INSTITUTE *for* SUPERCONDUCTING *and* ELECTRONIC MATERIALS

UNIVERSITY OF WOLLONGONG AUSTRALIA

isem.uow.edu.au

Institute for Superconducting and Electronic Materials

ANNUAL REPORT 2017 HIGHLIGHTS

Contents

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.

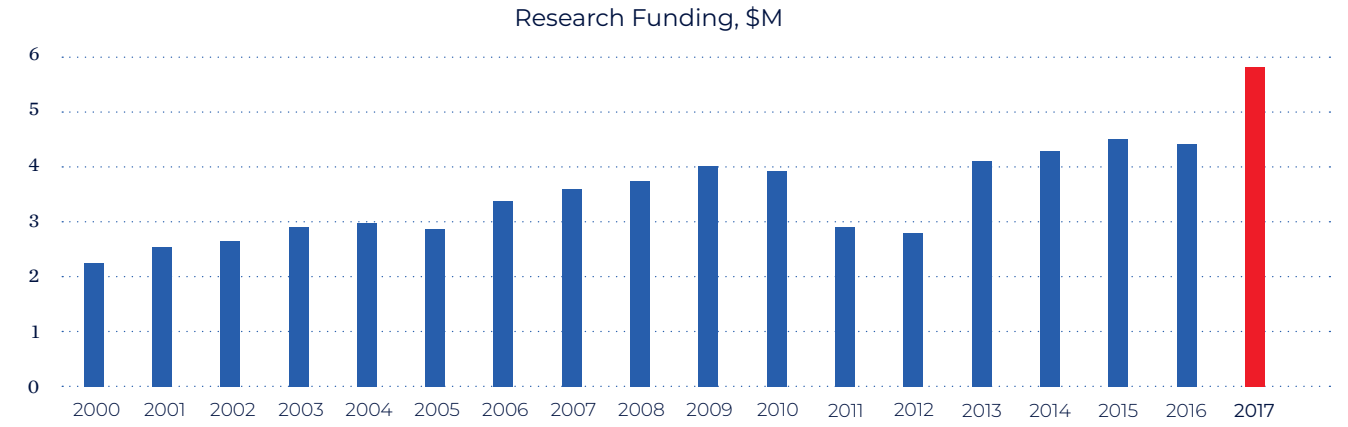
17 PhD students have graduated in 2017, bringing our total ISEM PhD completion to 178 who are widely distributed within five continents, with one (Jun Chen) elected to the most competitive fellow of Chinese Academy of Science and more than 40 professors and senior executives. Our academic staffs have 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.

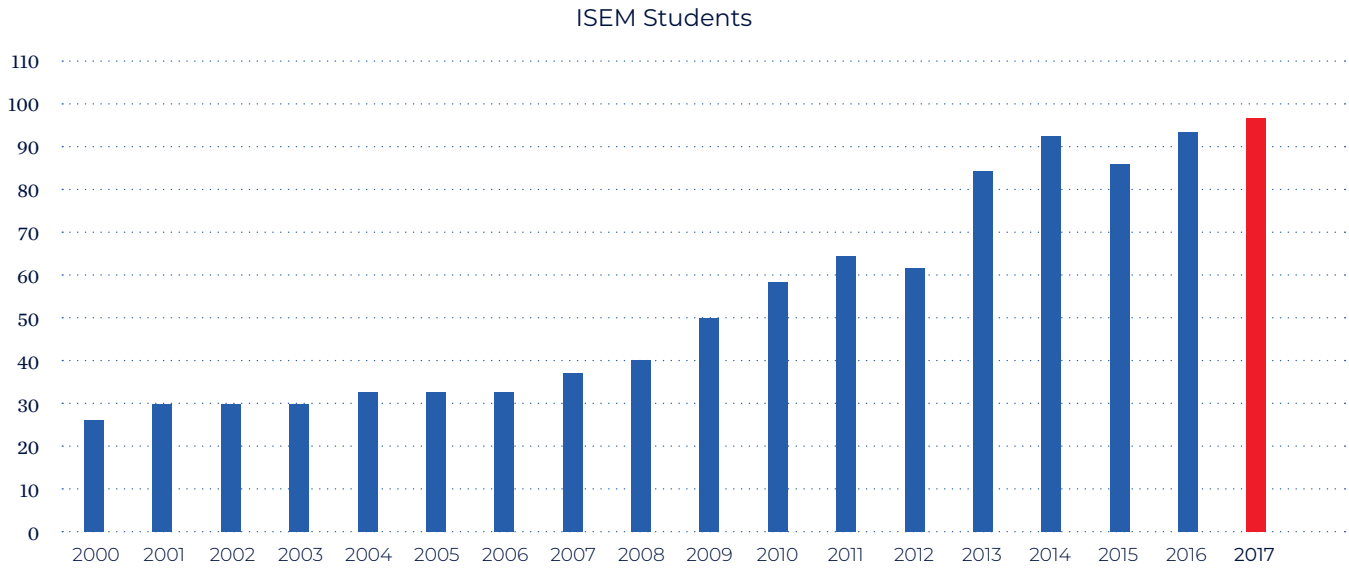
I would like to take this opportunity to sincerely acknowledge the strong support ISEM has received throughout the year from UOW Executives, faculty, administration staff, technical staff, OHS staff, commercial management staff, industry partners, and academic collaborators. I would also like to express 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.

