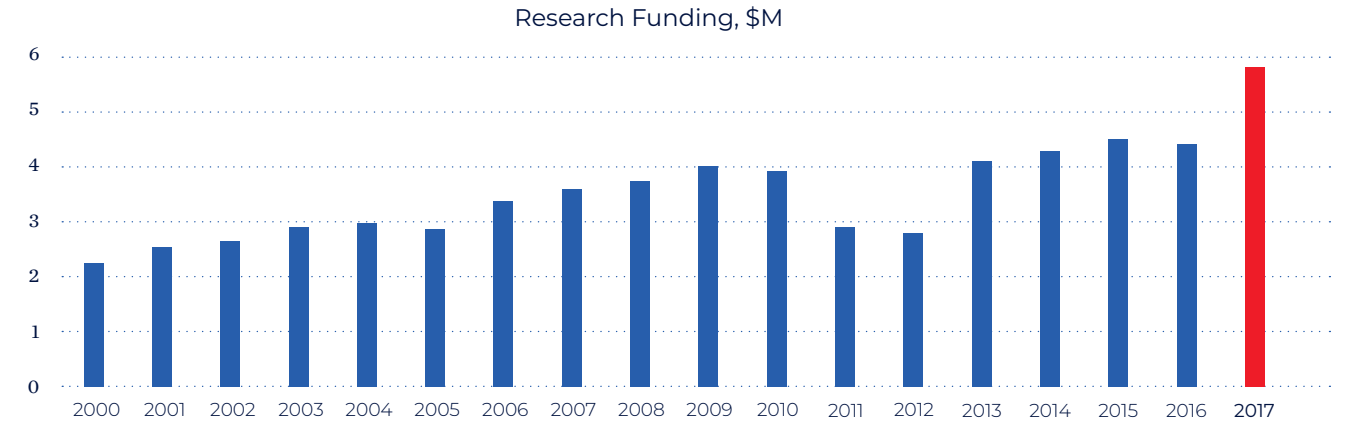
17 PhD students have graduated in 2017, bringing our total ISEM PhD completion to 178 who are widely distributed within five continents, with one (Jun Chen) elected to the most competitive fellow of Chinese Academy of Science and more than 40 professors and senior executives. Our academic staffs have further enhanced their international reputation as evidenced by their appointment as Honorary Professors, Members of Editorial Boards, and Advisory Boards at prestigious universities and journals. By now ISEM has won 65 ARC fellowships, more than 40% of UOW total during the same period. Our senior academic researchers have continued in their leading roles across their relevant disciplines, while our early career researchers have continued to be exceptionally proactive in establishing their leadership and research standing.

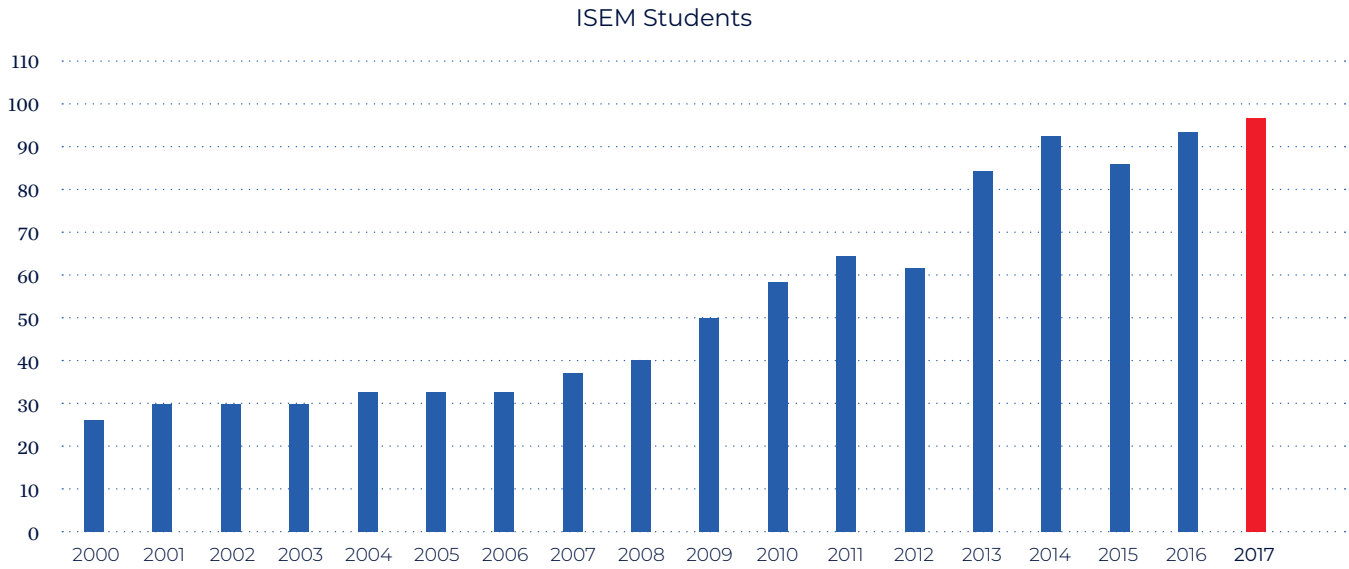
I would like to take this opportunity to sincerely acknowledge the strong support ISEM has received throughout the year from UOW Executives, faculty, administration staff, technical staff, OHS staff, commercial management staff, industry partners, and academic collaborators. I would also like to express my gratitude to ISEM staff, students, honorary professors, and visitors for their dedication and hard work. I am certain that ISEM will continue its success across the board in 2018 and will significantly contribute towards UOW's aspirational goal of reaching top 1% of universities worldwide.

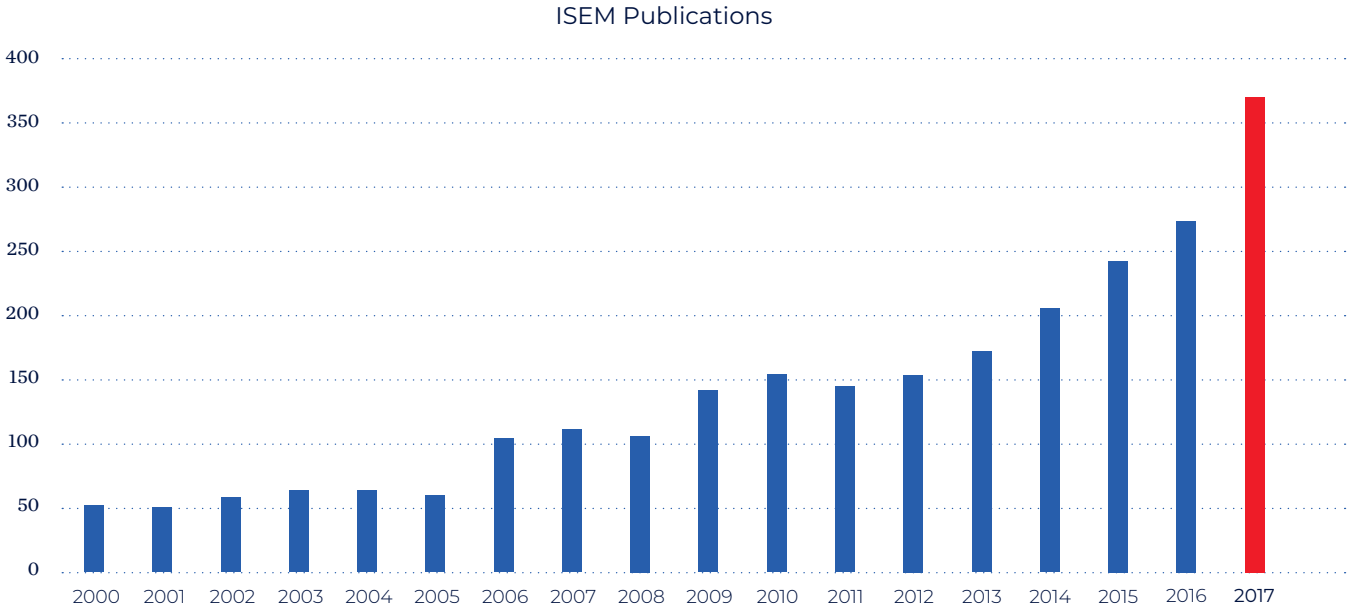
Sincerely yours,

Prof. Shi Xue Dou

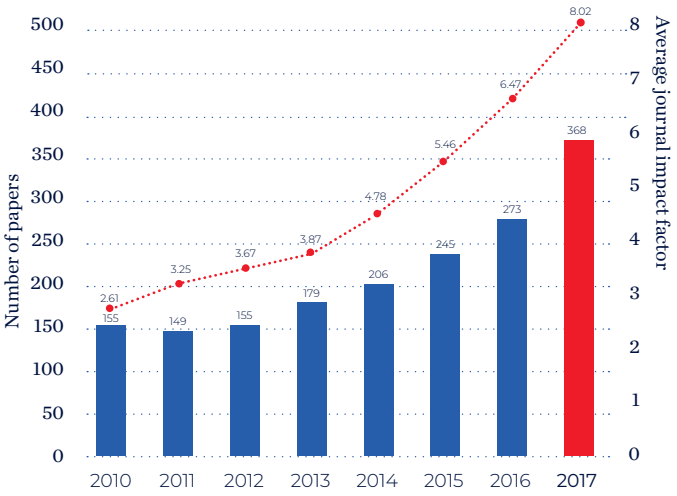
ISEM at a glance



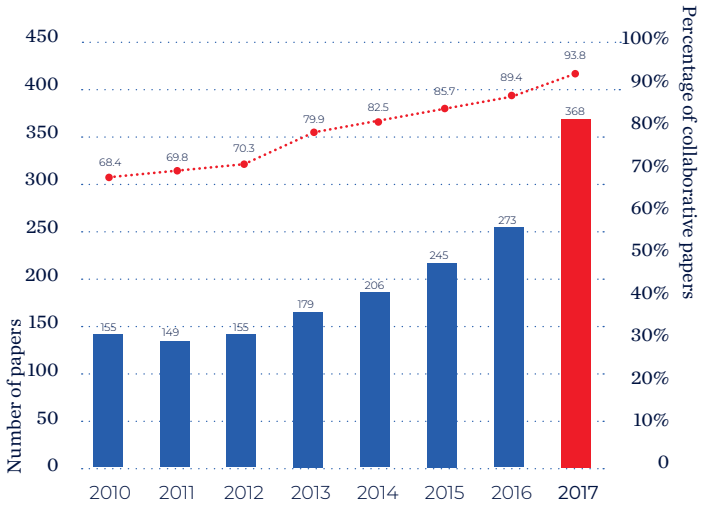




Average Impact Factor (IF) for ISEM publications 2010-2017



Share of Collaborative Publications for ISEM in 2010-2017



ISEM staff, students, and visitors at the 2017 Christmas Party

Management

MANAGEMENT COMMITTEE

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

INDUSTRY ADVISORY COMMITTEE

Ms. S. Moroz	CEO, Nano Nouvelle Ltd
Mr. B. Lynch	CEO, Valley International Ltd, Newcastle, Australia
Mr. M. Sahari	CEO, Malaysian Automotive Institute, Malaysia
Mr. R. Huang	President, Australian Innovative Industry Park, Australia
Mr. J. Grime	CEO, Australian Energy Storage Council, Australia
Mr. Y. C. Li	President, Hong Cheng Electric Power Co Ltd, Anshan, P. R. China
Mr. T. Lee	President, McNair Industrial Estate Ltd, P. R. China
Mr. H. Bustamante	Principal Scientist treatment, Sydney Water Co, Australia
Mr. M. Li	General Manager, Hebei ANZ New Energy Technology Co Ltd, China
Mr. J. 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. C.H. Yao	Institute of Tianjin Benefo, P. R. China
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 Jain Sen Mechanism Ltd
Mr. C. Fu	Chief Executive Officer, Zhuo Yi Technology Ltd, Yingko, China
Mr. R. Tandiono	Chief Executive Officer, PT Nipress Tbk, Indonesia

ADVISORY COMMITTEE

Prof. J. H. Li	Vice President, Chinese Academy of Sciences
Prof. P. J. Zhang	President, Bao Steel Research Institute
Prof. R. Taylor	Adjunct Professor, Queensland University of Technology, Australia
Prof. P. Robinson	Chair, Cast CRC Ltd

Personnel

EXECUTIVE

Distinguished Prof. Shi Xue Dou (PhD, DSc, FTSE)
Director
Senior Prof. Xiaolin Wang (BSc, MSc, PhD)
Associate Director
Dr. Germanas Peleckis (BCh, MSc, PhD)
Assistant Director

ARC FELLOWS

Senior Prof. Zaiping Guo (ARC FT-3 Fellow)
Senior Prof. Xiaolin Wang (ARC FT-3 Fellow)
Prof. Shujun Zhang (ARC FT-2 Fellow)
Prof. Yusuke Yamauchi (ARC FT-2 Fellow)
Dr. Wei Kong Pang (ARC FT-1 Fellow)
Dr. Yunxiao Wang (ARC DECRA Fellow)
Dr. Wenping Sun (ARC DECRA Fellow)
Dr. Ji Liang (ARC DECRA Fellow)
Dr. Chao Wu (ARC DECRA Fellow)
Dr. Guanglin Xia (ARC DECRA Fellow)

RESEARCH STAFF

Distinguished Prof. Hua Kun Liu
Prof. Jiazhao Wang (Professorial Fellow)
Prof. Zhenxiang Cheng (Professorial Fellow)
Prof. Jung Ho Kim (Professor)
A/Prof. Konstantin Konstantinov (Associate Professor)
Dr. Sima Aminorroaya-Yamini (Senior Research Fellow)
Dr. Zhenguo Huang (Senior Research Fellow)
Dr. Md Shahriar Hossain (Senior Research Fellow)
Dr. Yi Du (Senior Research Fellow)
Dr. Shulei Chou (Senior Research Fellow)
Dr. Xun Xu (Senior Research Fellow)
Dr. Khay Wai See (Senior Research Fellow)
Dr. Xiao Lu (Research Fellow)
Dr. Jeonghun Kim (Associate Research Fellow)
Dr. Zhi Li (UOW VC Fellow)
Dr. Jon Knott (Research Fellow)
Dr. Jianli Wang (Research Fellow)
Dr. Weijie Li (Research Fellow)
Dr. Wenbin Luo (Research Fellow)

ISEM FACULTY STAFF

Prof. Chris Cook (Executive Dean, Faculty of EIS)
Dr. Carey Freeth (Senior Lecturer, Faculty of EIS)
Prof. Roger Lewis (Associate Dean, Faculty of EIS)
Prof. Chao Zhang (Senior Professor, Faculty of EIS)
Prof. Alexey Pan (Professor, Faculty of EIS)
Prof. Zaiping Guo (Senior Professor, Faculty of EIS)
A/Prof. Rodney Vickers (Associate Professor, Faculty of EIS)
Prof. Zhixin Chen (Professor, Faculty of EIS)
A/Prof. Yue Zhao (Associate Professor, Faculty of EIS)
A/ Prof. Josip Horvat (Associate Professor, Faculty of EIS)
Dr. David Wexler (Senior Research Fellow, Faculty of EIS)

ISEM SUPPORT STAFF

Dr. Tania Silver (Technical Editor)
Dr. Dongqi Shi (Senior Instrument Scientist)
Mrs. Crystal Mahfouz (Administrative Officer)

HONORARY FELLOWS

Prof. Edward Collings, Ohio State University
Prof. Hui Ming Cheng, Institute of Metal Research, CAS
Prof. Liming Dai, UOW VISA Fellow, Case Western Reserve University
Prof. Wei Huang, North-western University of Technology
Prof. Lei Jiang, Chinese Academy of Science, Institute of Chemistry
Prof. Tom Johansen, Oslo University
Prof. Shane Kennedy, Deputy Director of Bragg Institute, ANSTO
Prof. Chang Ming Li, Royal Society of Chemistry, Southwest Univ.
Prof. Zhen Li, Soochow University
Prof. Zhong Fan Liu, Peking Uinversity, Fellow of CAS
Dr. Scott Needham, Xinova LLC
Prof. Kostya Ostrikov, ARC Future Fellow, CSIRO
Dr. Vanessa Patterson, Principal Scientist, ANSTO
Prof. Guoxiu Wang, Future Fellow, Univ. of Technology, Sydney
Prof. Yi Xie, University of Sci & Tech China, Hefei
Prof. Hua Zhang, Nanyang Technological University, Singapore
Prof. Dongyuan Zhao, Fellow of CAS, Fudan University

Postgraduate Students

CURRENT

PhD	Thesis Title	Supervisors
Ms. Wafa Afzal	Magnetic topological materials	Prof. Xiaolin Wang, Dr. Zhi Li
Mr. Kadhim Mustafa Kadhim Al-Attafi	Semiconductor solar cells	Prof. Jung Ho Kim, Prof. Shi Xue Dou
Mr. Jumlat Ahmed	Efficiency improvement of thermoelectric module using appropriate electrode and fabrication process for power generation application	Prof. Yusuke Yamauchi, Dr. S. Aminorroaya-Yamini
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 fiIm superconductors	Prof. Alexey Pan
Ms. Shaymaa Hadi Khudhair Al-Rubaye	Preparation of new ceramic-matrix nanocomposite and studying its properties	Prof. Zhenxiang Cheng, Prof. Shi Xue Dou
Mr. Samuel Michael Battenally	Embedded system for wireless communication technology	Dr. Khay Wai See, Prof. Shi Xue Dou
Mr. Md Motasim Billah	Modelling and synthesis of mesoscale perovskite for high energy density piezoelectric materials	Dr. Md Shahriar Hossain, Prof. Yusuke Yamauchi
Ms. Kathrin Bogusz	Engineering and study of multifunctional biocompatible nanoceramics	A/Prof. Kosta Konstantinov, Prof. Hua Kun Liu, Dr. Moeava Tehei
Mr. Dean Cardillo	Multifunctional metal oxide nanoparticles for biomedical applications	A/Prof. Kosta Konstantinov
Ms. Grace Causer	Spin structures in oxide thin films and crystals	Prof. Xiaolin Wang
Mr. Jiayi Chen	Development of new catalysts for water splitting	Prof. Shi Xue Dou, Dr. Wenping Sun
Mr. Mingzhe Chen	Hi Li content cathode materials for Li-ion battery	Prof. Shi Xue Dou
Ms. Yaping Chen	Smart storage materials	Prof. Shi Xue Dou, Dr. Wenping Sun
Ms. Lei Chen	Novel functional materials	Prof. Xiaolin Wang, Prof. Zhenxiang Cheng
Ms. Ningyan Cheng	Materials for photocatalysts	Prof. Shi Xue Dou, Dr. Xun Xu
Ms. Jing Cuan	Nano porous particles mediate for efficient hydrogen release and sustainable hydrogen storage of BN-based hydride	Prof. Zaiping Guo