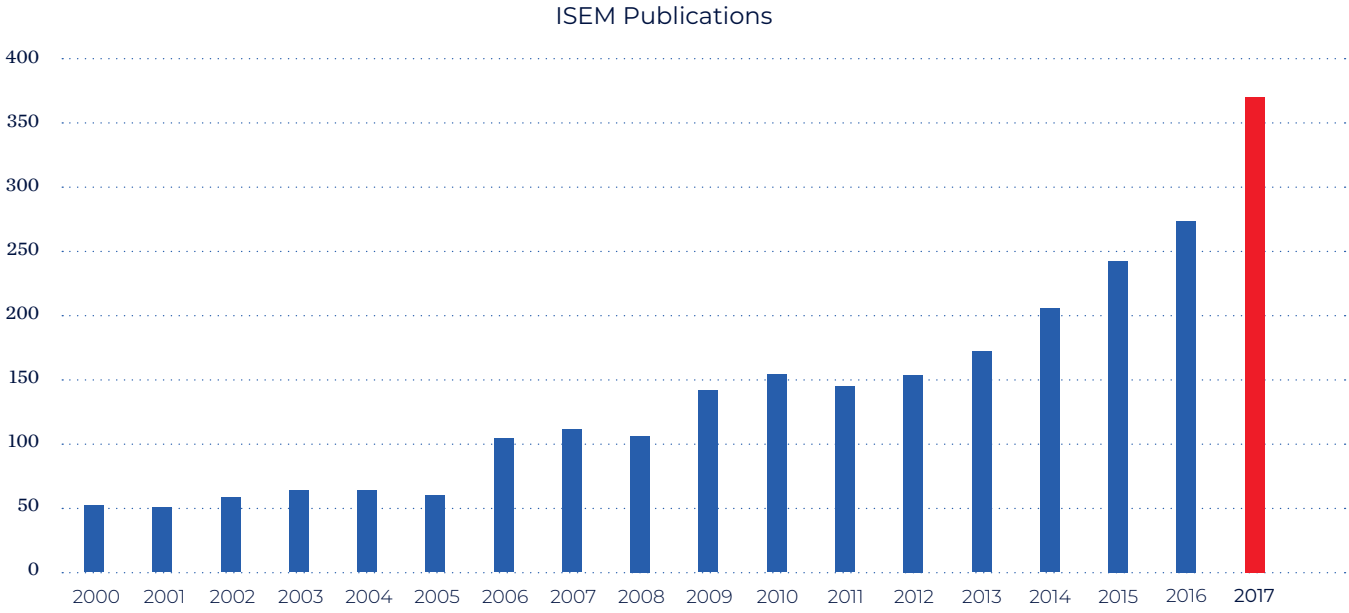
Sincerely yours,

Prof. Shi Xue Dou

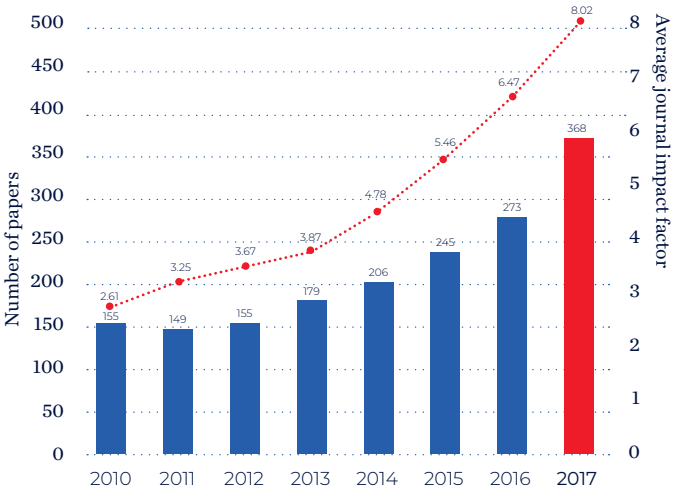
ISEM at a glance



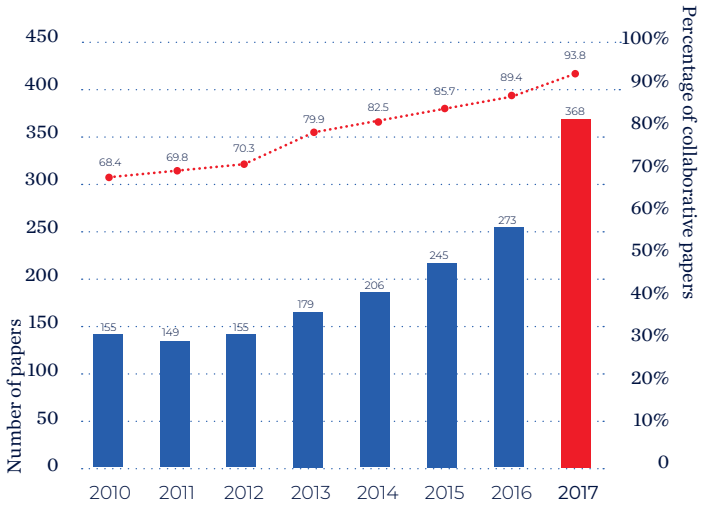




Average Impact Factor (IF) for ISEM publications 2010-2017



Share of Collaborative Publications for ISEM in 2010-2017



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

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	Prof. Chris Cook	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

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Senior Prof. Xiaolin Wang (BSc, MSc, PhD)
Associate Director
Dr. Germanas Peleckis (BCh, MSc, PhD)
Assistant Director

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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)

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A/Prof. Konstantin Konstantinov (Associate Professor)
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Prof. Roger Lewis (Associate Dean, Faculty of EIS)
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Prof. Alexey Pan (Professor, Faculty of EIS)
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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)

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Dr. Dongqi Shi (Senior Instrument Scientist)
Mrs. Crystal Mahfouz (Administrative Officer)

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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

Current and Ongoing Research Projects

ARC CENTRE OF EXCELLENCE

ARC Centre of Excellence in Future Low Energy Electronics Technologies

Years Funded:	2017	2018	2019	2020	2021	2022	2023
	$224,105	$216,211	$218,842	$218,842	$218,842	$221,474	$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	2017	2018	2019
	$152,000	$152,000	$152,000	$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

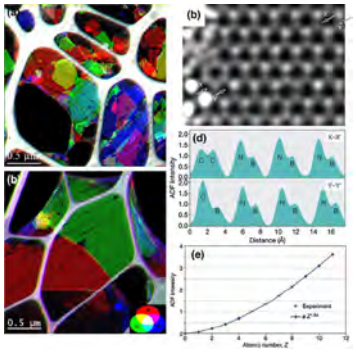
Years Funded:	2016	2017	2018
	$65,000	$130,000	65,000
Total Funding:	$260,000		
Chief Investigators:	S. J. Zhang, Z. X. Cheng, J. L. Wang		
Project Summary:	The main objective of the proposed research effort is to fundamentally understand the long-standing scientific question: what are the mesoscale 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 $Pb(Mg_{1/3}Nb_{2/3})O3\text{-}PbTiO_3$ (PMN-PT) and $Pb(Zn_{1/3}Nb_{2/3})O_3\text{-}PbTiO_3$ (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.			

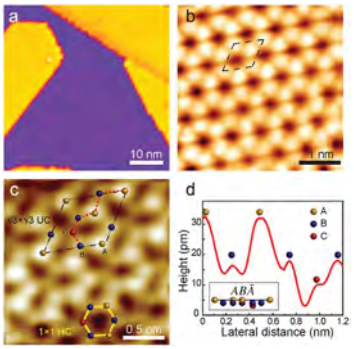
Selected Abstracts

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



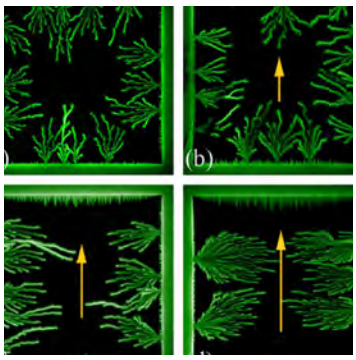
Two-dimensional (2D) materials have shown outstanding properties that make them the materials of choice for future semiconductor and flexible nanoelectronics. Hexagonal boron nitride nanosheet (BNNS) is one of the most studied 2D materials due to its extraordinary properties and potential applications. 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



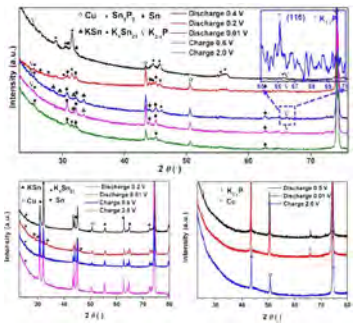
Silicene, a single-layer-thick silicon nanosheet with a honeycomb structure, is successfully fabricated by the molecular-beam-epitaxy (MBE) deposition method on metallic substrates and by the solid-state reaction method. Here, recent progress on the features of silicene that make it a prospective anode 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



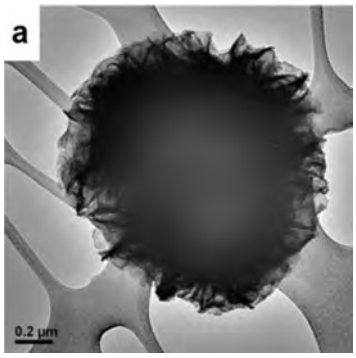
The electrodynamic behavior of isotropic superconducting Nb films cooled below their critical temperature in the presence of in-plane applied magnetic fields is investigated using magneto-optical imaging. A specially designed local flux injector is used to show that the frozen-in in-plane vortices strongly 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