PhD	Thesis Title	Supervisors
Mr. Chunsheng Fang	The physical principle of magnetic phase transitions for the magnetocaloric materials: RCo_2Mn_x and $Tb_{1-x}Y_xMn_2Ge_2$ (R = Tb, Ho, Dy, $0 \leq x \leq 1.0$) series compounds	Prof. Zhenxiang Cheng
Mr. Haifeng Feng	Exploration of novel nanomaterials for visible light photocatalysis	Dr. Yi Du, Prof. Shi Xue Dou, Dr. Xun Xu
Mr. Xavier Reales Ferreres	Efficient energy recovery in light and heavy vehicles.	Dr. S. Aminorroaya-Yamini, Prof. Shi Xue Dou
Mr. Florian Gebert	Research on electrolyte for sodium ion battery	Dr. Shulei Chou, Prof. Shi Xue Dou
Mr. Haipeng Guo	High voltage cathode materials for lithium ion batteries	Prof. Hua Kun Liu, Prof. Jiazhao Wang, Dr. Shulei Chou
Mr. Alaa Hamed Hamood	Influence of micro- and nano-patterning on superconducting thin films	Prof. Alexey Pan
Ms. Gao Hong	Synthesis and electrochemical properties of WO_3 nanocomposite	Prof. Zaiping Guo, 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
Mrs. Fanar Ali Husseinjawdat	Nano materials for energy storage.	Prof. Jung Ho Kim, Prof. Shi Xue Dou
Mr Zhe Hu	Nano materials for Na-ion battery	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. Hyunseock Jie	Investigation of phase, texture and micromechanical properties of advanced functional materials using neutron diffraction	Dr. Shahriar Hossain, Prof. Jung Ho Kim
Mr. Antony Jones	Superconductivity in unbalanced systems: properties and fabrication	Prof. Alexey Pan, Prof. Shi Xue Dou
Mr. Jicheng Jiang	Study of advanced materials for Li-ion batteries	Prof. Jiazhao Wang, A/Prof. Kosta Konstantinov
Ms. Xi Kong	Dielectric breakdown studies on lead free dielectric materials with high energy density	Prof. Shujun Zhang, Prof. Zhenxiang Cheng
Mr. Weihong Lai	Research on high energy Li Air battery	Dr. Shulei Chou, Prof. Jiazhao Wang
Ms. Mengmeng Lao	Solid state electrolytes for batteries	Dr. Wenping Sun, Prof. Shi Xue Dou

PhD	Thesis Title	Supervisors
Mr. Jaewoo Lee	High-performance, robust Si/SiO_x anode for lithium-ion battery	Prof. Jung Ho Kim, Prof. Hua Kun Liu, Prof. Shi Xue Dou
Ms. Fang Li	Development of specially designed flexible materials for bendable and wearable batteries	Prof. Jiazhao Wang
Mrs. Xiu Li	Novel composite anode materials for sodium ion battery	Dr. Shulei Chou, Prof. Shi Xue Dou, Dr. Xun Xu
Mr. Peng Li	Li rich cathode for Li ion battery	Dr. Wenping Sun, Prof. Shi Xue Dou
Mr. Gemeng Liang	High-voltage cathode materials and their mechanistic behavior in lithium-ion batteries	Dr. Wei Kong Pang, Prof. Zaiping Guo
Ms. Qiannan Liu	Development of porous materials for applications	Dr. Ziqi Sun, Prof. Shi Xue Dou
Ms. Yajie Liu	High voltage cathode materials for lithium ion batteries	Prof. Hua Kun Liu, Prof. Zaiping Guo
Ms. Nana Liu	Nanomaterials for energy application	Prof. Shi Xue Dou, Dr. Yi Du, Dr. Xun Xu
Mr. Yun Lu	Exploration of new mesoscale mechanisms for ultrahigh piezoelectric responses in relaxor ferroelectrics: demonstration of piezoelectric energy harvesting for the development of sustainable society	Prof. Shujun Zhang, Prof. Zhenxiang Cheng
Mr. Andrew George Manettas	Thermoelectric performance study of nanostructured, cost-effective Pb chalcogenides	Dr. S. Aminorroaya-Yamini, Prof. Alexey Pan
Mr. Mostafa Kamal Masud	A Microfluidic non-invasive approach for exosome profiling.	Dr. Md Shahriar Hossain, Prof. Shi Xue Dou, Prof. Yusuke Yamauchi
Mr. Mohanad Hazim Mohammad	Magnetic properties of rare earth orthoferrite	A/Prof. Josip Horvat, Prof. Roger Lewis, Prof. Zhenxiang Cheng
Mr. Alexander John Morlando	Next generation sunscreen products optimised for Australian conditions	A/Prof. Konstantin Konstantinov
Mr. Rafid Abdlateef Mueen	Preparation of chitosan based magnetic nanocomposites for biomedical and environmentally applications via green chemistry approach	A/Prof. Kosta Konstantinov, A/Prof. Michael Lerch, Prof. Zhenxiang Cheng
Mr. Muhammad Naadeem	Theoretical study of quantum systems	Prof. Xiaolin Wang, Prof. Chao Zhang
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

PhD	Thesis Title	Supervisors
Mr. Viet Thien Pham	Advanced materials for lithium air battery	Prof. Hua Kun Liu, Prof. Jiazhao Wang, Dr. Shulei Chou
Mr. Wenbin Qiu	Development of 2G superconductors for applications	Dr. Zongqing Ma, Prof. Shi Xue Dou, Dr. Shahriar Hossain
Mr. Long Ren	Study of photocatalysts	Dr. Yi Du, Prof. Shi Xue Dou, Dr. Xun Xu
Mr. Boyang Ruan	Exploring boron-containing hydrides for hydrogen storage	Prof. Jiazhao Wang, Prof. Hua Kun Liu, Dr. Shulei Chou
Mr. Joao Rafael Lourenco Santos	Efficient energy recovery in light and heavy vehicles	Dr. S. Aminorroaya-Yamini, Prof. Shi Xue Dou, Dr. Germanas Peleckis
Mr. Anoop Somanathan Pillai Sushamakumari Amma	High-energy-density positive electrodes for lithium-ion batteries	Dr. Wei Kong Pang, Prof. Zaiping Guo
Mr. Kyubin Shim	Design and development of functional mesoporous materials for the next generation drug delivery system	Dr. Shahriar Hossain, Prof. Jung Ho Kim
Ms. Yanhua Sun	Magnetoelectric nano materials for energy applications	Prof. Shujun Zhang, Prof. Zhenxiang Cheng
Mr. Shunsuke Tanaka	Metal organic framework-derived nanoporous carbon for supercapacitor	Dr. Shahriar Hossain, Prof. Shi Xue Dou, Prof. Yusuke Yamauchi
Ms. Li Wang	Design and development of p-block visible light photocatalysis	Dr. Yi Du, Prof. Shi Xue Dou, Dr. Xun Xu
Mr. Liang Wang	Development and exploration of novel photocatalysts by using STM	Dr. Yi Du, Prof. Shi Xue Dou, Dr. Xun Xu
Mr. Wanlin Wang	Advanced materials for lithium ion batteries	Prof. Hua Kun Liu, Dr. Shulei Chou, Dr. Weijie Li
Ms. Nana Wang	Nano materials for sodium ion battery	Prof. Shi Xue Dou, Dr. Xun Xu
Mr. Zhijie Wang	Development of advanced electrode materials for potassium-ion batteries	Prof. Zaiping Guo, Dr. Guanglin Xia
Mr. Chang Wu	Development of advanced materials for Li-air batteries	Prof. Jiazhao Wang Prof. Hua Liu Prof. Jun Chen

PhD	Thesis Title	Supervisors
Mr. Zhibin Wu	Embedding Sb nanosheets in graphene with tunable architectures for enhanced sodium and potassium storage	Prof. Hua Liu, Prof. Zaiping Guo
Mr. Qingbing Xia	High energy cathode materials for Li-ion batteries	Dr. Shulei Chou, Prof. Hua Kun Liu, Prof. Jiazhao Wang
Mr. Zichao Yan	Cathode materials for Na ion battery	Dr. Shulei Chou, Prof. Shi Xue Dou
Mr. Fuhua Yang	Nano-structured carbon materials for sodium ion batteries	Prof. Zaiping Guo, Prof. Jun Chen
Mr. Letao Yang	Exploration of new mesoscale mechanisms for high piezoelectric responses in relaxor ferroelectrics	Prof. Shujun Zhang, Prof. Zhenxiang Cheng
Mr. Guangsai Yang	Thermoelectric materials	Prof. Xiaolin Wang, Dr. Zhi Li
Ms. Huiling Yang	Nano materials for energy applications	Prof. Hua Liu, A/Prof. Konstantin Konstantinov, Dr. Yunxiao Wang
Ms. Qiuran Yang	Novel anode materials for sodium ion battery	Dr. Shulei Chou, Prof. Hua Liu
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. Hao Zhang	Terahertz and optical spectroscopic characterization for aerographite zinc oxide tetrapod interconnected networks and carbon nanostructures	A/Prof. Josip Horvat , Prof. Roger Lewis
Mr. Lei Zhang	Novel Si based composite materials as anodes for Li-ion batteries	Prof. Kua Kun Liu, Prof. Shi Xue Dou
Mr. Binwei Zhang	Materials for sodium ion battery	Prof. Shi Xue Dou, Prof. Hua Kun Liu
Mr. Shilin Zhang	Proposal of energy devices	Prof. Zaiping Guo, A/Prof. Kosta Konstantinov
Mr. Neng Zhang	Investigation of boost DC/AC converters and their applications in the integrated solar PV and energy storage system	Dr. Khay See, Prof. Shi Xue Dou
Ms. Qing Zhang	Synthesis and electrochemical properties of transition metal sulfides for magnesium ion battery	Prof. Zaiping Guo
Mr. Wenchao Zhang	Solidification and microstructure development of $Zn_{55}Al_{(2-5)}Mg_{(1.5-5)}Si$ (in wt coatings)	Dr. Zhixin Chen, Prof. Zaiping Guo
Mr. Xiaobo Zhang	Photocatalist materials	Prof Shi Xue Dou, Dr. Xun Xu, Dr. Wenping Sun
Mr. Guoqiang Zhao	Engineering efficient nanostructures for electrochemical water splitting	Dr. Wenping Sun, Prof Shi Xue Dou

PhD	Thesis Title	Supervisors
Mr. Weiyao Zhao	Crystal growth of oxide materials	Prof Xiaolin Wang, Dr. David Cortie
Mr. Xiaobo Zheng	Photocatalyst materials	Prof. Shi Xue Dou, Dr. Xun Xu, Dr. Wenping Sun
Mr. Yang Zheng	Selectivity facet exposed transition metal oxide nanostructures as advanced materials for energy storage applications	Prof. Zaiping Guo
Ms. Qian Zhou	Electrode materials for Li-ion batteries	Prof Shi Xue Dou, Dr. Xun Xu, Dr. Wenping Sun
Ms. Yanfang Zhu	Tin-based anode materials for sodium ion battery	Dr. Shulei Chou, Prof Shi Xue Dou

Master's	Thesis Title	Supervisors
Mr. Enad Abed Mahmood Alabed	Multifunctional advanced nanomaterials for biomedical applications	Dr. Lezanne Ooi, Prof. Jung Ho Kim, Dr. Md Shahriar Hossain
Mr. Nawfel Abdullah	Surface functionalization of magnetic nanoparticle for biomedical application.	Dr. Md Shahriar Hossain, A/Prof. Kosta Konstantinov, Dr. Vitor Sencadas Gomes da Silva Sencadas, Prof. Yusuke Yamauchi
Ms. Guyue Bo	Thermoelectric materials	Dr. Yi Du, Dr. Xun Xu
Mr. Nai-Sheng Hsu	Drug delivery multifunctional systems based on nanoceramic particles for cancer treatment	A/Prof. Kosta, Konstantinov
Mr. Junayet Khan	Titanium doped lanthanum oxide as potential UV filter with promising ROS scavenging activity for sunscreen products.	Dr. Md Shahriar Hossain, A/PR Konstantin Konstantinov, Prof Yusuke Yamauchi
Mr. Meng Li	Thermoelectric materials	Prof. Xiaolin Wang, Prof Shi Xue Dou
Mr. Hamzeh Qasem Mohammed Qutaish	Engineering multifunctional nano-composites for environmental and biomedical applications.	Dr. Md Shahriar Hossain, A//PR Konstantin Konstantinov, Prof Jung Ho Kim, Prof Yusuke Yamauchi

Seminars by Visiting Scientists

Date	Name	Institute	Title
25/01/2017	Prof. Guang-Hong Lu	Dean, School of Physics and Nuclear Engineering, Beihang University	Behaviour of hydrogen and helium in metals: new insights from modelling & simulation
24/02/2017	Prof. Tom H. Johansen	Department of Physics, University of Oslo, Norway	Magneto-optical imaging of flux dynamics in superconducting films
01/03/2017	Dr. Devaraj Shanmukaraj	Associate Research Scientist at CIC EnergiGune, Alava, Spain	Towards enhancing the performance of lithium batteries – role of electrolytes and additives
02/03/2017	Prof. Harald Schneider	Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany	Terahertz spectroscopy of semiconductor nanostructures with a free-electron laser
17/03/2017	Prof. Takao Mori	National Institute for Materials Science (NIMS), MANA	Key issues and developments in thermoelectrics and thermal management technology
17/03/2017	Dr. Soonil Lee	Korea Institute of Ceramic Engineering and Technology	Activities on thermoelectrics and ceramics in KICET
29/03/2017	Prof. Ajayan Vinu	Future Industries Institute, University of South Australia, South Australia, Australia	Functional nanoporous materials for energy and environment
30/05/2017	Prof. Veronica Augustyn	Dept. of Materials Science & Engineering, North Carolina State University	The Effect of structural water on proton and magnesium intercalation into tungsten oxides
20/07/2017	Prof. S. Ravi P. Silva	Advanced Technology Institute, University of Surrey, Guildford GU2 7XH, United Kingdom	Large area carbon electronics
28/07/2017	Efrat Moyal	Co-founder of LatticeGear LLC, USA	Cleaving and scribing reinvented
02/08/2017	Prof. Lei Jiang	School of Chemistry and Environment, Beihang University and Chinese Academy of Sciences, China	Smart interfacial materials from super-wettability to binary cooperative complementary systems
24/08/2017	Dr. Rong Liu	Secondary Ion Mass Spectrometry Laboratory, University of Western Sydney	Nano-resolution secondary ion mass spectrometry (SIMS): techniques and applications in emerging materials and biological science
15/11/2017	Prof. V. V. Srinivasu	Research Chair for Superconductivity Technology, UNISA	Superconductivity and related activities at University of South Africa
16/11/2017	Dr. Qinfen Gu	Australian Synchrotron (ANSTO)	Tackling material research challenges with synchrotron based techniques
16/11/2017	Prof. Minoru Osada	National Institute for Materials Science (NIMS), Tsukuba, Japan	2D Oxide nanosheets: exploring new flatland

Postgraduate Completions

PHD GRADUATES

Name	Thesis Title	Year
V. H. Duong	Adaptive & robust algorithm for lithium-ion battery states estimation for application in electric vehicles	2017
Md. M Islam	Advanced 3d architecture of conductive polymer/nanoceramic matrix for flexible supercapacitors	2017
M. R. Kaiser	Development of cathode materials for room temperature lithium/sulfur batteries	2017
J. C. Knott	Design, modelling, characterisation and analysis of biasing techniques for saturated core fault current limiters	2017
K. C. Lim	Battery management system for electric vehicles	2017
L. Liu	Development of efficient electro catalysts for lithium oxygen batteries	2017
N. Masilamani	Graphene and superconducting thin film – a study on electronic and magnetic transport properties for detectors applications	2017
R. Rajagopalan	Nasicon based materials for high voltage lithium-ion and sodium-ion batteries	2017
C. Mayandi-Subramaniyam	Development of advanced electrodes and electrolyte for the lithium battery	2017
A. D. Squires	Terahertz technology and applications: 3D printing and art conservation	2017
Z. Tai	Development of advanced electrode materials for alkali metal ions batteries	2017
F. S. Wells	Investigating vortex behaviour in superconducting thin film through magnetic microscopy techniques	2017
F. Xiang	Quantum transport on topological matter	2017
Z. Yu	Metal oxide/hydroxide materials for electrochemical capacitors	2017
L. Zhang	Novel si based composite materials as anodes for energy storage	2017
S. Zhang	Transition metal chalcogenides based molecular probe in biomedical applications	2017
J. Zhuang	STM Investigation of silicene	2017
C. Bleasdale	The diamagnetic Kepler problem in a semiconductor environment	2016
X. Chen	Design and synthesis of binary and ternary copper chalcogenide nanostructures for energy conversion	2016
M. F. Md Din	Magnetic phase transitions and novel materials for magneto-caloric effect	2016
Y. H. Dou	Atomically thin transition metal oxides for energy conversion and storage	2016