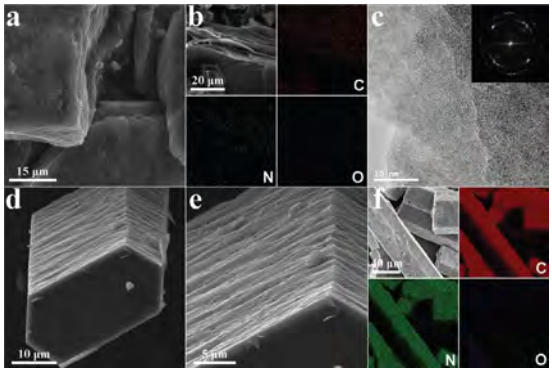
Potassium-ion batteries (PIBs) are interesting as one of the alternative metal-ion battery systems to lithium-ion batteries (LIBs) due to the abundance and low cost of potassium. We have herein investigated Sn_4P_3/C composite as a novel anode material for PIBs. The electrode delivered a reversible capacity 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



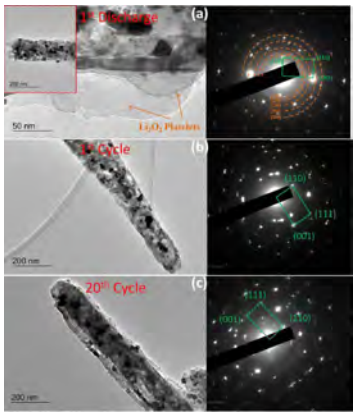
Energy storage and conversion technologies are vital to the efficient utilization of sustainable renewable energy sources. Rechargeable lithium-ion batteries (LIBs) and the emerging sodium-ion batteries (SIBs) are considered as two of the most promising energy storage devices, and electrocatalysis processes 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



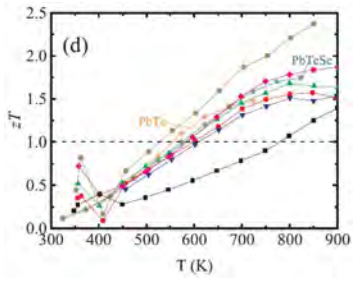
Novel layered 2D frameworks (C_3N and C_2N-450) with well-defined crystal structures are explored for use as anode materials in lithium-ion batteries (LIBs) for the first time. As anode materials for LIBs, C_3N and C_2N-450 exhibit unusual electrochemical characteristics. For example, C_2N-450 (and C_3N) 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



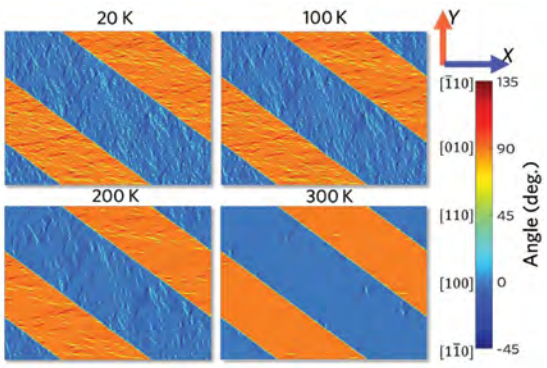
The nonaqueous lithium–oxygen battery is a promising candidate as a next-generation energy storage system because of its potentially high energy density (up to 2–3 kW kg^{-1}), exceeding that of any other existing energy storage system for storing sustainable and clean energy to reduce greenhouse gas 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



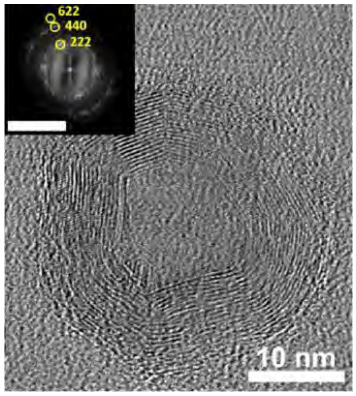
Liquid-like ionic conductors in the copper selenide family represent a promising class of thermoelectric materials capable of recycling waste heat into electrical energy with an exemplary figure-of-merit (zT >1.4) above 800 K. Ion diffusion, however, is enhanced at such high temperatures and drives a 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



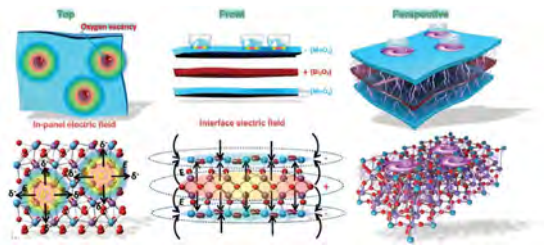
The existence of polar nanoregions is the most important characteristic of relaxor-based ferroelectric materials. Recently, the contributions of polar nanoregions to the shear piezoelectric property of relaxor-$PbTiO_3$ (PT) crystals are confirmed in a single domain state, accounting for 50%–80% of room 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



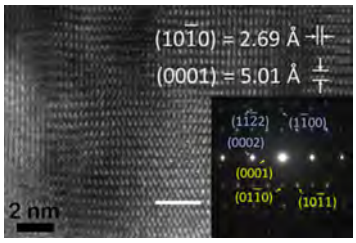
We demonstrate a magnetocaloric ferrofluid based on a gadolinium saturated liquid metal matrix, using a gallium-based liquid metal alloy as the solvent and suspension medium. The material is liquid at room temperature, while exhibiting spontaneous magnetization and a large magnetocaloric effect. The 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



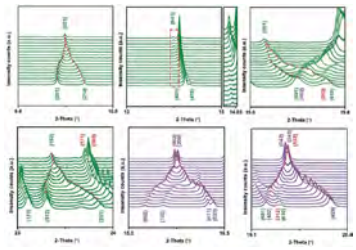
Ultrathin 2D materials can offer promising opportunities for exploring advanced energy storage systems, with satisfactory electrochemical performance. Engineering atomic interfaces by stacking 2D crystals holds huge potential for tuning material properties at the atomic level, owing to the strong layer–layer 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



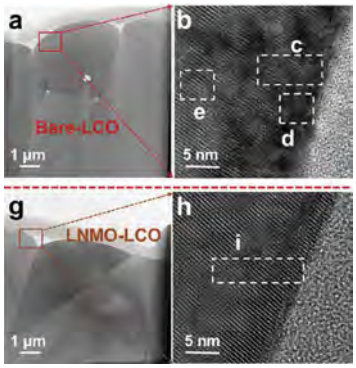
Co doped ZnO films have been deposited by a laser-molecular beam epitaxy system. X-ray diffraction and UV spectra analysis show that Co effectively substitutes the Zn site. Transmission electron microscopy (TEM) and secondary ion mass spectroscopy analysis indicate that there are no clusters. Co dopants 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



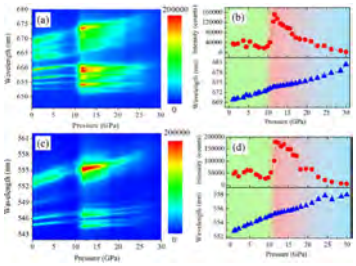
The ultrahigh thermoelectric performance of SnSe-based single crystals has attracted considerable interest in their polycrystalline counterparts. However, the temperature-dependent structural transition in SnSe-based thermoelectric materials and its relationship with their thermoelectric performance 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



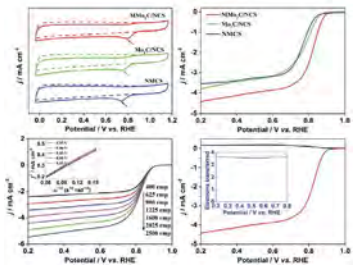
Battery industries and research groups are further investigating $LiCoO_2$ to unravel the capacity at high-voltages (>4.3 vs Li). The research trends are towards the surface modification of the $LiCoO_2$ and stabilize it structurally and chemically. In this report, the recent progress in the surface-coating 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:$GdVO_4$



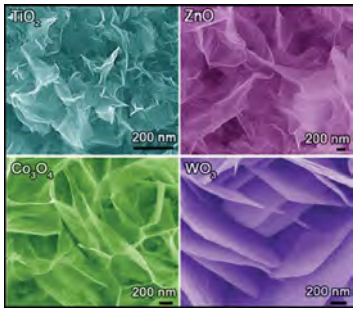
Rare earth phosphors have been widely studied because of their sharp emission lines and excellent optical performance. However, photoluminescence (PL) tuning by crystal field in Er^{3+} embedded phosphors has always been a challenge. Here, we demonstrate that pressure can help to enhance the red and 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



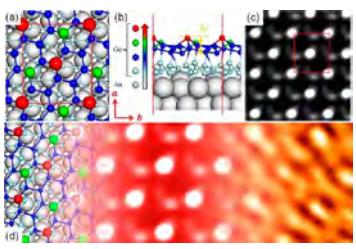
A simplemethod is developed to assemble Mo_2C nanocrystals on the surfaces of hollow, highly conductive mesoporous nanoparticles. Diblock copolymer (PS-*b*-PEO) micelles are used as templates to assist in the fast complexation of molybdate (MoO_4^{2-}) and polydopamine (PDA) precursors to make hollow 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



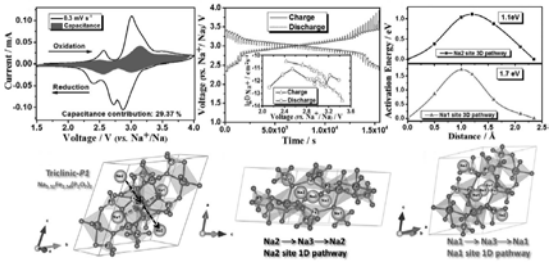
After the discovery of graphene, two-dimensional nanomaterials with atomic thickness and large lateral size have attracted tremendous research interest due to their high specific surface areas, exotic electronic structures, and fascinating physical and chemical properties. Even though recent studies 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)