Name	Thesis Title	Year
C. Han	Synthesis of nanostructured metal chalcogenides used for energy conversion and storage	2016
M. Ihsan	Advanced transition metal oxide materials as electrodes for lithium ion batteries	2016
S. Kalluri	Nano-engineering and advanced characterizations of layered-structure electrode materials for lithium-ion and sodium-ion batteries	2016
M. H. Khan	Synthesis and application of few-layered hexagonal boron nitride	2016
W. Li	Investigation on the promising electrode materials for rechargeable sodium ion batteries	2016
X. Liang	Study on sulfur cathode materials for high performance lithium/sulfur batteries	2016
W. Luo	Advanced materials for rechargeable lithium-oxygen batteries	2016
Y. Pan	Advanced materials for stable Li-S and Li-organic batteries	2016
D. J. Patel	Design and fabrication of solid nitrogen cooled MgB_2 based persistent magnet for MRI application	2016
B. Shabbir	Effects of hydrostatic pressure on critical current density & pinning mechanism of iron based superconductors and MgB_2	2016
J. Wang	Development of new electrode materials for lithium ion batteries and lithium oxygen batteries	2016
H. Q. Wang	Design and modification of cathode materials for high-performance lithium-sulfur and lithium-selenium batteries	2016
F. Xiao	Hexagonal boron nitride nanosheets synthesis and applications	2016
J. Y. Xiong	Advanced one dimensional plasmonic photocatalysts	2016
L. Zhao	Investigation on the electronic structures, hardness and thermoelectric properties of superionic thermoelectric materials	2016
Q. Chen	Electrical and optical properties of functional thermoelectric materials	2015
E. Constable	Strong magnetic field effects in the terahertz regime	2015
S. Fedoseev	Investigation of superconducting thin films and multilayered structures for electronic applications	2015
X. W. Gao	Composites and ionic liquid-based electrolytes for rechargeable lithium batteries	2015
I. Golovchanskiy	Thin films: growth mechanisms, superconducting and functional properties, modelling of vortex behaviour	2015
T. Katkus	Thermoelectric modules for high temperature power generation	2015
P. S. Lavers	Electronic structure of perovskite and related materials	2015
L. M. Lepodise	Terahertz spectroscopy of electronic materials	2015
D. Li	Three-dimensional porous electrode materials for lithium ion batteries	2015
S. Li	Bio-compatible materials for batteries	2015
J. J. Lin	Nanomaterials for catalyst	2015
A. Motaman	Current limiting mechanism in MgB_2	2015

Name	Thesis Title	Year
S. Porter	Perovskite titanium and niobium oxide nitrides: synthesis and characterization	2015
Y. Shi	Development of materials for room temperature sulfur batteries	2015
A. A. T. Tawfiq	Quantum properties of graphene and carbon nanostructures	2015
Y. Wang	Nanomaterials for LIBs	2015
G. Xia	Light metal hydrides for reversible hydrogen storage applications	2015
Z. J. Zhang	Development of advanced materials for rechargeable lithium batteries	2015
C. Zhu	Spin wave and spin density wave in magnetic materials	2015
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
A. Chowdhury	Synthesis of nano-ceramics for supercapacitors	2014
D. Cortie	Interface effects in magnetic metal/metal-oxide thin film systems	2014
L. Feng	Simulation of crystal, electronic and magnetic structures, and gas adsorption of two dimensional materials	2014
F. Hong	The magnetic and electric properties in novel magnetic systems	2014
A. Jalalian	Lead free piezoelectric materials	2014
J. G. Kim	Ti-based nanostructured materials for lithium-ion batteries	2014
L. M. Lepodise	THz spectroscopic studies of materials using the FTIR technique: Experiment and simulation	2014
L. Li	Nanostructured anode materials with high capacity for rechargeable energy storage	2014
V. Malgras	Lead sulfide colloidal quantum dots: passivation and optoelectronic characterisation for photovoltaic device applications	2014
M. Shahbazi	Study of iron pnictide superconductors	2014
J. Xu	Advanced materials for lithium-ion batteries and sodium-ion batteries	2014
Z. Yue	Transport properties of topological insulators Sb2Te3 and Bi2Te3 crystals and films	2014
C. Zhong	Graphene materials for Li-ion batteries	2014
F. Bijarbooneh	Improved nano-structures in hydrolysis-derived titanium dioxide particles for dye sensitized solar cell applications	2013
K. S. De Silva	Improving superconducting properties of MgB_2 by chemical doping using graphene as C source	2013
Q. Li	Research on superconducting films and buffer layers for electronic applications	2013

Name	Thesis Title	Year
L. Lu	Electrolytes for rechargeable batteries	2013
M. Mustapic	Enhancement of MgB_2 superconductor by magnetic nanoparticle doping	2013
L. Noerochim	Improving the capacity and safety of lithium ion battery	2013
E. Pogson	Terahertz applications in medicine, the environment and optics	2013
K. Radhanpura	Semiconductor materials and structures for the efficient generation of terahertz radiation	2013
M. Salari	Application of nanostructural titania in supercapacitors	2013
P. Shamba	Novel magnetocaloric materials for room temperature magnetic refrigeration	2013
K. H. Seng	Advanced nanomaterials for lithium ion batteries	2013
C. Zhong	Three-dimensional nano-materials for lithium-ion batteries	2013
C. F. Zhang	Advanced electrode materials for lithium ion batteries	2013
J. Debnath	Nanostructure control of MgB_2 by chemical doping	2012
N. Idris	Nanomaterials for lithium rechargeable batteries	2012
M. Ismail	Hydrogen storage materials	2012
J. F. Mao	Study on hydrogen storage behaviour of $LiBH_4$	2012
K. W. See	Experimental and theoretical approaches for AC losses in practical superconducting tapes for engineering applications	2012
P. Jood	Oxide thermoelectric materials for high temperature power generation	2012
G. Du	Performance improvement of cathode materials for lithium batteries	2012
Y. Du	Multiferroic transition metal oxides: structural, magnetic, ferroelectric, and thermal properties	2011
M. F. Hassan	Nanostructured materials for lithium ion batteries	2011
S. Hargreaves	High efficiency terahertz emitters	2011
H. Liu	Design of nano-structured materials and their applications for lithium ion batteries	2011
M. Maeda	Densification and connectivity in polycrystalline MgB_2 materials for improvement of critical current density	2011
C. K. Poh	Metallic nanostructures, ultrathin films and optical technologies for hydrogen storage and switchable mirrors	2011
J. Park	Nanostructured semiconducting metal oxides for use in gas sensors	2011
M. M. Rahman	Advanced materials for lithium-ion batteries	2011
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

Name	Thesis Title	Year
H. Wu	New catalyst materials for hydrogen fed fuel-cells and hydrogen storage on double walled carbon nanotubes	2011
L. Wang	Chemical solution deposition for YBCO superconducting films and Sm_2O_3 buffer layers on single crystal and biaxially textured metallic substrates	2011
P. Zhang	Synthesis and characterization of nanostructured electrodes for lithium-ion batteries	2011
S. L. Chou	Nanostructured / composite materials for rechargeable Li-ion battery and supercapacitor	2010
W. X. Li	Carbohydrate doping effect on the superconductivities and microstructure of MgB_2 superconductor	2010
S. Pysarenko	HTS multi-layers thin films fabrication	2010
R. Nigam	Study of magnetic behaviour of Ru-based superconducting ferromagnets	2010
A. Ranjbar	Effect of catalysts on hydrogen storage properties of MgH_2	2010
Q. Yao	Study of newly discovered two dimensional cobalt based perovskite compounds doped with various rare earth elements	2009
Y. Zhang	Improvement of critical current density in MgB_2 by optimizing process parameters and chemical doping	2009
X. Xu	Effect of starting boron powder on the superconducting properties of MgB_2	2009
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
M. M. Farhoudi	Studies of structures, transport and magnetic properties of doped novel three dimensional perovskite compounds	2009
Y. P. Yao	A study of electro materials for lithium-ion batteries	2008
S. H. Ng	Nanostructured materials for electrodes in lithium-ion batteries	2008
O. Shcherbakova	Development of $MgB_{2-x}C_x$ superconductors and understanding their electromagnetic behaviour	2008
M. S. Park	Synthesis and characterization of nanostructured electrode materials for rechargeable lithium ion batteries	2008
M. S. A. Hossain	Study of superconducting and electromagnetic properties of un-doped and organic compound doped MgB_2 conductors	2008
Z. G. Huang	Effects of compositions and mechanical milling modes on hydrogen storage properties	2008
S. A. Needham	Development of advanced electrode materials for lithium-ion batteries	2007
G. Peleckis	Studies on diluted oxide magnetic semiconductors for spin electronic applications	2007
M. Roussel	Magneto-optical imaging in superconductors	2007
L. Yuan	Investigation of anode materials for lithium-ion batteries	2007
M. O'Dwyer	Solid-state refrigeration and power generation using semiconductor nanostructures	2007
Y. Chen	Investigation on advanced active materials for lithium-ion batteries	2006
S. Bewlay	Investigation on Li-Co-Ni system for lithium ion batteries	2006

Name	Thesis Title	Year
A. Li	A study of the fabrication and characterization of high temperature superconductor $YBa_2Cu_3O_7$ thin films	2006
S. H. Pilehrood	Electronic properties of semiconductor nanostructures under intense terahertz radiation	2006
W. K. Yeoh	Control of nanostructure for enhancing superconductor performance through chemical doping	2006
Y. Zhao	Fabrication and characterization of superconducting PLD MgB_2 thin films	2006
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
F. Gao	Studies on the synthesis, characterization and properties of colossal magnetoresistive (CMR) materials	2004
M. Lindsay	Data analysis and anode materials for lithium ion batteries	2004
B. Lough	Investigations into thermionic cooling for domestic refrigeration	2004
D. Milliken	Uranium doping of silver sheathed bismuth-strontium-calcium-copper-oxide superconducting tapes for increased critical current density through enhanced flux pinning	2004
S. Soltanian	Development of superconducting magnesium diboride conductors	2004
C. Wang	Cathodic materials for nickel-metal hydride batteries	2004
S. H. Zhou	Processing and characterization of MgB_2 superconductors	2004
Z. P. Guo	Investigation on cathode materials for lithium-ion batteries	2003
J. McKinnon	The fundamental mechanisms involved in the production of thin films by pulsed laser	2003
D. Marinaro	A study into the effects of fission-fragment damage on activation energies in Ag/Bi2223 tapes	2003
D. Q. Shi	Buffer layers for YBCO superconducting films on single crystal YSZ substrates and cubic texture Ni substrates	2003
J. Wang	Development of a novel plate making processing technique for manufacturing valve-regulated lead-acid batteries	2003
R. Baker	Zeeman and piezo-spectroscopy of antimony and aluminium in germanium	2001
X. K. Fu	Fabrication and characterization of Bi-2223 current lead	2002
K. Uprety	Magnetic hysteresis and relaxation in Bi-2212 single crystals doped with iron and lead	2002
F. Darmann	AC Loss in high temperature superconductor	2001
G. X. Wang	Investigation on electrode materials for lithium-ion batteries	2001
J. P. Chelliah	Optical spectroscopy of semiconductors	2000
L. Sun	Amorphous and nanocrystalline hydrogen storage alloy materials for nickel-metal hydride batteries	2000
X. L. Wang	Spiral growth, flux pinning and peak effect in doped and pure Bi-2212 HTS single crystal	2000
R. Zeng	Processing and characterization of Bi-2223/Ag superconducting tapes	2000
J. Chen	High energy storage material for rechargeable nickel-metal hydride batteries	1999

Name	Thesis Title	Year
T. Silver	Near band-edge optical properties of MBE GaAs and related layered structures	1999
G. Takacs	Spectroscopy of the effect of strains and magnetic field on shallow acceptor levels in germanium	1999
N. Cui	Magnesium based hydrogen storage alloy anode materials for Ni-MH secondary batteries	1998
R. J. Heron	Far-infrared studies of semiconductors in large magnetic fields	1998
M. Ionescu	Growth and characterization of Bi-2212 crystals and improvement of Bi-2212/Ag superconducting tapes	1998
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
M. Lerch	Optical & electrical studies of resonant tunnelling heterostructure	1998
S. Stewart	Thermodynamic and dielectric properties in modulated two-dimensional electronic systems	1998
W. G. Wang	Fabrication and improvement of silver sheathed $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10}$ tapes By powder-in-tube technique	1998
B. Zeimetz	High temperature superconducting tapes & current leads	1998
S. Zhong	Investigation on lead-calcium-tin-aluminium grid alloys for valve-regulated lead-acid batteries	1998
B. L. Luan	Investigations on Ti_2Ni hydrogen storage alloy electrode for rechargeable nickel-metal hydride batteries	1997
N. Vo	Design and characterization of HTS coils	1997
A. Warner	A spectroscopic study of acceptors in germanium	1997
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
M. Yavus	Powder processing of Bi-Pb-Sr-Ca-Cu-O superconducting materials	1997
Q. Y. Hu	Fabrication and enhancement of critical currents of silver sheathed $Bi,Pb_2Sr_2Ca_3Cu_3O_{10}$ tapes	1996
J. Yau	Ag/Bi-2223 tape processing and mechanical properties	1994
J. A. Xia	Characterization of melt-texture of YBCO HTS	1994
Y. C. Guo	Investigation of silver-clad $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10-x}$ superconducting tapes	1994
A. Bourdillion	Microstructure, phase characterization and texture processing of HTS	1992
M. Apperley	The fabrication of high Tc superconductor wire	1992

MASTERS GRADUATES

Name	Thesis Title	Year
J. Byrnes	Advanced microscopy of thermoelectric materials	2017
Y. Chen	Study of electrochemical properties of liquid gallium	2017
J. George	A Study of vortex dynamics in patterned superconducting thin films	2017
V. Patterson	Band gap study of lead chalcogenide alloys	2017
Y. Xu	Optimizing Sn-based anode nanostructure and binder material for use in high-performance lithium-ion batteries	2016
Q. Yang	Novel anode materials for sodium ion battery	2016
K. Huang	One-dimensional anode materials for sodium ion batteries	2015
C. Stewart	An investigation into the tailoring of bismuth oxide nanoceramic with a biomedical application as a high Z radiation enhancer for cancer therapy.	2015
F. Yun	Energy materials	2014
I.M. Hashim	Corrosion evaluation of Al-based alloys	2014
R. Hargreaves	Ultrafast demagnetization as a terahertz source	2014
M. Sale	Large throughput analysis of crystal structures for identification of promising Li-ion battery materials.	2014
H. Baiej	Superconducting thin films	2013
A. Chowdhury	Synthesis of nanoceramics for supercapacitors	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
C. Zhong	Development of new electrode materials for lithium ion batteries	2010
L. Lu	Enhancement of connectivity and flux pinning in MgB_2 superconducting bulk and wires	2009
Y. S. Wu	Fabrication of in-situ MgB_2 thin films on Al_2O_3 substrate using off-axis PLD technique	2007
Z. J. Lao	New materials for supercapacitors	2006
B. Winton	A study of the magnetoresistance effect in Bi-2212 for the purposes of utilisation in magnetic field sensors	2005
Q. Yao	MgB_2 thin films	2005
P. Lavers	The mobility of large anions in crystals with the fluorite structure	2004

Name	Thesis Title	Year
J. Yao	Carbon based anode materials for lithium-ion batteries	2004
Z. W. Zhao	Nano-oxides fabricated in-situ by spray pyrolysis technique as anode materials for lithium secondary batteries	2004
K. Ishida	Landau spectra of ZnH and neutral Zn in germanium	2004
S. Lee	Multilayer thermionic cooling in GaAs-AlxGa1-xAs heterostructures	2003
Z. Zhang	The comparative research on the Ag-alloy sheathed Bi-2223 tapes	2003
A. Li	Fabrication and characterization of novel substrates and superconducting thick films	2002
M. Farhoudi	AC loss in Ag/Bi-2223 tape in AC field	2002
M. Ling	Mechanism of outgrowth in multifilament Bi-2223 tape	2001
E. Sotirova	Investigation of colossal magnetoresistance materials	2001
K. Uprety	Vortex properties of Bi-HTS	1999
J. Z. Wang	Investigations on anode materials for rechargeable lithium-ion batteries	1999
F. Chen	The influence of selenium on lead-calcium-tin-aluminium	1998
G. Yang	Effect of element substitution on superconductivity	1997
N. Zahir	A new method for production and study of electrical properties of carbon foam	1996
J. X. Jin	$(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10+x}$/Ag high Tc superconductors and their applications in an electrical fault current limiter and an electronic high voltage generator	1994

Postgraduate Student Awards 2017

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.

ISEM POSTGRADUATE STUDENT EXCELLENCE AWARD

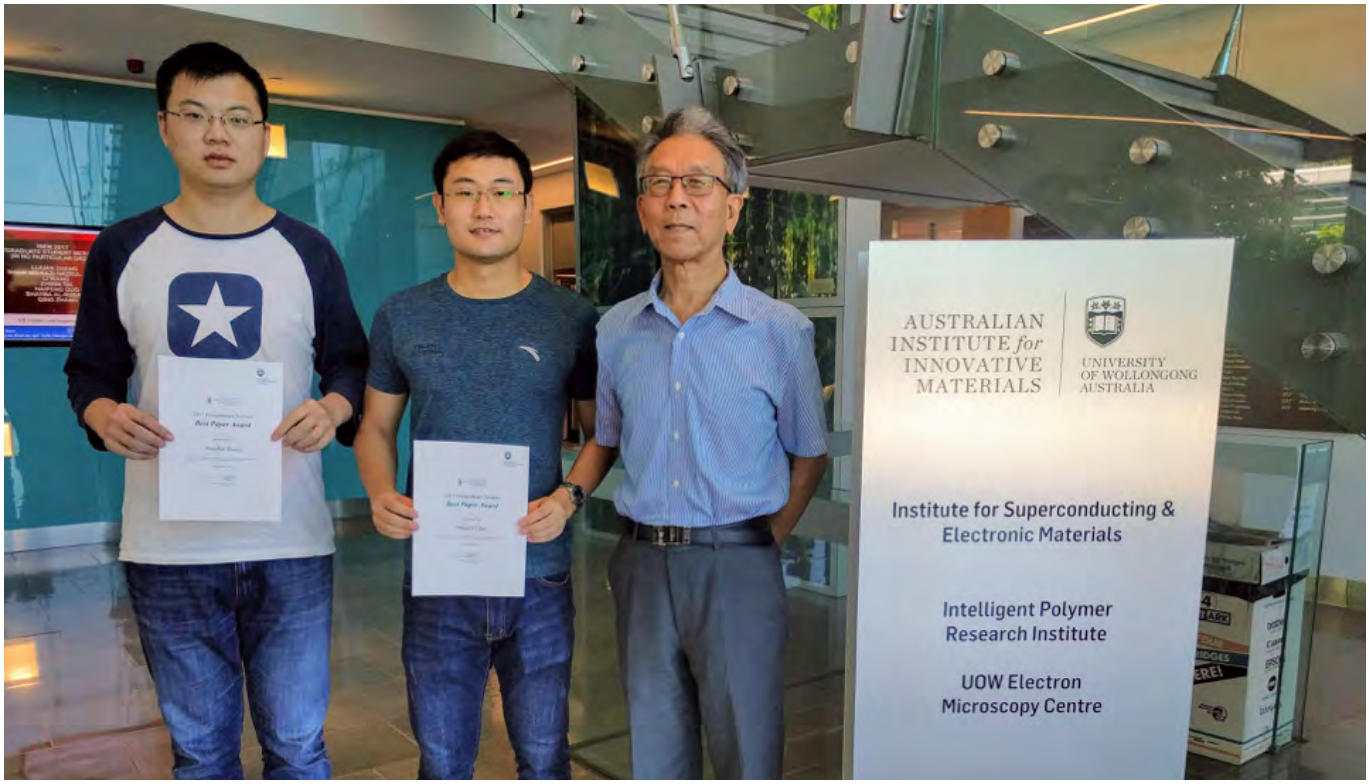
(left to right): Wenbin Qiu, Neng Zhang, Yajie Liu, Binwei Zhang, Zhe Hu, Distinguished Professor Shi Xue Dou

ISEM POSTGRADUATE STUDENT MERIT AWARD

(left to right): Haipeng Guo, Sheik Md Kazi Naszul Islam, Lijuan Zheng, Qing Zhang, Li Wang, Shaymaa Al-Rubaye, Distinguished Professor Shi Xue Dou

ISEM POSTGRADUATE STUDENT BEST PAPER AWARD

(left to right): Wenchao Zhang, Mingzhe Chen, Distinguished Professor Shi Xue Dou



PAST ISEM CHINESE GOVERNMENT PRIVATE POSTGRADUATE STUDENT AWARD WINNERS

Name	Year
Yue Zhao	2006
Zhen Guo Huang	2007
Jerry Zhao	2007
Wen Xian Li	2008
Da Peng Chen	2008
Shulei Chou	2009
Hao Liu	2009
Peng Zhang	2009

Name	Year
Guo Dong Du	2010
Yi Du	2010
Jian Feng Mao	2010
Chao Zhong	2011
Chao Feng Zhang	2012
Hong Fang	2012
Xuan Wen Gao	2013
Yi Shi	2013

Name	Year
Zengji Yue	2013
Guang Lin Xia	2014
Jian Jian Lin	2015
Tengfei Zhou	2016
Hong Chao Wang	2016
Lili Liu	2016

A high-performance titanium-oxide electrocatalyst for water splitting fabricated in collaboration with Beihang University.

Current and Ongoing Research Projects

ARC CENTRE OF EXCELLENCE

ARC Centre of Excellence in Future Low Energy Electronics Technologies

Years Funded:	2017 $224,105	2018 $216,211	2019 $218,842	2020 $218,842	2021 $218,842	2022 $221,474	2023 $221,474
Total Funding:	$1,539,788						
Project ID:	CE170100039						
Lead CI:	M. Fuhrer (University of Melbourne)						
UOW CI:	X. L. Wang						
Project Summary:	This Centre aims to develop the scientific foundation and intellectual property for new electronics technologies. Decreasing energy use is a major societal challenge, and this Centre aims to meet that challenge by realising fundamentally new types of electronic conduction without resistance in solid-state systems at room temperature. Novel resistance-free electronic phenomena at room temperature are expected to form the basis of integrated electronics technology with ultra-low energy consumption. This Centre's development of innovative electronics could put Australia at the forefront of the international electronics industry.						

ARC DISCOVERY PROJECTS

Multifunctional 2D materials for sustainable energy applications

Years Funded:	2016 $152,000	2017 $152,000	2018 $152,000	2019 $154,000
Total Funding:	$610,000			
Project ID:	DP160102627			
Chief Investigators:	S. X. Dou, Z. Q. Sun, X. Xu, T. Liao			
Partner Investigator:	Z. F. Liu, H. Zhang, J.-B. Baek, L. M. Dai			
Project Summary:	This project seeks to explore the great potential of novel graphene-like two dimensional (2-D) materials for energy applications. 2-D materials, which possess atomic or molecular thickness and infinite planar lengths, are regarded as a building block for many applications due to their unique nanostructures, electronic and mechanical properties. This project is focused on the design and exploration of layered two-dimensional artificial graphene and graphene analogues with 'on-demand' properties to exploit advanced energy applications. There is now a pressing need to integrate graphene sheets into multidimensional and multifunctional systems with spatially well-defined configurations, and integrated systems with a controllable structure and predictable performance. Project outcomes may lead to next-generation devices in energy storage and other applications.			

Coherent, tuned terahertz photons from nonlinear processes in graphene

Years Funded:	2016	2017	2018
	$135,000	$130,000	$130,000
Total Funding:	$395,000		
Project ID:	DP160101474		
Chief Investigators:	C. Zhang, R. Lewis, Z. Li		
Partner Investigator:	F. Q. Wang, H. Schneider, M. Johnston		
Project Summary:	The project aims is to develop a low cost, tunable, efficient and coherent source of terahertz light. While much of the electromagnetic spectrum is in common use, the terahertz region, lying in frequency above electronics and radio waves but below photonics and visible light, is still relatively unexploited. Today the biggest challenge in the field remains the radiation source. This project aims to develop a new type of terahertz source based on strong nonlinear optical processes in graphene and cognate materials. It proposes the direct transformation of the surface plasmon polariton to terahertz photons. A high efficiency terahertz radiation source would significantly expand the use of terahertz technology in science, medicine, industry and defence.		

Liquid phase hydrogen carriers for energy storage and delivery

Years Funded:	2017	2018	2019
	$131,000	$130,000	$130,000
Total Funding:	$391,000		
Project ID:	DP170101773		
Chief Investigators:	Z. G. Huang, H. K. Liu		
Partner Investigator:	H. B. Yu, X. B. Yu		
Project Summary:	This project aims to overcome hydrogen storage and delivery issues by developing liquid-phase hydrogen storage materials with high hydrogen capacity, exceptional stability and that do not change phase during hydrogen evolution. This project will build on the recent synthesis of strategically important hydrogen storage compounds. The innovative liquid-phase hydrogen storage and delivery technology will enable effective usage of established liquid fuel distribution techniques and infrastructure throughout the country. The project would benefit renewable energy, chemical, and manufacturing industries, where new employment opportunities would be created.		

Atomically thin superconductors

Years Funded:	2017	2018	2019
	$124,500	$124,000	$124,000
Total Funding:	$372,500		
Project ID:	DP170104116		
Chief Investigators:	X. L. Wang, Z. Li, Z. X. Cheng, Y. Du		
Partner Investigator:	Q. K. Xue		
Project Summary:	This project aims to explore two-dimensional superconducting materials and elucidate the origins of their superconductivity. High temperature superconductivity in single layer iron-based superconductors offers a platform for exploring superconductors with even higher critical temperature (Tc) and has aroused great hope of understanding the underlying mechanisms for high Tc superconductivity. This project is expected to introduce physics and materials, leading to a better understanding of the two-dimensional superconducting phenomenon and the discovery of physical phenomena for new electronic devices.		

Two-dimensional plasmonic heterogeneous nanostructures for photocatalysis

Years Funded:	2017	2018	2019		
	$171,000	$171,000	$171,000		
Total Funding:	$513,000				
Project ID:	DP170101467				
Chief Investigators:	S. X. Dou, Y. Du, X. Xu, G. Peleckis				
Partner Investigator:	J. H. Ye, W. C. Hao, L. Chen				
Project Summary:	This project aims to design and explore two-dimensional heterogeneous photocatalysts that can convert solar energy into usable chemical energy. This project will investigate the correlation between surface plasmonic resonance and photocatalytic activities on the atomic level. Heterogeneous engineering and in-situ investigation of atomic-level photocatalytic dynamics is expected to yield several new full-solar-spectrum photocatalysts. The project is expected to contribute to the understanding of the processes and mechanisms underlying photocatalysis, and lead to useable, stable and durable photocatalytics. The outcomes will enable efficient, cost-effective and reliable production of clean energy in a low-emission way.				

Potassium ion batteries for large scale renewable energy storage

Years Funded:	2017	2018	2019		
	$165,500	$164,000	$164,000		
Total Funding:	$493,500				
Project ID:	DP170102406				
Chief Investigators:	Z. P. Guo, K. Konstantinov				
Partner Investigator:	X. W. Lou, Z. Zhou				
Project Summary:	The project aims to develop potassium ion batteries for renewable energy storage and conversion. Potassium ion batteries could be the most promising choice for large-scale electrical energy storage, particularly for renewable energy sources and smart electrical grids, due to their low cost, natural abundance and the advantages of potassium compared to lithium/sodium ion batteries. This study will research the electrochemical reactions and charge transfer pathway of electrode materials with excellent potassium ion storage performance. This project is expected to develop high performance potassium ion batteries and advance the prominence of Australia in the global renewable energy market.				

FUTURE FELLOWSHIPS

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.				

Exploration of advanced nanostructures for sodium-ion battery application

Years Funded:	2015	2016	2017	2018	2019
	$117,000	$222,000	$222,000	$222,000	$117,000
Total Funding:	$900,000				
Project ID:	FT150100109				
Chief Investigator:	Z. P. Guo				
Project Summary:	The aim of this project is to develop advanced nanostructured electrode materials for high energy, long service life sodium ion batteries. Sodium-ion batteries are the most promising choice for large-scale electrical energy storage, in particular for renewable energy sources and smart electric grids, owing to their low cost and natural abundance of sodium. The success of this project will advance fundamental understanding of sodium-ion batteries, and provide techniques for the development of a promising low-cost system for renewable energy storage, which is urgently needed in smart electricity grids.				

All-metal nanoporous materials as highly active electrocatalysts

Years Funded:	2015	2016	2017	2018	2019
	$97,000	$197,000	$197,000	$197,000	$97,000
Total Funding:	$785,000				
Project ID:	FT150100479				
Chief Investigator:	Y. Yamauchi				
Project Summary:	This project aims to create new avenues for large-scale and well-controlled synthesis of novel hierarchical nanoporous Pt-based architectures, and develop the device applications using the resultant new generation of electrocatalysts. The key concept and strategy lie in the utilization of the unique properties of well-defined nanoarchitectures to reduce the content of Pt and to improve its electrocatalytic performance in practical devices. Nanoporous systems in electrocatalysts can provide more active sites (e.g., sufficient edge and corner atoms, and rich steps and kinks) and effective surface permeability, which will result in the enhancement of catalytic activity.				

High-voltage electrode materials for lithium-ion batteries

Years Funded:	2016	2017	2018	2019	2020
	$82,000	$163,000	$163,000	$163,000	$82,000
Total Funding:	$653,000				
Project ID:	FT160100251				
Chief Investigator:	W. K. Pang				
Project Summary:	This project aims to establish a complete battery research system and develop high-voltage electrode materials for lithium-ion batteries through mechanistic understanding obtained in operando studies. Lithium-ion batteries are the most promising choice for portable electronic devices, including electric vehicles, due to their high power and energy performance compared with other battery technologies. The success of this project is expected to advance fundamental understanding of lithium-ion batteries, and provide techniques to develop a promising high-energy and high-power battery system.				

DECRA FELLOWSHIPS

Lithium-ion conducting sulfide cathodes for all-solid-state Li-S batteries

Years Funded:	2016	2017	2018
	$124,000	$124,000	$124,000
Total Funding:	$372,000		
Project ID:	DE160100596		
Chief Investigators:	W. P. Sun		
Project Summary:	The aim of the project is to develop lithium-ion conducting sulphide cathode materials for high performance all-solid-state lithium-sulphur (Li–S) batteries. Substituting solid-state electrolyte for liquid electrolyte is the most efficient approach to eliminate the polysulfide shuttle effect, which is the biggest obstacle for the practical application of Li–S batteries based on liquid electrolytes. The project aims to develop novel Li_2S-rich cathode materials with high lithium-ion conductivity, which will form the basis of all-solid state Li–S batteries with high energy density. The new battery is expected to have wide applications in portable electronic devices, electric vehicles and grid-scale renewable energy storage.		

Nanostructured metal hydrides for practical hydrogen storage applications

Years Funded:	2017	2018	2019
	$120,000	$120,000	$120,000
Total Funding:	$360,000		
Project ID:	DE170100362		
Chief Investigators:	G. L. Xia		
Project Summary:	This project aims to synthesise nanostructured metal hydrides with particle size smaller than 5 nm. The practical applications of metal hydrides as advanced solid-state hydrogen storage materials require substantial knowledge and delicate engineering of materials on the nanoscale. Combined with controllable modification on the nanoscale, the optimised metal hydrides will enhance the performance of hydrogen storage materials. This project is expected to advance understanding of the technologies of metal hydrides as hydrogen storage materials and develop practical applications of metal hydrides in storage tanks for fuel cells. Hydrogen energy could also reduce carbon dioxide emissions and alleviate air pollution.		

Carbon-based catalysts for polysulphide redox reactions in lithium-silicon batteries

Years Funded:	2017	2018	2019
	$120,000	$120,000	$120,000
Total Funding:	$360,000		
Project ID:	DE170100871		
Chief Investigators:	J. Liang		
Project Summary:	This project aims to develop surface-engineered carbons as multifunctional catalysts to accelerate the polysulphide redox reactions for lithium-silicon batteries. High capacity storage of electricity is the key to efficient use of renewable and clean energy resources and the development of emission-free technologies. This project will provide high-performance lithium-silicon batteries with high energy density, high efficiency, and long life. Its success is expected to contribute to energy technologies, reduce the dependence of household and industrial energy consumption on fossil fuels, enhance Australia's long-term viability, and bring economic, environmental, and social benefits to the nation.		

Room-temperature sodium-sulphur batteries

Years Funded:	2017	2018	2019
	$120,000	$120,000	$120,000
Total Funding:	$360,000		
Project ID:	DE170100928		
Chief Investigators:	Y. X. Wang		
Project Summary:	This project aims to develop silicon-based cathode materials for high-performance RT-sodium/sulphur batteries. These are expected to improve the sulphur electroactivity with sodium and supress the shuttle effect, achieving high energy density and cycling stability. This project will accelerate the sluggish electrochemical reactions between sulphur and sodium by embedding sulphur in hollow mesoporous carbon nanospheres, and modify the surface of the mesoporous carbon nanospheres' host. A superior RT-sodium/sulphur battery with high energy density, a long cycling life, and stationary storage has potential to shift fossil fuels towards renewable energy system to power the economy in the long run.		

Electrode materials for sodium storage

Years Funded:	2017	2018	2019
	$120,000	$120,000	$120,000
Total Funding:	$360,000		
Project ID:	DE170101426		
Chief Investigators:	C. Wu		
Project Summary:	This project aims to develop phosphide-based electrode materials for high-performance sodium-ion batteries (SIBs) with high reversible capacity, superior rate capability and long cycle life. SIBs have great advantages in terms of low cost and infinite sodium resources, but the large size of the sodium-ion creates kinetic problems and a significant volume change for electrode materials. This project aims to design and synthesise phosphide-carbon hybrids with multi-scale, multi-dimension and hierarchical architectures as electrodes to overcome these problems. Expected outcomes include understanding the sodium-storage mechanisms, the size effect, and the architecture role for phosphide-based electrodes.		

ARC LINKAGE PROJECTS

Development of the next generation battery storage system for smart grid

Years Funded:	2016	2017	2018	2019
	$90,000	$90,000	$90,000	$90,000
Industry Fund:		$100,000	$100,000	$50,000
Total Funding:	$610,000			
Project ID:	LP160100273			
Chief Investigators:	S. X. Dou, W. P. Sun, K. W. See, X. Xu			
Industry Partner:	Tianjin Benefo Machinery Equipment Group Central Research Institute			
Project Summary:	This project aims to significantly improve the energy density, safety and robust storage performance of lithium batteries with reduced cost, by developing a next-generation battery with lithium-rich layered oxide cathodes and titanium oxide-based and silicon-based anodes. Intelligent features will make the whole energy network a next-generation battery storage system, with mechanisms to protect the battery from hazardous and inefficient operating conditions. This lithium ion battery storage system is expected to create opportunities for businesses that harvest renewable energy and make existing industries more environmentally benign.			

Development of novel safe lithium metal-free sulfur batteries

Years Funded:	2016	2017	2018	2019
	$32,000	$73,000	$73,000	$32,000
Industry Fund:		$39,000	$26,000	$13,000
Total Funding:	$288,000			
Project ID:	LP160100914			
Chief Investigators:	J. Z. Wang, H. K. Liu, K. Konstantinov, S. L. Chou			
Industry Partner:	Nipress TBK, PT			
Project Summary:	This project aims to develop a lithium-metal-free sulphur battery system, and technology to commercialise this battery technology. Expected outcomes include an electrochemical system consisting of a selected promising lithium sulphide cathode, an alloying type anode and a liquid-based electrolyte, and large lithium-ion sulphur batteries with selected advanced electrode materials and electrolytes. Anticipated outcomes are the improved safety of typical lithium-sulphur batteries; that Australia will be internationally competitive in the area of energy storage; and increased overseas demand for Australian raw materials for manufacturing lithium-ion batteries.			