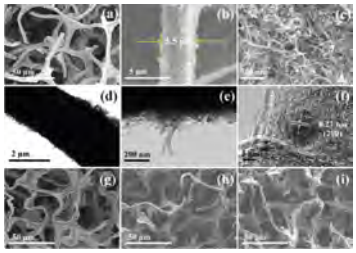
Germanene, a single-atom-thick germanium nanosheet in a honeycomb lattice, was proposed to be a Dirac fermion material beyond graphene. We performed scanning tunneling microscopy and in situ Raman spectroscopy studies combined with first-principles calculations on the atomic structures and the electronic 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



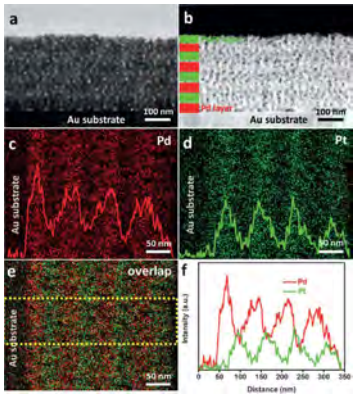
Rechargeable sodium-ion batteries are proposed as the most appropriate alternative to lithium batteries due to the fast consumption of the limited lithium resources. Due to their improved safety, polyanion framework compounds have recently gained attention as potential candidates. With the earth-abundant 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



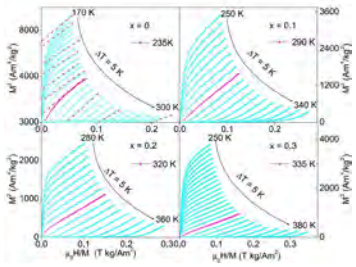
One of the critical challenges to develop advanced lithium-sulfur (Li-S) batteries lies in exploring a high efficient stable sulfur cathode with robust conductive framework and high sulfur loading. Herein, a 3D flexible multifunctional hybrid is rationally constructed consisting of nitrogen-doped carbon 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



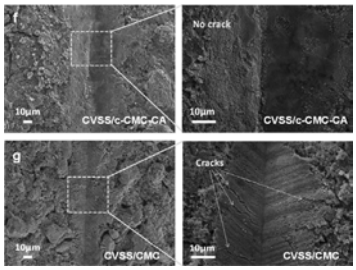
Although multilayer films have been extensively reported, most compositions have been limited to non-catalytically active materials (e.g. polymers, proteins, lipids, or nucleic acids). Herein, we report the preparation of binder-free multilayer metallic mesoporous films with sufficient accessibility 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



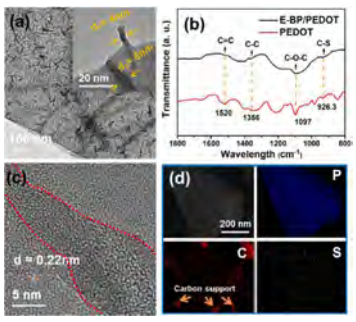
The wide ranging magnetic behavior in intermetallic compounds continues to attract broad interest. Effective control of their magnetic properties is of great importance for fundamental research and potential applications. In this work the structural and magnetic properties of $TbCo_2Mn_x$ compounds are 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 $Fd^{-}3m$ to rhombohedral $R^{-}3m$ 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



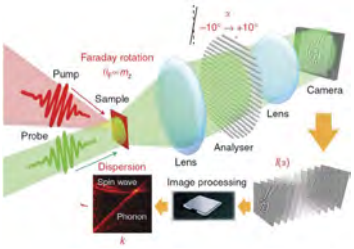
The concept of an all-integrated design with multifunctionalization is widely employed in optoelectronic devices, sensors, resonator systems, and microfluidic devices, resulting in benefits for many ongoing research projects. Here, maintaining structural/electrode stability against large volume change 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



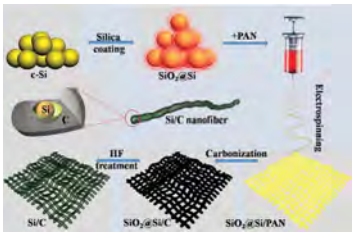
Few-layer black phosphorus (BP) is a promising anode material for sodium ion batteries (SIBs) due to its high theoretical capacity and favorable layered structure. However, practical implementation is hindered by sluggish reaction kinetics and large volume change during de/sodiation process. Especially, 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



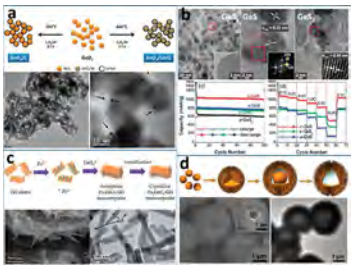
To know the properties of a particle or a wave, one should measure how its energy changes with its momentum. The relation between them is called the dispersion relation, which encodes essential information of the kinetics. In a magnet, the wave motion of atomic spins serves as an elementary excitation, 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



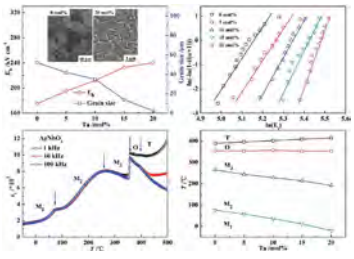
The electrochemical mechanism of nanocrystalline silicon anode in sodium ion batteries is first studied via in operando Raman and in operando X-ray diffraction. An irreversible structural conversion from crystalline silicon to amorphous silicon takes place during the initial cycles, leading to ultrafast 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