High energy density, long life, safe lithium Ion battery for electric cars

Years Funded:	2016 $70,000	2017 $140,000	2018 $140,000	2019 $70,000
Industry Fund:		$145,000	$96,000	$49,000
Total Funding:	$710,000			
Project ID:	LP160101629			
Chief Investigators:	Z. P. Guo, J. F. Mao, W. Li			
Industry Partner:	Tianneng Power International Limited			
Project Summary:	This project aims to develop next-generation lithium-ion batteries with high energy density, safety, long cycle life, and fast charge capability, using a Ni-rich layered oxide cathode and silicon/carbon composite anode. This lithium-ion battery system is expected to meet 2020 targets for electric vehicles. The project will also investigate the reaction/electrode fading mechanism of the proposed anode/cathode materials for the deep understanding of these electrode materials, and provide guidance for future electrode materials design and battery research. This will provide significant benefits for automotive industries, smart grid, and business in storing renewable energy and better environment and sustainability.			

Nanostructure engineered low activation superconductors for fusion energy

Years Funded:	2016 $54,000	2017 $106,000	2018 $106,000	2019 $54,000
Industry Fund:		$55,000	$55,000	$55,000
Total Funding:	$485,000			
Project ID:	LP160101784			
Chief Investigators:	M. S. A. Hossain, S. X. Dou, J. H. Kim, Y. Yamauchi, R. Taylor, V. Luzin, A. Devred			
Industry Partner:	QUT, ANSTO, ITER, Hyper Tech Research Inc., Pavezyum, Magnix Technologies			
Project Summary:	This project aims to develop a novel, low activation and liquid helium-free superconducting solution with superior electromagnetic, mechanical and thermal properties for use in fusion reactors. Superconducting magnets and their associated cryogenic cooling systems represent a key determinant of thermal efficiency and the construction/operating costs of fusion reactors. The project expects to overcome these barriers so that widespread uptake of these reactors becomes viable. Outcomes from the project will include a fundamental understanding of pure and doping-induced isotopic magnesium diboride superconductors and their behaviour under high neutron flux and harsh plasma atmosphere, which are specifically designed for application in next-generation, low-cost fusion reactors.			

AUTO CRC PROJECTS

High energy anode materials for lithium ion batteries

Years Funded:	2015	2016 $113,000	2017 $190,000	$77,000
Total Funding:	$380,000			
Project ID:	1-117			
Chief Investigators:	H. K. Liu, Z. P. Guo, J. Z. Wang, J. H. Kim, K. Konstantinov, S. L. Chou			
Industry Partner:	Baosteel Company			
Project Summary:	The global market for energy storage, including lithium ion batteries (LIBs) for electric vehicles (EVs), will experience unprecedented growth in the next decade. The challenges of EV LIBs are related to the materials used in the LIBs. This project aims to study high energy anode materials with reduced cost and improved safety to meet the requirements for the next generation of LIBs and make them more suitable for EVs.			

AUSTRALIAN RENEWABLE ENERGY AGENCY PROJECT

The Smart Sodium Storage Solution (S^4) Project

Years Funded:	2016	2017	2018	2019	2020
	$579,500	$869,500	$1,328,000	$1,181,500	$558,500
Total Funding:	$4,517,000				
Chief Investigators:	S. X. Dou, H. K. Liu, S. L. Chou, K. W. See, D. Soetanto, K. Muttaqi, S. Ville				
Project Summary:	This project will develop and integrate a new type of sodium-ion battery in a low-cost, modular and expandable energy storage system to be demonstrated at the Illawarra Flame House and Sydney Water's Bondi Sewage Pumping Station. This project will develop a new sodium-ion battery architecture, optimised for use in renewables storage applications, by building on the world-class energy materials research and deep industry ties of the Institute for Superconducting and Electronic Materials (ISEM). Facilities at the ISEM used to prototype and characterise the sodium-ion batteries for ISEM's industry-leading researchers will be upgraded and expanded to support the rapid development of the battery architecture. A modular, expandable packaging system with integrated battery and thermal management systems will be developed, produced and validated through two applications: a 5 kWh battery at Illawarra Flame House, an award-winning net-zero energy home, and a 30 kWh integrated battery and energy management system at Sydney Water's Bondi Sewage Pumping Station. The Sydney Water site will also have an energy management system developed as part of this project, which will integrate and manage renewable energy generation, storage and consumption in an efficient manner by utilising intelligent algorithms and control strategies. The Sydney Water site will demonstrate the turn-key nature of the system and highlight the suitability of sodium-ion batteries for use in utility applications.				

OTHER GRANTS

Coal Services – Health and Safety Trust
Diesel-Free environment for underground coal mines

Years Funded:	2015	2016	2017	2018
	$81,000	$277,000	$224,000	$88,000
Total Funding:	$670,000			
Chief Investigators:	S. X. Dou, K. W. See			
Project Summary:	The potential for adverse health effects arising from occupational exposure to diesel particulate has been the subject of intense scientific debate for the past 25 years. Diesel exhaust (DE) and diesel particulate matter (DPM) in underground mines are a health risk for workers, who can suffer acute and chronic health conditions (e.g. asthma, nausea, lung inflammation, headaches, eye and nose irritation, cardiopulmonary disease, cardiovascular disease, and cancer) through exposure to NO_x (nitric oxide and nitrogen dioxide (NO_2)). Also, noise levels in the proximity of diesel-vehicle operation – particularly in confined settings – impair the hearing of operators following many hours of exposure. This project takes the stance that from a regulatory perspective emission prevention, not reduction, should be the ultimate policy goal. We aims to remove barriers to the adoption of electric-drive diesel free general purpose vehicles in underground mines, which have clear benefit to Australian mines via lower operating costs and cleaner environments for workers.			

Baosteel Australia Joint Research Centre
High energy anode materials for lithium ion batteries

Years Funded:	2015	2016	2017
	$100,000	$50,000	$50,000
Total Funding:	$200,000		
Project ID:	BA14006		
Chief Investigators:	H. K. Liu, Z. P. Guo, J. Z. Wang, J. H. Kim, K. Konstantinov, S. L. Chou		
Project Summary:	The global market for energy storage, including lithium ion batteries (LIBs) for electric vehicles (EVs), will experience unprecedented growth in the next decade. The challenges of EV LIBs are related to the materials used in the LIBs. This project aims to study high energy anode materials with reduced cost and improved safety to meet the requirements for the next generation of LIBs and make them more suitable for EVs.		

US Office of Naval Research
Exploration of new mesoscale mechanisms for ultrahigh piezoelectric responses in relaxor ferroelectrics

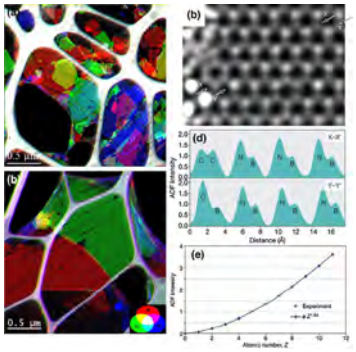
Years Funded:	2016	2017	2018
	$65,000	$130,000	65,000
Total Funding:	$260,000		
Chief Investigators:	S. J. Zhang, Z. X. Cheng, J. L. Wang		
Project Summary:	The main objective of the proposed research effort is to fundamentally understand the long-standing scientific question: what are the mesoscale mechanisms responsible for the ultrahigh piezoelectric responses of relaxor ferroelectrics. A key signature of relaxor ferroelectrics is the presence of polar nanoregions (PNRs). However, despite two decades of extensive studies, the role of PNRs in the extraordinary electromechanical properties of relaxor ferroelectric solid-solution crystals is yet not well understood. We propose a closely integrated experimental and computational program to validate our hypothesis (the polar directions of PNRs are collinear with the spontaneous polarization of the normal ferroelectric domains), employing $Pb(Mg_{1/3}Nb_{2/3})O3$-$PbTiO_3$ (PMN-PT) and $Pb(Zn_{1/3}Nb_{2/3})O_3$-$PbTiO_3$ (PZN-PT) solid solution single crystals as model systems. We will conduct advanced structural characterization of both long-range ferroelectric domain structures (LRFDs) and polar nanoregions (PNRs), together with the temperature and frequency spectroscopic measurements, to isolate the contribution of PNRs to piezoelectric and dielectric responses. In addition, phase-field simulations of mesoscale relaxor ferroelectric microstructures and the corresponding piezoelectric and dielectric responses will be performed. The fundamental understanding achieved in the proposed project is expected to benefit the exploration of new relaxor ferroelectric materials and understand the general class of ferroic glasses, such as spin glass and strain glass.		

Korean Institute of Energy Technology Evaluation and Planning (KETEP)
Development of long-life Li-S battery with high energy density

Years Funded:	2015	2016	2017	2018
	$40,977	$81,954	$81,954	$40,977
Total Funding:	$246,000			
Chief Investigators:	J. H. Kim, M. S. A. Hossain, J. H. Kim			
Project Summary:	This project aims to develop the lithium-sulfur (Li-S) batteries having ultra-high energy density (>300 Wh/kg) and long life (>700 cycles). The Li-S battery is one of the strong candidates for electric vehicles and stationary energy storage systems in future due to the 3-5 times higher energy density comparing to commercialized Li-ion batteries and the cost-effectiveness of sulfur material. Therefore, the research of Li-S batteries has received much attention worldwide as next-generation battery. This project conducted with collaborative works of (1) Korea Electronics Technology Institute (KETI); (2) Korea Advanced Institute of Science and Technology (KAIST); University of Wollongong (UOW) who are experts in battery fabrication, functional polymers, and nanoporous materials of cathode, respectively. The developed results will help the next-generation secondary battery for commercialization and their application to electric vehicle.			

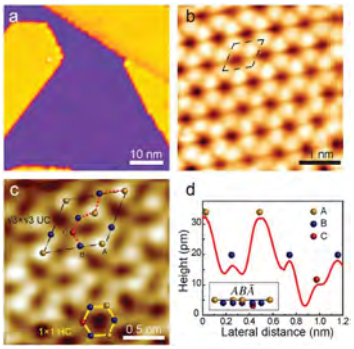
Selected Abstracts

Few-atomic-layered hexagonal boron nitride: CVD growth, characterization, and applications



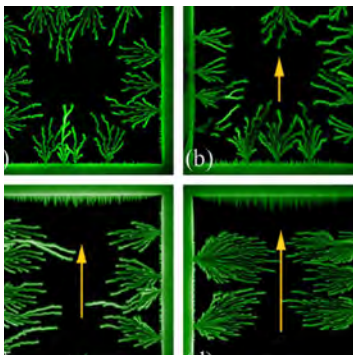
Two-dimensional (2D) materials have shown outstanding properties that make them the materials of choice for future semiconductor and flexible nanoelectronics. Hexagonal boron nitride nanosheet (BNNS) is one of the most studied 2D materials due to its extraordinary properties and potential applications. The synthesis of large, homogeneous, and few-layered BNNS, however, remains challenging. Among the various synthetic routes, chemical vapour deposition (CVD) is preferred on the grounds of its potential to yield large BNNS with controllable atomic layers and minimal contamination. We thus devote this review to the CVD growth of BNNS, and its characterization and applications. The recent progresses in the CVD growth of BNNS is firstly summarized from the aspects of precursors, substrates, growth mechanisms, and transfer techniques. This review then moves on to the characterization of few-atomic-layered h-BN sheets, covering a variety of microscopic and spectroscopic techniques that have proved useful for assessing the quality of BNNS. The applications of the BNNS are also summarized. This review is expected to instigate new methods and improvements in relation to the CVD growth of BNNS, which has enabled exceptional performance as a key component of nanoscale electronics. (M. H. Khan et al., ***Materials Today*** 20, 611 (2017))

Silicene: A promising anode for lithium-ion batteries



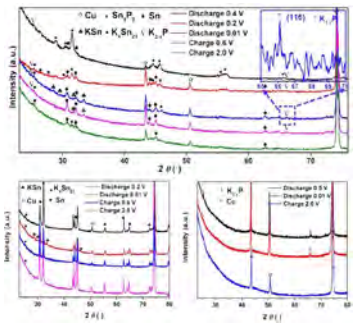
Silicene, a single-layer-thick silicon nanosheet with a honeycomb structure, is successfully fabricated by the molecular-beam-epitaxy (MBE) deposition method on metallic substrates and by the solid-state reaction method. Here, recent progress on the features of silicene that make it a prospective anode for lithium-ion batteries (LIBs) are discussed, including its charge-carrier mobility, chemical stability, and metal–silicene interactions. The electrochemical performance of silicene is reviewed in terms of both theoretical predictions and experimental measurements, and finally, its challenges and outlook are considered. (J. C. Zhuang et al., ***Advanced Materials*** 29, 1606716 (2017))

Anisotropic thermomagnetic avalanche activity in field-cooled superconducting films



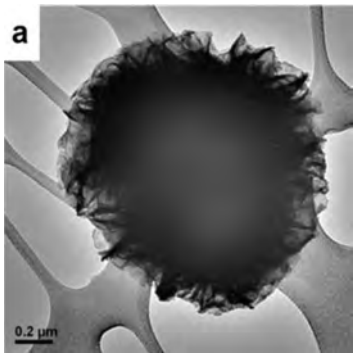
The electrodynamic behavior of isotropic superconducting Nb films cooled below their critical temperature in the presence of in-plane applied magnetic fields is investigated using magneto-optical imaging. A specially designed local flux injector is used to show that the frozen-in in-plane vortices strongly guide and enhance the penetration of perpendicular vortices, whereas their penetration across the array of in-plane vortices is essentially unchanged. This result provides the key to understanding why field-cooled square superconducting films show anisotropic nucleation of flux avalanches (jumps) along the four edges. The explanation is based on an analytical model for thermomagnetic avalanche nucleation in type-II superconducting films, and allows one to understand the entire scenario of different flux dynamics observed experimentally. (F. Colauto et al., ***Physical Review B*** 96, 060506R (2017))

Phosphorus-based alloy materials for advanced potassium-ion battery anode



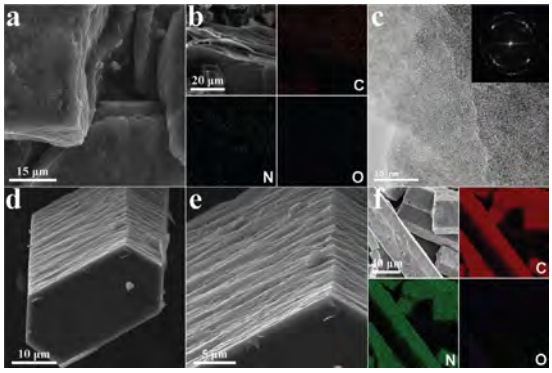
Potassium-ion batteries (PIBs) are interesting as one of the alternative metal-ion battery systems to lithium-ion batteries (LIBs) due to the abundance and low cost of potassium. We have herein investigated Sn_4P_3/C composite as a novel anode material for PIBs. The electrode delivered a reversible capacity of 384.8 mA h g^{-1} at 50 mA g^{-1} and a good rate capability of 221.9 mA h g^{-1}, even at 1 A g^{-1}. Its electrochemical performance is better than any anode material reported so far for PIBs. It was also found that the Sn_4P_3/C electrode displays a discharge potential plateau of 0.1 V in PIBs, slightly higher than for sodium-ion batteries (SIBs) (0.01 V), and well above the plating potential of metal. This diminishes the formation of dendrites during cycling, and thus Sn_4P_3 is a relatively safe anode material, especially for application in large-scale energy storage, where large amounts of electrode materials are used. Furthermore, a possible reaction mechanism of the Sn_4P_3/C composite as PIB anode is proposed. This work may open up a new avenue for further development of alloy-based anodes with high capacity and long cycle life for PIBs. (W. C. Zhang et al., ***Journal of the American Chemical Society*** 139, 3316 (2017))

Nanostructured metal chalcogenides for energy storage and electrocatalysis



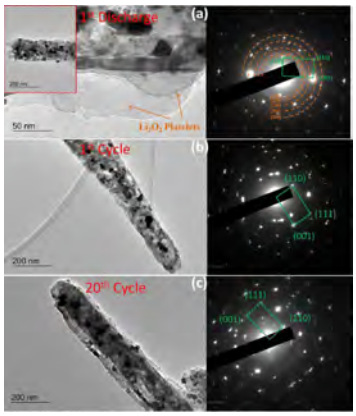
Energy storage and conversion technologies are vital to the efficient utilization of sustainable renewable energy sources. Rechargeable lithium-ion batteries (LIBs) and the emerging sodium-ion batteries (SIBs) are considered as two of the most promising energy storage devices, and electrocatalysis processes play critical roles in energy conversion techniques that achieve mutual transformation between renewable electricity and chemical energies. It has been demonstrated that nanostructured metal chalcogenides including metal sulfides and metal selenides show great potential for efficient energy storage and conversion due to their unique physicochemical properties. In this feature article, the recent research progress on nanostructured metal sulfides and metal selenides for application in SIBs/LIBs and hydrogen/oxygen electrocatalysis (hydrogen evolution reaction, oxygen evolution reaction, and oxygen reduction reaction) is summarized and discussed. The corresponding electrochemical mechanisms, critical issues, and effective strategies towards performance improvement are presented. Finally, the remaining challenges and perspectives for the future development of metal chalcogenides in the energy research field are proposed. (Y. Zhang et al., ***Advanced Functional Materials*** 27, 1702317 (2017))

2D frameworks of C_2N and C_3N as new anode materials for lithium-ion batteries



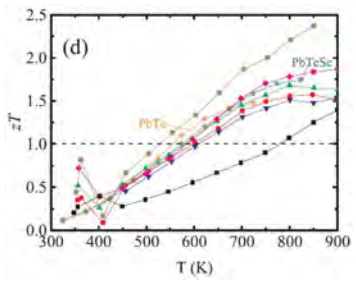
Novel layered 2D frameworks (C_3N and C_2N-450) with well-defined crystal structures are explored for use as anode materials in lithium-ion batteries (LIBs) for the first time. As anode materials for LIBs, C_3N and C_2N-450 exhibit unusual electrochemical characteristics. For example, C_2N-450 (and C_3N) display high reversible capacities of 933.2 (383.3) and 40.1 (179.5) mAh g^{-1} at 0.1 and 10 C, respectively. Furthermore, C_3N shows a low hypothetical voltage (≈0.15 V), efficient operating voltage window with ≈85% of full discharge capacity secured at >0.45 V, and excellent cycling stability for more than 500 cycles. The excellent electrochemical performance (especially of C_3N) can be attributed to their inherent 2D polyaniline frameworks, which provide large net positive charge densities, excellent structural stability, and enhanced electronic/ionic conductivity. Stable solid state interface films also form on the surfaces of the 2D materials during the charge/discharge process. These 2D materials with promising electrochemical performance should provide insights to guide the design and development of their analogues for future energy applications. (J. T. Xu et al., ***Advanced Materials*** 29, 1702007 (2017))

Three-dimensional array of TiN@Pt_3Cu nanowires as an efficient porous electrode for the lithium–oxygen battery



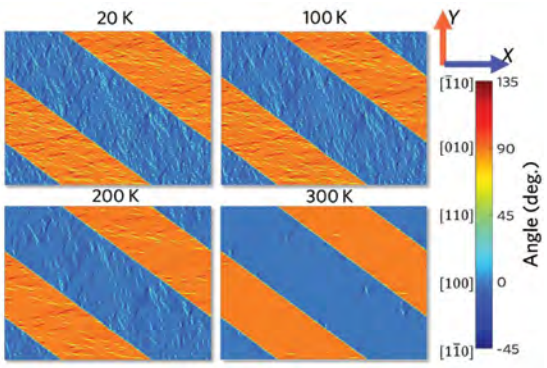
The nonaqueous lithium–oxygen battery is a promising candidate as a next-generation energy storage system because of its potentially high energy density (up to 2–3 kW kg^{-1}), exceeding that of any other existing energy storage system for storing sustainable and clean energy to reduce greenhouse gas emissions and the consumption of nonrenewable fossil fuels. To achieve high round-trip efficiency and satisfactory cycling stability, the air electrode structure and the electrocatalysts play important roles. Here, a 3D array composed of one-dimensional TiN@ Pt_3Cu nanowires was synthesized and employed as a whole porous air electrode in a lithium–oxygen battery. The TiN nanowire was primarily used as an air electrode frame and catalyst support to provide a high electronic conductivity network because of the high-orientation one-dimensional crystalline structure. Meanwhile, deposited icosahedral Pt3Cu nanocrystals exhibit highly efficient catalytic activity owing to the abundant {111} active lattice facets and multiple twin boundaries. This porous air electrode comprises a one-dimensional TiN@Pt_3Cu nanowire array that demonstrates excellent energy conversion efficiency and rate performance in full discharge and charge modes. The discharge capacity is up to 4600 mAh g^{-1} along with an 84% conversion efficiency at a current density of 0.2 mA cm^{-2}, and when the current density increased to 0.8 mA cm^{-2}, the discharge capacity is still greater than 3500 mAh g^{-1} together with a nearly 70% efficiency. This designed array is a promising bifunctional porous air electrode for lithium–oxygen batteries, forming a continuous conductive and high catalytic activity network to facilitate rapid gas and electrolyte diffusion and catalytic reaction throughout the whole energy conversion process. (W. B. Luo et al., ***ACS Nano*** 11, 1747 (2017))

Significant enhancement of figure-of-merit in carbon-reinforced Cu_2Se nanocrystalline solids



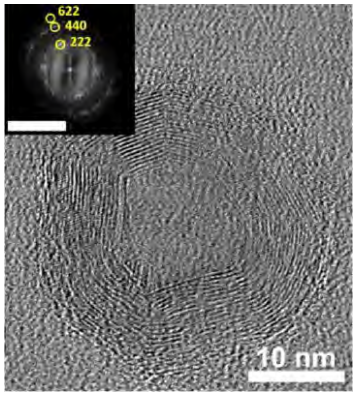
Liquid-like ionic conductors in the copper selenide family represent a promising class of thermoelectric materials capable of recycling waste heat into electrical energy with an exemplary figure-of-merit (zT >1.4) above 800 K. Ion diffusion, however, is enhanced at such high temperatures and drives a non-reversible phase segregation that inhibits practical applications. In tandem, the thermoelectric performance at moderate temperatures (500–750 K) where ion diffusion is less problematic, is not optimal for real-world applications (zT < 1). In this work, we demonstrate that incorporating a small weight fraction of carbon using various carbon sources can significantly enhance the zT of Cu_2Se at both middle and high temperatures. All the carbon-doped Cu_2Se samples exhibit weak temperature dependent zT higher than 1.0 over a broad temperature range from 600 to 900 K, with the 0.6 *wt%* Super P doped Cu_2Se sample achieving a zT of 1.85 at 900 K. Furthermore, the 0.3 *wt%* carbon fiber doped Cu_2Se shows zT >1 for T >520 K and reaches a record level of zT of ~ 2.4 at 850 K. These values for the carbon doped Cu_2Se are comparable or superior to those for the current state-of-the-art thermoelectric materials. Microstructure studies on graphite incorporated Cu_2Se revealed that graphite nanostructures interspace between Cu_2Se nanoscale grains being responsible for the significantly enhanced zT. The low thermal conductivity in the nanostructured composite is attributed to the high density of interfaces caused by the small grain diameters (30–60 nm), along with the strong acoustic mismatch between Cu_2Se and carbon phonon states which enhances the thermal boundary resistance. This discovery indicates strong prospects for engineering carbon thermoelectric nanocomposites for a range of energy applications. (L. L. Zhao et al., ***Nano Energy*** 41, 164 (2017))

The contributions of polar nanoregions to the dielectric and piezoelectric responses in domain-engineered relaxor-$PbTiO_3$ crystals



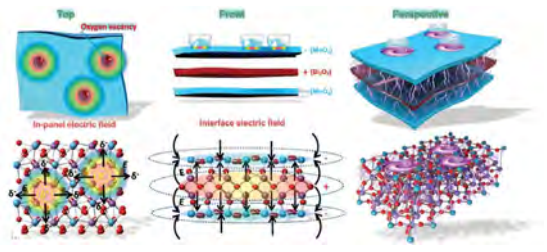
The existence of polar nanoregions is the most important characteristic of relaxor-based ferroelectric materials. Recently, the contributions of polar nanoregions to the shear piezoelectric property of relaxor-$PbTiO_3$ (PT) crystals are confirmed in a single domain state, accounting for 50%–80% of room temperature values. For electromechanical applications, however, the outstanding longitudinal piezoelectricity in domain-engineered relaxor-PT crystals is of the most significance. In this paper, the contributions of polar nanoregions to the longitudinal properties in [001]-poled $Pb(Mg_{1/3}Nb_{2/3})O_3$-0.30$PbTiO_3$ and [110]-poled $Pb(Zn_{1/3}Nb_{2/3})O_3$-0.15$PbTiO_3$ (PZN-0.15PT) domain-engineered crystals are studied. Taking the [110]-poled tetragonal PZN-0.15PT crystal as an example, phase-field simulations of the domain structures and the longitudinal dielectric/piezoelectric responses are performed. According to the experimental results and phase-field simulations, the contributions of polar nanoregions (PNRs) to the longitudinal properties of relaxor-PT crystals are successfully explained on the mesoscale, where the PNRs behave as "seeds" to facilitate macroscopic polarization rotation and enhance electric-field-induced strain. The results reveal the importance of local structures to the macroscopic properties, where a modest structural variation on the nanoscale greatly impacts the macroscopic properties. (F. Li et al., ***Advanced Functional Materials*** 27, 1700310 (2017))

A gallium-based magnetocaloric liquid metal ferrofluid



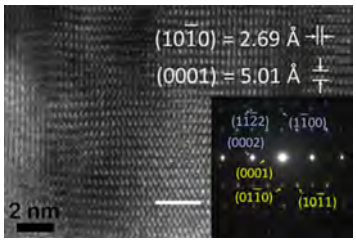
We demonstrate a magnetocaloric ferrofluid based on a gadolinium saturated liquid metal matrix, using a gallium-based liquid metal alloy as the solvent and suspension medium. The material is liquid at room temperature, while exhibiting spontaneous magnetization and a large magnetocaloric effect. The magnetic properties were attributed to the formation of gadolinium nanoparticles suspended within the liquid gallium alloy, which acts as a reaction solvent during the nanoparticle synthesis. High nanoparticle weight fractions exceeding 2% could be suspended within the liquid metal matrix. The liquid metal ferrofluid shows promise for magnetocaloric cooling due to its high thermal conductivity and its liquid nature. Magnetic and thermoanalytic characterizations reveal that the developed material remains liquid within the temperature window required for domestic refrigeration purposes, which enables future fluidic magnetocaloric devices. Additionally, the observed formation of nanometer-sized metallic particles within the supersaturated liquid metal solution has general implications for chemical synthesis and provides a new synthetic pathway toward metallic nanoparticles based on highly reactive rare earth metals. (I. A. de Castro et al., ***Nano Letters*** 17, 7831 (2017))

Atomic interface engineering and electric-field effect in ultrathin Bi_2MoO_6 nanosheets for superior lithium ion storage



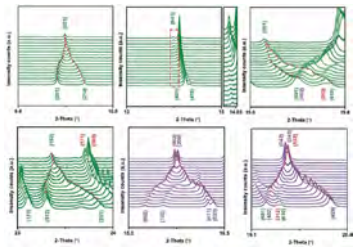
Ultrathin 2D materials can offer promising opportunities for exploring advanced energy storage systems, with satisfactory electrochemical performance. Engineering atomic interfaces by stacking 2D crystals holds huge potential for tuning material properties at the atomic level, owing to the strong layer–layer interactions, enabling unprecedented physical properties. In this work, atomically thin Bi_2MoO_6 sheets are acquired that exhibit remarkable high-rate cycling performance in Li-ion batteries, which can be ascribed to the interlayer coupling effect, as well as the 2D configuration and intrinsic structural stability. The unbalanced charge distribution occurs within the crystal and induces built-in electric fields, significantly boosting lithium ion transfer dynamics, while the extra charge transport channels generated on the open surfaces further promote charge transport. The in situ synchrotron X-ray powder diffraction results confirm the material's excellent structural stability. This work provides some insights for designing high-performance electrode materials for energy storage by manipulating the interface interaction and electronic structure. (Y. Zheng et al., ***Advanced Materials*** 29, 1700396 (2017))

Intrinsic and spatially nonuniform ferromagnetism in Co-doped ZnO films



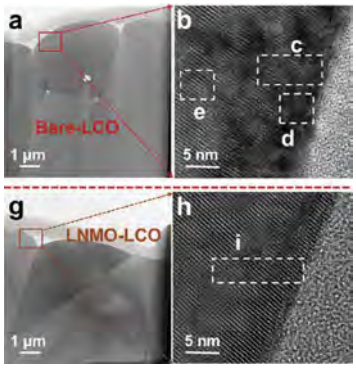
Co doped ZnO films have been deposited by a laser-molecular beam epitaxy system. X-ray diffraction and UV spectra analysis show that Co effectively substitutes the Zn site. Transmission electron microscopy (TEM) and secondary ion mass spectroscopy analysis indicate that there are no clusters. Co dopants are uniformly distributed in ZnO film. Ferromagnetic ordering is observed in all samples deposited under an oxygen partial pressure, $PO_2 = 10^{-3}$, 10^{-5}, and 10^{-7} torr, respectively. However, the magnetization of $PO_2 = 10^{-3}$ and 10^{-5} is very small at room temperature. At low temperature, the ferromagnetic ordering is enhanced. Muon spin relaxation (μSR) measurements confirm the ferromagnetism in all samples, and the results are consistent with magnetization measurements. From μSR and TEM analysis, the film deposited under $PO_2 = 10^{-7}$ torr shows intrinsic ferromagnetism. However, the volume fraction of the ferromagnetism phase is approximately 70%, suggesting that the ferromagnetism is not carrier mediated. Resistivity versus temperature measurements indicate Efros variable range hopping dominates the conductivity. From the above results, we can confirm that a bound magnetic polaron is the origin of the ferromagnetism. (L. T. Tseng et al., ***Physical Review B*** 96, 104423 (2017))

Three-stage inter-orthorhombic evolution and high thermoelectric performance in Ag-doped nanolaminar SnSe polycrystals



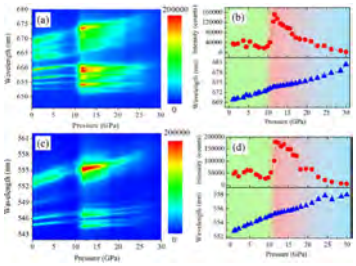
The ultrahigh thermoelectric performance of SnSe-based single crystals has attracted considerable interest in their polycrystalline counterparts. However, the temperature-dependent structural transition in SnSe-based thermoelectric materials and its relationship with their thermoelectric performance are not fully investigated and understood. In this work, nanolaminar SnSe polycrystals are prepared and characterized in situ using neutron and synchrotron powder diffraction measurements at various temperatures. Rietveld refinement results indicate that there is a complete inter-orthorhombic evolution from Pnma to Cmcm by a series of layer slips and stretches along the a- and b-axes over a 200 K temperature range. This phase transition leads to drastic enhancement of the carrier concentration and phonon scattering above 600 K. Moreover, the unique nanolaminar structure effectively enhances the carrier mobility of SnSe. Their grain and layer boundaries further improve the phonon scattering. These favorable factors result in a high ZT of 1.0 at 773 K for pristine SnSe polycrystals. The thermoelectric performances of polycrystalline SnSe are further improved by p-type and n-type dopants (i.e., doped with Ag and $SnCl_2$, respectively), and new records of ZT are achieved in $Ag_{0.015}Sn_{0.985}Se$ (ZT of 1.3 at 773 K) and $SnSe_{0.985}Cl_{0.015}$ (ZT of 1.1 at 773 K) polycrystals. (L. J. Zhang et al., Advanced Energy Materials 7, 1700573 (2017))

Surface engineering strategies of layered $LiCoO_2$ cathode material to realize high-energy and high-voltage Li-ion cells



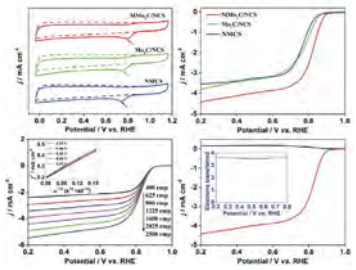
Battery industries and research groups are further investigating $LiCoO_2$ to unravel the capacity at high-voltages (>4.3 vs Li). The research trends are towards the surface modification of the $LiCoO_2$ and stabilize it structurally and chemically. In this report, the recent progress in the surface-coating materials i.e., single-element, binary, and ternary hybrid-materials etc. and their coating methods are illustrated. Further, the importance of evaluating the surface-coated $LiCoO_2$ in the Li-ion full-cell is highlighted with our recent results. Mg,P-coated $LiCoO_2$ full-cells exhibit excellent thermal stability, hightemperature cycle and room-temperature rate capabilities with high energydensity of ≈1.4 W h cc^{-1} at 10 C and 4.35 V. Besides, pouch-type full-cells with high-loading (18 mg cm^{-2}) electrodes of layered-Li(Ni,Mn)O_2 -coated $LiCoO_2$ not only deliver prolonged cycle-life at room and elevated-temperatures but also high energy-density of ≈2 W h cc^{-1} after 100 cycles at 25 °C and 4.47 V (vs natural graphite). The post-mortem analyses and experimental results suggest enhanced electrochemical performances are attributed to the mechanistic behaviour of hybrid surface-coating layers that can mitigate undesirable side reactions and micro-crack formations on the surface of $LiCoO_2$ at the adverse conditions. Hence, the surface-engineering of electrode materials could be a viable path to achieve the high-energy Li-ion cells for future applications. (S. Kalluri et al., Advanced Energy Materials 7, 1601507 (2017))

Pressure-enhanced light emission and its structural origin in Er:$GdVO_4$



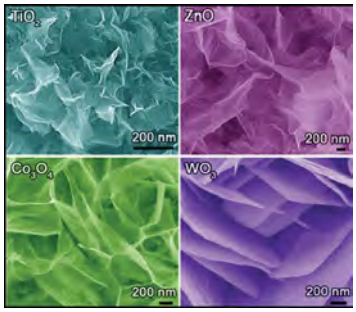
Rare earth phosphors have been widely studied because of their sharp emission lines and excellent optical performance. However, photoluminescence (PL) tuning by crystal field in Er^{3+} embedded phosphors has always been a challenge. Here, we demonstrate that pressure can help to enhance the red and green light emission simultaneously in Er:$GdVO_4$. Synchrotron X-ray diffraction investigations revealed that a structural phase transition was responsible for the enhancement. Our work brightens the future prospects for applications of Er^{3+}-based PL materials in various fields, such as high power lasers and (bio) medical imaging. (F. Hong et al., ***Applied Physics Letters*** 110, 021903 (2017))

Assembly of hollow mesoporous nanoarchitectures composed of ultrafine Mo_2C nanoparticles on N-doped carbon nanosheets for efficient electrocatalytic reduction of oxygen



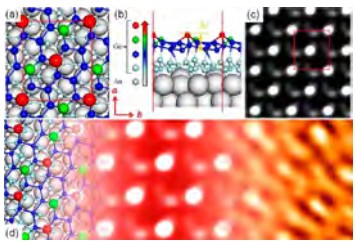
A simplemethod is developed to assemble Mo_2C nanocrystals on the surfaces of hollow, highly conductive mesoporous nanoparticles. Diblock copolymer (PS-*b*-PEO) micelles are used as templates to assist in the fast complexation of molybdate (MoO_4^{2-}) and polydopamine (PDA) precursors to make hollow precursor MoO_4^{2-}/PDA/ PS-b-PEO particles. Then these particles are carbonized to generate mesoporous N-doped carbon nanosheets riddled with ultrafine molybdenum carbide (Mo_2C) nanoparticles (MMo_2C/NCS). An N-doped carbon matrix serves as an electron conductor and helps to prevent the aggregation of the Mo_2C nanoparticles. The Mo_2C nanoparticles in turn enhance the catalytic performance for the oxygen reduction reaction (ORR). The unique mesoporous 2D nanosheet and its derived 3D hollow structure expose numerous active catalytic sites while enabling free diffusion of the electrolyte and mass transfer. Based on these properties, MMo_2C/NCS show enhanced catalytic activity for the ORR. (Y. Guo et al., ***Materials Horizons*** 4, 1171 (2017))