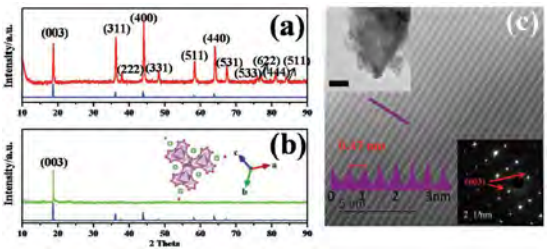
Germanium-based materials are arousing increasing interest as anodes for lithium-ion batteries, stemming from the intrinsic physical and chemical advantages of germanium. This progress report provides a brief review on the current development of germanium-based materials in lithium storage. The state-of-the-art 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



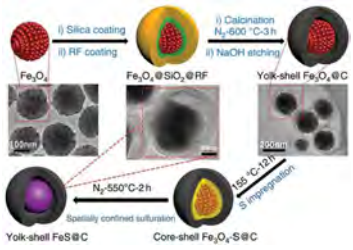
Antiferroelectric materials that display double ferroelectric hysteresis loops are receiving increasing attention for their superior energy storage density compared to their ferroelectric counterparts. Despite the good properties obtained in antiferroelectric La-doped $Pb(Zr,Ti)O_3$-based ceramics, lead-free 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



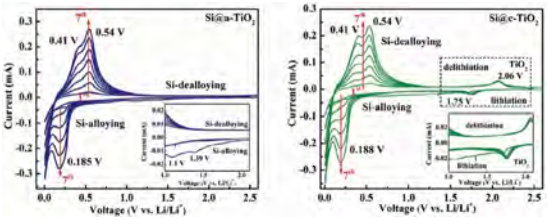
The most promising cathode materials, including $LiCoO_2$ (layered), $LiMn2O_4$ (spinel), and $LiFePO_4$ (olivine), have been the focus of intense research to develop rechargeable lithium-ion batteries (LIBs) for portable electronic devices. Sluggish lithium diffusion, however, and unsatisfactory long-term 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



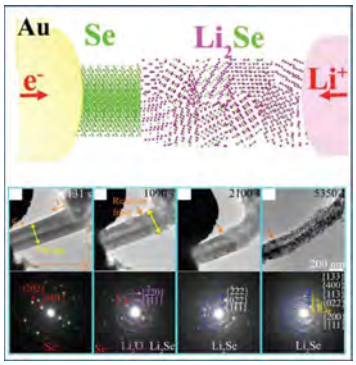
Rechargeable sodium-ion batteries (SIBs), as the most promising alternative to commercial lithium-ion batteries, have received tremendous attention during the last decade. Among all the anode materials for SIBs, metal sulfides/selenides (MXs) have shown inspiring results because of their versatile material 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



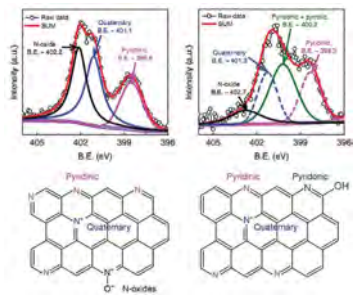
Smart surface coatings of silicon (Si) nanoparticles are shown to be good examples for dramatically improving the cyclability of lithium-ion batteries. Most coating materials, however, face significant challenges, including a low initial Coulombic efficiency, tedious processing, and safety assessment. 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



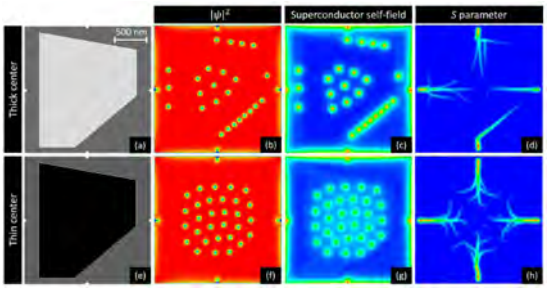
Layered α-$Ni(OH)_2$ and its derivative bimetallic hydroxides (e.g., α-$(Ni/Co)(OH)_2$) have attracted much attention due to their high specific capacitance, although their insufficient cycling stability has blocked their wide application in various technologies. In this work, we demonstrate that the 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 $w = 2/\mu_0\sigma t$ where σ 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))

Selected Refereed Publications

ISEM has published 368 articles in 2017 with an average IF of 8.02. Below are 96 selected high-impact papers.