Atomically thin non-layered nanomaterials for energy storage and conversion



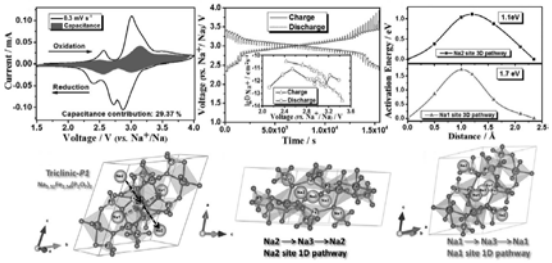
After the discovery of graphene, two-dimensional nanomaterials with atomic thickness and large lateral size have attracted tremendous research interest due to their high specific surface areas, exotic electronic structures, and fascinating physical and chemical properties. Even though recent studies are mainly focused on atomically thin nanomaterials with layered structures due to their easy preparation and characterization, the investigation of non-layered nanomaterials is also proceeding as new types of ultrathin nanostructures are constantly being created, such as metals, metal oxides, metal chalcogenides, some transition metal dichalcogenides, and perovskites. Here in this review, we comprehensively summarize the preparation methods for atomically thin non-layered nanomaterials, study their exotic electronic structures, introduce electronic-structure manipulation strategies, and provide an overview of their applications in energy storage and conversion, with particular emphasis on lithium-ion batteries, sodium-ion batteries, catalysis of hydrogen evolution, oxygen evolution, CO_2 reduction, CO oxidation reactions, etc. The central theme of this review is to provide correlation among the materials synthesis, structural and electronic properties, and their major applications. Finally, based on current research progress, we propose future directions yet to be explored for enhanced properties and novel functionalities in practical applications. (Y. H. Dou et al., ***Chemical Society Reviews*** 46, 7338 (2017))

Cooperative electron–phonon coupling and buckled structure in germanene on Au(111)



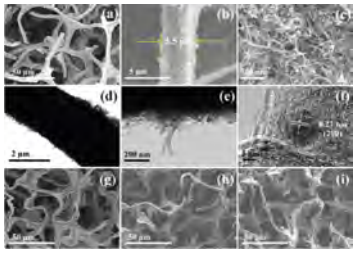
Germanene, a single-atom-thick germanium nanosheet in a honeycomb lattice, was proposed to be a Dirac fermion material beyond graphene. We performed scanning tunneling microscopy and in situ Raman spectroscopy studies combined with first-principles calculations on the atomic structures and the electronic and phonon properties of germanene on Au(111). The low-buckled 1 × 1 germanene honeycomb lattice was determined to exist in an unexpected rectangular √7 × √7 superstructure. Through in situ Raman measurements, distinctive vibrational phonon modes were discovered in √7 × √7 germanene, revealing the special coupling between the Dirac fermion and lattice vibrations, namely, electron–phonon coupling (EPC). The significant enhancement of EPC is correlated with the tensile strain, which is evoked by the singular buckled structure of √7 × √7 germanene on the Au(111) substrate. Our results present clear evidence for the existence of epitaxial germanene and elucidate the exotic properties of germanene on Au(111). (J. C. Zhuang et al., ***ACS Nano*** 11, 3553 (2017))

Carbon-coated $Na_{3.32}Fe_{2.34}(P_2O_7)_2$ cathode material for high-rate and long-life sodium-ion batteries



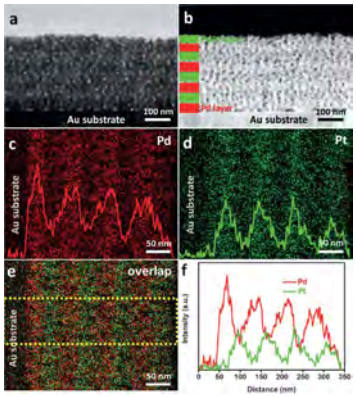
Rechargeable sodium-ion batteries are proposed as the most appropriate alternative to lithium batteries due to the fast consumption of the limited lithium resources. Due to their improved safety, polyanion framework compounds have recently gained attention as potential candidates. With the earth-abundant element Fe being the redox center, the uniform carboncoated $Na_{3.32}Fe_{2.34}(P_2O_7)_2$/C composite represents a promising alternative for sodium-ion batteries. The electrochemical results show that the as-prepared $Na_{3.32}Fe_{2.34}(P_2O_7)_2$/C composite can deliver capacity of ≈100 mA h g^{-1} at 0.1 C (1 C = 120 mA g^{-1}), with capacity retention of 92.3% at 0.5 C after 300 cycles. After adding fluoroethylene carbonate additive to the electrolyte, 89.6% of the initial capacity is maintained, even after 1100 cycles at 5 C. The electrochemical mechanism is systematically investigated via both in situ synchrotron X-ray diffraction and density functional theory calculations. The results show that the sodiation and desodiation are single-phase-transition processes with two 1D sodium paths, which facilitates fast ionic diffusion. A small volume change, nearly 100% first-cycle Coulombic efficiency, and a pseudocapacitance contribution are also demonstrated. This research indicates that this new compound could be a potential competitor for other iron-based cathode electrodes for application in large-scale Na rechargeable batteries. (M. Z. Chen et al., ***Advanced Materials*** 29, 1605535 (2017))

A flexible 3D multifunctional MgO-decorated carbon foam@CNTs hybrid as self-supported cathode for high-performance lithium-sulfur batteries



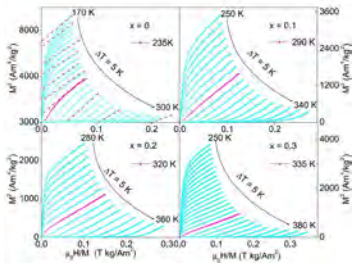
One of the critical challenges to develop advanced lithium-sulfur (Li-S) batteries lies in exploring a high efficient stable sulfur cathode with robust conductive framework and high sulfur loading. Herein, a 3D flexible multifunctional hybrid is rationally constructed consisting of nitrogen-doped carbon foam@CNTs decorated with ultrafine MgO nanoparticles for the use as advanced current collector. The dense carbon nanotubes uniformly wrapped on the carbon foam skeletons enhance the flexibility and build an interconnected conductive network for rapid ionic/electronic transport. In particular, a synergistic action of MgO nanoparticles and in situ N-doping significantly suppresses the shuttling effect via enhanced chemisorption of lithium polysulfides. Owing to these merits, the as-built electrode with an ultrahigh sulfur loading of 14.4 mg cm^{-2} manifests a high initial areal capacity of 10.4 mAh cm^{-2}, still retains 8.8 mAh cm^{-2} (612 mAh g^{-1} in gravimetric capacity) over 50 cycles. The best cycling performance is achieved upon 800 cycles with an extremely low decay rate of 0.06% at 2 C. Furthermore, a flexible soft-packaged Li-S battery is readily assembled, which highlights stable electrochemical characteristics under bending and even folding. This cathode structural design may open up a potential avenue for practical application of high-sulfur-loading Li-S batteries toward flexible energy-storage devices. (M. W. Xiang et al., ***Advanced Functional Materials*** 27, 1702573 (2017))

Layer-by-layer motif architectures: programmed electrochemical syntheses of multilayer mesoporous metallic films with uniformly sized pores



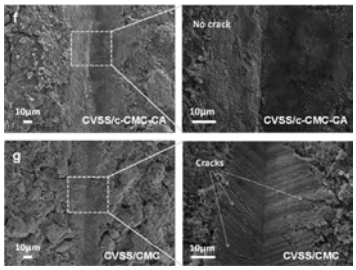
Although multilayer films have been extensively reported, most compositions have been limited to non-catalytically active materials (e.g. polymers, proteins, lipids, or nucleic acids). Herein, we report the preparation of binder-free multilayer metallic mesoporous films with sufficient accessibility for high electrocatalytic activity by using a programmed electrochemical strategy. By precisely tuning the deposition potential and duration, multilayer mesoporous architectures consisting of alternating mesoporous Pd layers and mesoporous PdPt layers with controlled layer thicknesses can be synthesized within a single electrolyte, containing polymeric micelles as soft templates. This novel architecture, combining the advantages of bimetallic alloys, multilayer architectures, and mesoporous structures, exhibits high electrocatalytic activity for both the methanol oxidation reaction (MOR) and the ethanol oxidation reaction (EOR). (B. Jiang et al., ***Angewandte Chemie – International Edition*** 129, 7944 (2017))

Tuning the magnetic and structural transitions in $TbCo_2Mn_x$ compounds



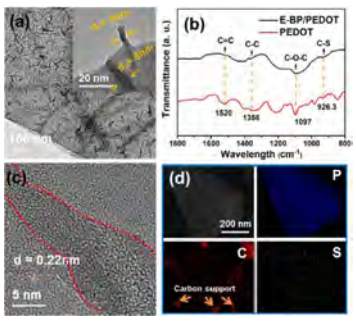
The wide ranging magnetic behavior in intermetallic compounds continues to attract broad interest. Effective control of their magnetic properties is of great importance for fundamental research and potential applications. In this work the structural and magnetic properties of $TbCo_2Mn_x$ compounds are studied by a combination of temperature dependent synchrotron x-ray diffraction, neutron powder diffraction, specific heat, and magnetic measurements. Magnetization measurements show that the addition of Mn can modify the magnetic behavior significantly: first, the magnetic transition temperatures increase from ~227 K to 332 K with x = 0.0 to 0.3; secondly, the nature of the magnetic transitions change from the first order to second order, as identified by three methods (Banerjee criterion, master curves of magnetic entropy changes, and detailed crystal structure analysis through neutron diffraction). Both synchrotron x-ray diffraction and neutron diffraction confirm that a structural transition, from cubic $Fd\bar{3}m$ to rhombohedral $R\bar{3}m$ on cooling, occurred accompanying the magnetic transition. To further clarify the nature of the second order magnetic phase transitions, we have carried out a detailed critical exponent analysis. The derived critical exponents are close to the theoretical prediction from the mean-field model, indicating the magnetic interactions are long range. This work benefits our general understanding of magnetic interactions in intermetallic compounds and provides guidance to design a functional magnetic material for room temperature magnetic devices. (C. S. Fang et al., ***Physical Review B*** 96, 064425 (2017))

An all-integrated anode via interlinked chemical bonding between double-shelled–yolk-structured silicon and binder for lithium-ion batteries



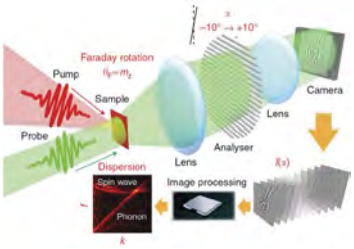
The concept of an all-integrated design with multifunctionalization is widely employed in optoelectronic devices, sensors, resonator systems, and microfluidic devices, resulting in benefits for many ongoing research projects. Here, maintaining structural/electrode stability against large volume change by means of an all-integrated design is realized for silicon anodes. An all-integrated silicon anode is achieved via multicomponent interlinking among carbon@ void@ silica@silicon (CVSS) nanospheres and cross-linked carboxymethyl cellulose and citric acid polymer binder (c-CMC-CA). Due to the additional protection from the silica layer, CVSS is superior to the carbon@void@silicon (CVS) electrode in terms of long-term cyclability. The as-prepared all-integrated CVSS electrode exhibits high mechanical strength, which can be ascribed to the high adhesivity and ductility of c-CMC-CA binder and the strong binding energy between CVSS and c-CMC-CA, as calculated based on density functional theory (DFT). This electrode exhibits a high reversible capacity of 1640 mA h g^{-1} after 100 cycles at a current density of 1 A g^{-1}, high rate performance, and long-term cycling stability with 84.6% capacity retention after 1000 cycles at 5 A g^{-1}. (Y. J. Liu et al., ***Advanced Materials*** 29, 1703028 (2017))

Functionalized few-layer black phosphorus with super-wettability towards enhanced reaction kinetics for rechargeable batteries



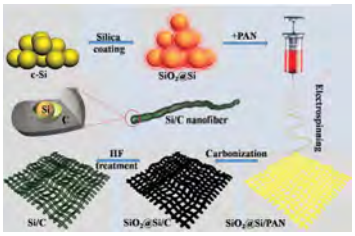
Few-layer black phosphorus (BP) is a promising anode material for sodium ion batteries (SIBs) due to its high theoretical capacity and favorable layered structure. However, practical implementation is hindered by sluggish reaction kinetics and large volume change during de/sodiation process. Especially, combining BP with large portion of low-capacity carbonaceous materials is a common strategy to improve the Na storage properties, but leading to reduced specific capacity based on the overall mass of the whole electrode. To address these challenges, nanoscale surface engineering of few-layer BP is herein performed by homogeneously depositing horizontally aligned Poly(3, 4-ethylenedioxythiophene) (PEDOT) nanofibers on specially surface-modified BP nanosheets. Such material design could achieve simultaneously: (1) enhanced charge transfer kinetics and (2) super surface wettability with electrolyte. Benefiting from the unique functionalization, the reaction kinetics are greatly enhanced accordingly for both sodium and lithium storage. Our strategy sheds light on designing advanced electrodes for high-performance rechargeable batteries and other energy storage/conversion devices. (Y. Zhang et al., ***Nano Energy*** 40, 576 (2017))

All-optical observation and reconstruction of spin wave dispersion



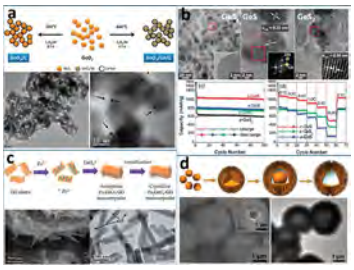
To know the properties of a particle or a wave, one should measure how its energy changes with its momentum. The relation between them is called the dispersion relation, which encodes essential information of the kinetics. In a magnet, the wave motion of atomic spins serves as an elementary excitation, called a spin wave, and behaves like a fictitious particle. Although the dispersion relation of spin waves governs many of the magnetic properties, observation of their entire dispersion is one of the challenges today. Spin waves whose dispersion is dominated by magnetostatic interaction are called pure-magnetostatic waves, which are still missing despite of their practical importance. Here, we report observation of the band dispersion relation of pure-magnetostatic waves by developing a table-top all-optical spectroscopy named spin-wave tomography. The result unmasks characteristics of pure-magnetostatic waves. We also demonstrate time-resolved measurements, which reveal coherent energy transfer between spin waves and lattice vibrations. (Y. Hashimoto et al., ***Nature Communications*** 8, 15859 (2017))

In operando mechanism analysis on nanocrystalline silicon anode material for reversible and ultrafast sodium storage



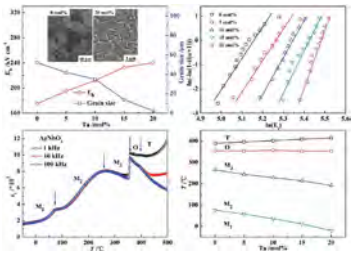
The electrochemical mechanism of nanocrystalline silicon anode in sodium ion batteries is first studied via in operando Raman and in operando X-ray diffraction. An irreversible structural conversion from crystalline silicon to amorphous silicon takes place during the initial cycles, leading to ultrafast reversible sodium insertion in the newly generated amorphous silicon. Furthermore, an optimized silicon/carbon composite has been developed to further improve its electrochemical performance. (L. Zhang et al., ***Advanced Materials*** 29, 1604708 (2017))

Unique structural design and strategies for germanium-based anode materials toward enhanced lithium storage



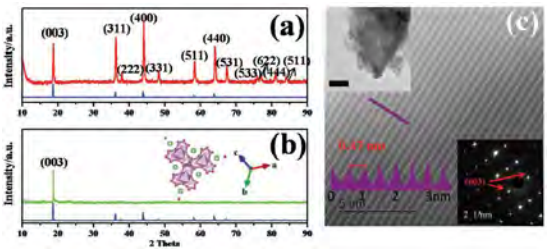
Germanium-based materials are arousing increasing interest as anodes for lithium-ion batteries, stemming from the intrinsic physical and chemical advantages of germanium. This progress report provides a brief review on the current development of germanium-based materials in lithium storage. The state-of-the-art strategies to achieve enhanced electrochemical properties are highlighted, with their main aim being to resolve the trickiest issue: vast volume changes in germanium during cycling. These strategies include structural modification, modification by surface coating, forming germaniumbased alloys, and forming binary or ternary germanium-based composites. The recent work on a novel composite of germanium and tin particles encapsulated in double-concentric carbon hollow spheres is also presented here, with an emphasis on the relationship between structural design and improved performance. (D. Li et al., ***Advanced Energy Materials*** 7, 1700488 (2017))

Lead-free antiferroelectric silver niobate tantalate with high energy storage performance



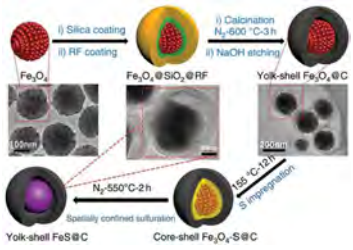
Antiferroelectric materials that display double ferroelectric hysteresis loops are receiving increasing attention for their superior energy storage density compared to their ferroelectric counterparts. Despite the good properties obtained in antiferroelectric La-doped $Pb(Zr,Ti)O_3$-based ceramics, lead-free alternatives are highly desired due to the environmental concerns, and $AgNbO_3$ has been highlighted as a ferrielectric/antiferroelectric perovskite for energy storage applications. Enhanced energy storage performance, with recoverable energy density of 4.2 J cm^{-3} and high thermal stability of the energy storage density (with minimal variation of ≤□}5%) over 20–120 °C, can be achieved in Ta-modified $AgNbO_3$ ceramics. It is revealed that the incorporation of Ta to the Nb site can enhance the antiferroelectricity because of the reduced polarizability of B-site cations, which is confirmed by the polarization hysteresis, dielectric tunability, and selected-area electron diffraction measurements. Additionally, Ta addition in $AgNbO_3$ leads to decreased grain size and increased bulk density, increasing the dielectric breakdown strength, up to 240 kV cm^{-1} versus 175 kV cm^{-1} for the pure counterpart, together with the enhanced antiferroelectricity, accounting for the high energy storage density. (L. Zhao et al., ***Advanced Materials*** 29, 1701824 (2017))