JOURNAL ARTICLES

1. S. Al-Rubaye, R. Rajagopalan, S. X. Dou, and Z. X. Cheng, "Facile synthesis of a reduced graphene oxide wrapped porous $NiCo_2O_4$ composite with superior performance as an electrode material for supercapacitors", ***Journal of Materials Chemistry A*** 5, 18989 (2017); [IF: 9.931]
2. R. B. Ambade, S. B. Ambade, N. K. Shrestha, R. R. Salunkhe, W. Lee, S. S. Bagde, J. H. Kim, F. J. Stadler, Y. Yamauchi, and S. H. Lee, "Controlled growth of polythiophene nanofibers in TiO_2 nanotube arrays for supercapacitor applications", ***Journal of Materials Chemistry A*** 5, 172 (2017); [IF: 9.931]
3. Y. S. Ang, S. Y. A. Yang, C. Zhang, Z. S. Ma, and L. K. Ang, "Valleytronics in merging Dirac cones: All-electric-controlled valley filter, valve, and universal reversible logic gate", ***Physical Review B*** 96, 245410 (2017); [IF: 3.831]
4. J. Brisbois, V. N. Gladilin, J. Tempere, J. T. Devreese, V. V. Moshchalkov, F. Colauto, M. Motta, T. H. Johansen, J. Fritzsche, O. A. Adami, N. D. Nguyen, W. A. Ortiz, R. B. G. Kramer, and A. V. Silhanek, "Flux penetration in a superconducting film partially capped with a conducting layer", ***Physical Review B*** 95, 094506 (2017); [IF: 3.831]
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7. Y. Z. Chen, W. K. Pang, H. H. Bai, T. F. Zhou, Y. N. Liu, S. Li, and Z. P. Guo, "Enhanced structural stability of nickel-cobalt hydroxide via intrinsic pillar effect of metaborate for high-power and long-life supercapacitor electrodes", ***Nano Letters*** 17, 429 (2017); [IF: 12.080]
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9. S. K. Chong, Y. Z. Chen, Y. Zheng, Q. Tan, C. Y. Shu, Y. N. Liu, and Z. P. Guo, "Potassium ferrous ferricyanide nanoparticles as a high capacity and ultralong life cathode material for nonaqueous potassium-ion batteries", ***Journal of Materials Chemistry A*** 5, 22465 (2017); [IF: 9.931]
10. S. L. Chou and S. X. Dou, "Next-Generation Batteries", ***Advanced Materials*** 29, 1705871 (2017); [IF: 21.950]
11. S. L. Chou and Y. Yu, "Next Generation Batteries: Aim for the Future", ***Advanced Energy Materials*** 7, 1703223 (2017); [21.875]
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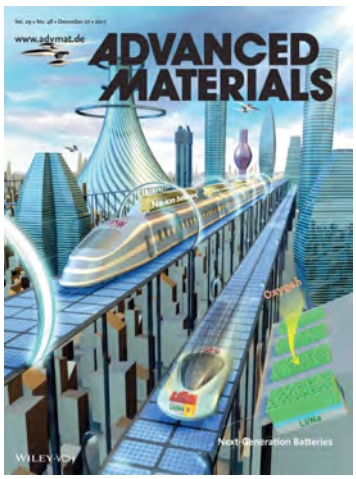

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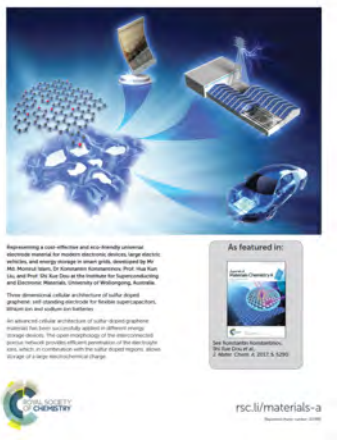

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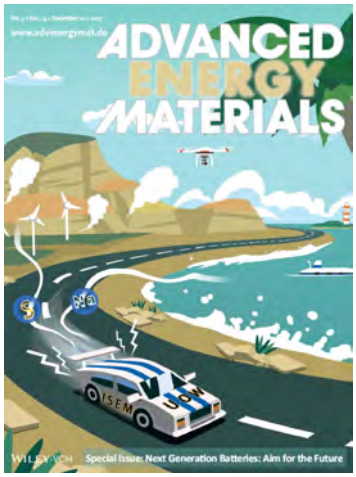

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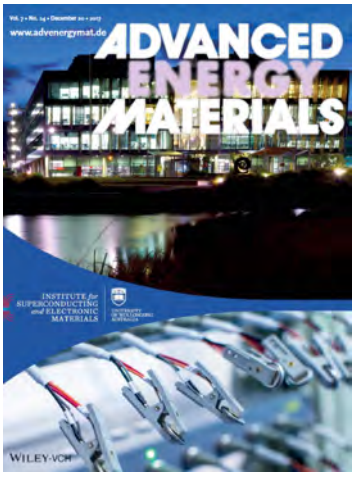

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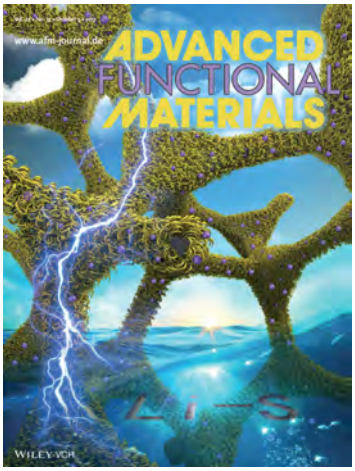

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Funding 2017

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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