Few atomic layered lithium cathode materials to achieve ultrahigh rate capability in lithium-ion batteries



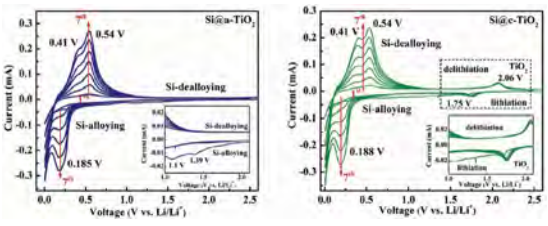
The most promising cathode materials, including $LiCoO_2$ (layered), $LiMn2O_4$ (spinel), and $LiFePO_4$ (olivine), have been the focus of intense research to develop rechargeable lithium-ion batteries (LIBs) for portable electronic devices. Sluggish lithium diffusion, however, and unsatisfactory long-term cycling performance still limit the development of present LIBs for several applications, such as plug-in/hybrid electric vehicles. Motivated by the success of graphene and novel 2D materials with unique physical and chemical properties, herein, a simple shear-assisted mechanical exfoliation method to synthesize few-layered nanosheets of $LiCoO_2$, $LiMn_2O_4$, and $LiFePO_4$ is used. Importantly, these as-prepared nanosheets with preferred orientations and optimized stable structures exhibit excellent C-rate capability and long-term cycling performance with much reduced volume expansion during cycling. In particular, the zero-strain insertion phenomenon could be achieved in 2–3 such layers of $LiCoO_2$ electrode materials, which could open up a new way to the further development of next-generation long-life and high-rate batteries. (Z. X. Tai et al., ***Advanced Materials*** 29, 1700605 (2017))

Advances and challenges in metal sulfides/selenides for next-generation rechargeable sodium-ion batteries



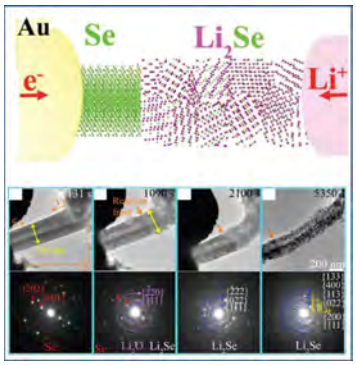
Rechargeable sodium-ion batteries (SIBs), as the most promising alternative to commercial lithium-ion batteries, have received tremendous attention during the last decade. Among all the anode materials for SIBs, metal sulfides/selenides (MXs) have shown inspiring results because of their versatile material species and high theoretical capacity. They suffer from large volume expansion, however, which leads to bad cycling performance. Thus, methods such as carbon modification, nanosize design, electrolyte optimization, and cut-off voltage control are used to obtain enhanced performance. Here, recent progress on MXs is summarized in terms of arranging the crystal structure, synthesis methods, electrochemical performance, mechanisms, and kinetics. Challenges are presented and effective ways to solve the problems are proposed, and a perspective for future material design is also given. It is hoped that light is shed on the development of MXs to help finally find applications for next-generation rechargeable batteries. (Z. Hu et al., ***Advanced Materials*** 29, 1700606 (2017))

Amorphous TiO_2 shells: A vital elastic buffering layer on silicon nanoparticles for high-performance and safe lithium storage



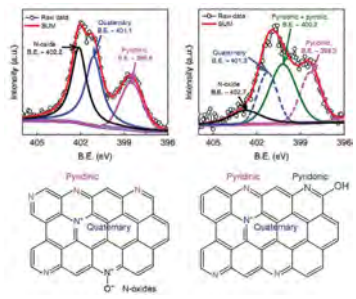
Smart surface coatings of silicon (Si) nanoparticles are shown to be good examples for dramatically improving the cyclability of lithium-ion batteries. Most coating materials, however, face significant challenges, including a low initial Coulombic efficiency, tedious processing, and safety assessment. In this study, a facile sol–gel strategy is demonstrated to synthesize commercial Si nanoparticles encapsulated by amorphous titanium oxide (TiO_2), with core–shell structures, which show greatly superior electrochemical performance and high-safety lithium storage. The amorphous TiO_2 shell (≈3 nm) shows elastic behavior during lithium discharging and charging processes, maintaining high structural integrity. Interestingly, it is found that the amorphous TiO_2 shells offer superior buffering properties compared to crystalline TiO_2 layers for unprecedented cycling stability. Moreover, accelerating rate calorimetry testing reveals that the TiO_2-encapsulated Si nanoparticles are safer than conventional carbon-coated Si-based anodes. (J. P. Yang et al., ***Advanced Materials*** 29, 1700523 (2017))

Enhanced structural stability of nickel–cobalt hydroxide via intrinsic pillar effect of metaborate for high-power and long-life supercapacitor electrodes



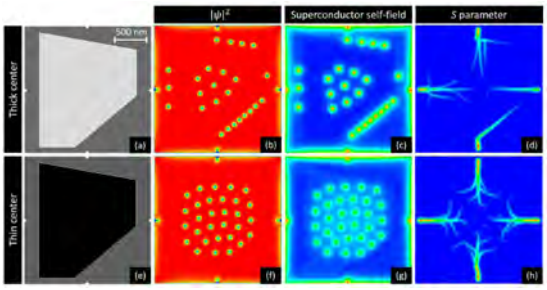
Layered α-$Ni(OH)_2$ and its derivative bimetallic hydroxides (e.g., α-$(Ni/Co)(OH)_2$) have attracted much attention due to their high specific capacitance, although their insufficient cycling stability has blocked their wide application in various technologies. In this work, we demonstrate that the cycling performance of α-$(Ni/Co)(OH)_2$ can be obviously enhanced via the intrinsic pillar effect of metaborate. Combining the high porosity feature of the metaborate stabilized α-$(Ni/Co)(OH)_2$ and the improved electronic conductivity offered by graphene substrate, the average capacitance fading rate of the metaborate stabilized α-$(Ni/Co)(OH)_2$ is only ~0.0017% per cycle within 10 000 cycles at the current density of 5 A g^{-1}. The rate performance is excellent over a wide temperature range from −20 to 40 °C. We believe that the enhancements should mainly be ascribed to the excellent structural stability offered by the metaborate pillars, and the detailed mechanism is discussed. (Y. Z. Chen et al., ***Nano Letters*** 17, 429 (2017))

Metal-free carbon materials for CO_2 electrochemical reduction



The rapid increase of the CO_2 concentration in the Earth's atmosphere has resulted in numerous environmental issues, such as global warming, ocean acidification, melting of the polar ice, rising sea level, and extinction of species. To search for suitable and capable catalytic systems for CO_2 conversion, electrochemical reduction of CO_2 (CO_2RR) holds great promise. Emerging heterogeneous carbon materials have been considered as promising metal-free electrocatalysts for the CO_2RR, owing to their abundant natural resources, tailorable porous structures, resistance to acids and bases, high-temperature stability, and environmental friendliness. They exhibit remarkable CO_2RR properties, including catalytic activity, long durability, and high selectivity. Here, various carbon materials (e.g., carbon fibers, carbon nanotubes, graphene, diamond, nanoporous carbon, and graphene dots) with heteroatom doping (e.g., N, S, and B) that can be used as metal-free catalysts for the CO_2RR are highlighted. Recent advances regarding the identification of active sites for the CO_2RR and the pathway of reduction of CO_2 to the final product are comprehensively reviewed. Additionally, the emerging challenges and some perspectives on the development of heteroatom-doped carbon materials as metal-free electrocatalysts for the CO_2RR are included. (X. C. Duan et al., ***Advanced Materials*** 29, 1701784 (2017))

Flux penetration in a superconducting film partially capped with a conducting layer



The influence of a conducting layer on the magnetic flux penetration in a superconducting Nb film is studied by magneto-optical imaging. The metallic layer partially covering the superconductor provides an additional velocity-dependent damping mechanism for the flux motion that helps to protect the superconducting state when thermomagnetic instabilities develop. If the flux advances with a velocity slower than $w = 2/\mu_0\mu t$ where μ is the cap layer conductivity and t is its thickness, the flux penetration remains unaffected, whereas for incoming flux moving faster than w, the metallic layer becomes an active screening shield. When the metallic layer is replaced by a perfect conductor, it is expected that the flux braking effect will occur for all flux velocities. We investigate this effect by studying Nb samples with a thickness step. Some of the observed features, namely the deflection of the flux trajectories at the border of the thick center, as well as the favored flux penetration at the indentation, are reproduced by time-dependent Ginzburg-Landau simulations. (J. Brisbois et al., ***Physical Review B*** 95, 094506 (2017))

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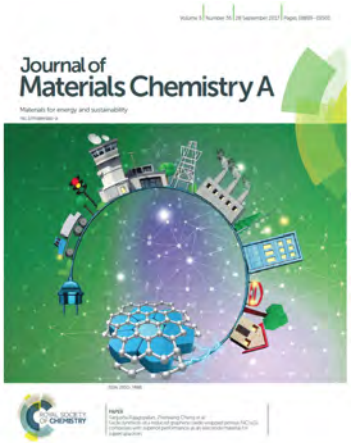

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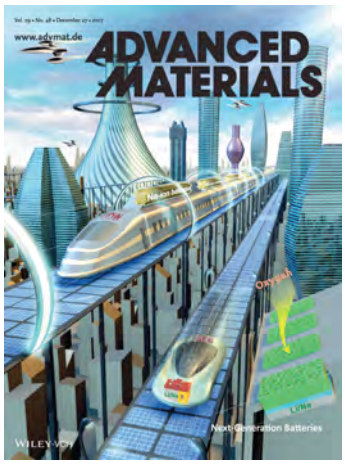

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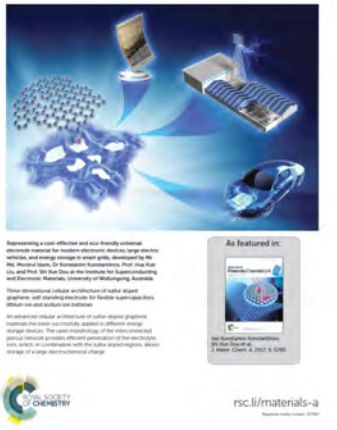

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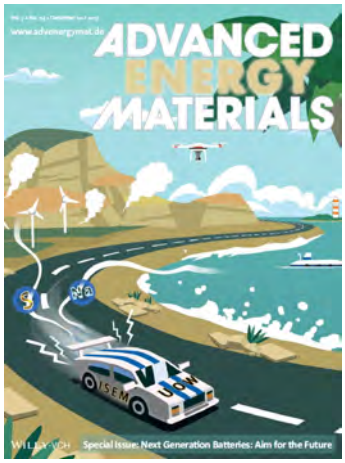

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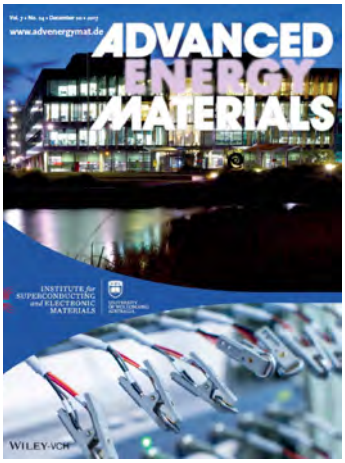

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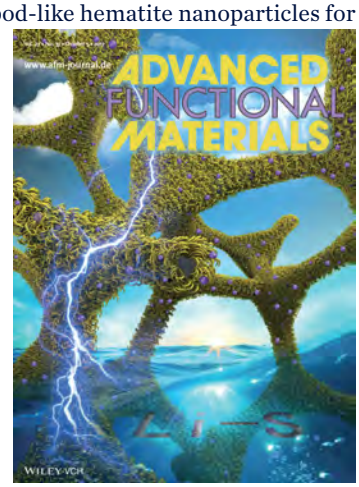

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Funding 2017

AUSTRALIAN RESEARCH COUNCIL GRANTS

ARC CENTRE OF EXCELLENCE

Chief Investigators	Title	2017 Funding
X. L. Wang via M. Fuhrer et al.	ARC Centre of Excellence in Future Low Energy Electronics Technologies	$224,100
Total		$224,100

ARC DISCOVERY SCHEME GRANTS

Chief Investigators	Title	2017 Funding
S. X. Dou, Z. Q. Sun, X. Xu, T. Liao, Z. F. Liu, H. Zhang, J.-B. Baek, L. M. Dai	Multifunctional 2D materials for sustainable energy applications	$152,000
C. Zhang, R. Lewis, Z. Li, F. Q. Wang, H. Schneider, M. Johnston	Coherent, tuned terahertz photons from nonlinear processes in graphene	$130,000
Z. G. Huang, H. K. Liu, H. B. Yu, X. B. Yu	Liquid phase hydrogen carriers for energy storage and delivery	$131,000
X. L. Wang, Z. Li, Z. X. Cheng, Y. Du	Atomically thin superconductors	$124,500
S. X. Dou, Y. Du, X. Xu, G. Peleckis, J. H. Ye, W. X. Hao, L. Chen	Two-dimensional plasmonic heterogeneous nanostructures for photocatalysis	$171,000
Z. P. Guo, K. Konstantinov, X. W. Lou, Z. Zhou	Potassium ion batteries for large scale renewable energy storage	$165,500
Total		$874,000

ARC FUTURE FELLOWSHIPS

Chief Investigators	Title	2017 Funding
X. L. Wang	Electronic topological materials	$124,000
S. J. Zhang	Lead-free bismuth based dielectric materials for energy storage	$222,000
Z. P. Guo	Exploration of advanced nanostructures for sodium-ion battery application	$222,000
Y. Yamauchi	All-metal nanoporous materials as highly active electrocatalysts	$197,000
W. K. Pang	High-voltage electrode materials for lithium-ion batteries	$163,000
Total		$928,000

ARC DECRA FELLOWSHIPS		
Chief Investigators	Title	2017 Funding
W. P. Sun	Lithium-ion conducting sulphide cathodes for all-solid-state Li-S batteries	$124,000
J. Liang	Carbon-based catalysts for polysulphide redox reactions in lithium-silicon batteries	$120,000
C. Wu	Electrode materials for sodium storage	$120,000
Y. X. Wang	Room-temperature sodium sulphur batteries	$120,000
G. L. Xia	Nanostructure metal hydrides for practical hydrogen storage applications	$120,000
Total		$604,000

ARC LINKAGE PROJECTS		
Chief Investigators	Title	2017 Funding
S. X. Dou, W. P. Sun, K. W. See, X. Xu	Development of the next generation battery storage system for smart grid	$190,000
J. Z. Wang, H. K. Liu, K. Konstantinov, S. L. Chou	Development of novel safe lithium metal-free sulfur batteries	$112,000
M. S. A. Hossain, S. X. Dou, J. H. Kim, Y. Yamauchi, R. Taylor, V. Luzin, A. Devred	Nanostructure engineered low activation superconductors for fusion energy	$161,000
Z. P. Guo, J. F. Mao, W. Li	High energy density, long life, safe lithium ion battery for electric cars	$285,000
Total		$748,000
2017 Australian Research Council Grants Total		$3,378,100

AUTO CRC PROJECTS		
Chief Investigators	Title	2017 Funding
H. K. Liu, Z. P. Guo, J. Z. Wang, J. H. Kim, K. Konstantinov, S. L. Chou	High energy anode materials for lithium ion batteries	$77,000
2017 Auto CRC Projects Total		$77,000

ARENA PROJECT		
Chief Investigators	Title	2017 Funding
S. X. Dou, H. K. Liu, S. L. Chou, K. W. See, D. Soetanto	The Smart Sodium Storage Solution (S^4)	$869,500
2017 ARENA Project Total:		$869,500

OTHER GRANTS		
Chief Investigators	Title	2017 Funding
S. X. Dou, K. W. See	Diesel-free environment for underground coal mines	$224,000
H. K. Liu, Z. P. Guo, J. Z. Wang, J. H. Kim, K. Konstantinov, S. L. Chou	High energy anode materials for lithium ion batteries	$50,000
S. J. Zhang, Z. X. Cheng, J. L. Wang	Exploration of new mesoscale mechanisms for ultrahigh piezoelectric responses in relaxor ferroelectrics	$130,000
J. H. Kim, M. S. A. Hossain, J. H. Kim	Development of long-life Li-S battery with high energy density	$82,000
Total		$486,000

UOW GRANTS		
Chief Investigators	Title	2017 Funding
M. S. A. Hossain	Adding value to microalgae: development of magnetic catalysts for algae oil-to-bio diesel and algae debris-to-HMF conversions	$15,000
W. P. Sun	Developing new 2D materials for energy storage and conversion	$10,000
Y. Yamauchi, K. Konstantinov, M. S. A. Hossain	Advanced materials for nanobiotechnology: strengthening the UOW-Indian research and teaching alliance	$17,000
X. L. Wang, P. Innis, J. Chen, S. X. Dou, R. A. Lewis, W. H. Li, K. Carpenter, Z. P. Guo, D. Cortie, Z. Li, Z. X. Cheng, S. J. Zhang, C. Richardson	A complete materials characterisation facility for thermomechanical and thermoelectric properties	$246,000
G. Peleckis	PANalytical Empyrean X-ray diffraction goniometer	$400,000
Z. Li	Exploring exotic electronic states in silicene	$10,000
J. C. Zhuang	Exploration of silicene/germanene by chemical routes in energy applications	$5,000
Total		$703,000

UOW support	Performance, Management, PGS Maintenance	$300,000
Total Funding 2017		$5,813,600

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