香港科技大學
THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

香港科大能源研究院
The HKUST Energy Institute

HKUST Energy Institute Newsletter

June 2017

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Message from the Director

Welcome to HKUST Energy Institute's inaugural newsletter. It is with profound pleasure that we now have the opportunity to share our ground-breaking research projects, inform you about our community engagement activities and introduce our outstanding faculty members.

Since the founding of the Energy Institute (EI) in 2012, it has been well-positioned to become a leading international center for innovation, collaborative energy research and an education hub to meet global energy challenges. With this strong foundation, we continue to pursue multidisciplinary, collaborative projects that go beyond traditional academic boundaries. We are thrilled to be able to leverage HKUST's leading position and wealth of energy expertise to foster partnerships among world-class scientists.

Leveraging EI's platform, we aim to establish a vibrant interactive environment that brings together academia, government and industry locally and internationally to pursue transformative solutions to tackle important energy issues. Our role is to connect these avenues to exchange ideas, knowledge and conversation, and announce the findings to our target audience and the public.

Our multidisciplinary research, drawing on long-standing collaborative links among HKUST, industry, the government as well as other internationally-renowned academic institutions, spans a diverse portfolio of interests with an emphasis on four primary areas: energy generation, energy storage and distribution, energy efficiency, and energy policy.

With ardent support from both internal and external parties, we are pleased to have achieved initial success in the past few years. Besides identifying four cutting-edge energy research focused areas mentioned earlier, the Central Energy Research Lab (CERL) has also been set up to functionally integrate and facilitate cross-disciplinary collaborative research.

Prof Tianshou Zhao
Director of HKUST
Energy Institute

Enhancing collaboration among faculty members across various disciplines is of prime importance. This has been evidenced by an increase in applications for collaborative projects such as the HKUST-MIT Alliance Project, RGC Theme-based Research Scheme and RGC Collaborative Research Fund (CRF).

Our audience is not limited to professionals in the field. Dedicated to broadening the educational experience of students and the general public, we have organized lectures and workshops featuring renowned scholars on energy issues.

Looking forward, we will continue to strengthen the dialogue among research disciplines, further engage in emerging research with a long-term and transformative impact on Hong Kong and China's energy future. We will also develop technologies, strategies, policies and educational programs with the potential to offer impactful solutions to pressing near-term energy issues, as well as develop and organize undergraduate and postgraduate educational energy programs to nurture the next generation of leaders in energy.

These accomplishments and future plans have been made possible owing to your involvement and support. Sincerely hoping that you can join us in this mission, we welcome your participation, insights and ideas.

Low-cost, Efficient and Environmentally-friendly Solar Cell Breaking World Record

Prof Henry He Yan
Associate Professor of Chemistry
Associate Director of HKUST Energy Institute

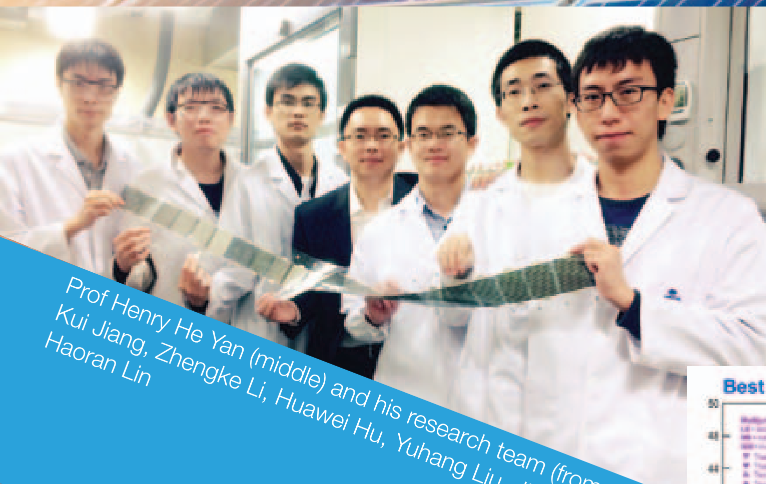
You may have seen Si solar panels on rooftops that are as heavy as a human being, but can you imagine that light-weight, flexible solar cell panels can be produced as easily as the printing of newspapers?

This is not a fantasy. This is a real technology!

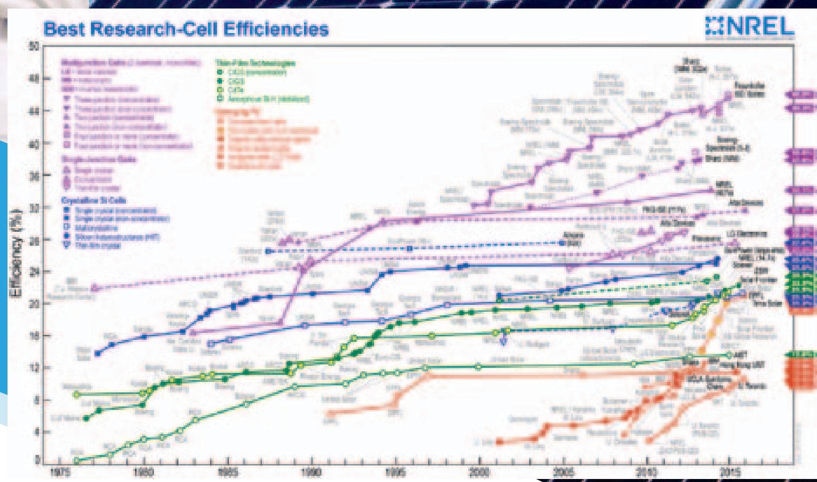
Prof Henry He Yan, Associate Director of the HKUST Energy Institute and Associate Professor of the Department of Chemistry, is working on a revolutionary solar cell technology called organic solar cell (OSC). It is based on solution-printable organic materials that are low-cost, efficient and environmentally friendly.

In 2016, Prof Yan's team developed a record-efficient organic solar cell, which was listed on the renowned "Best Research-Cell Efficiencies Chart" by the National Renewable Energy Laboratory in the US. This is the first time a solar cell developed by an institution in Hong Kong appeared on the historic chart, which records all the best efficiency cells around the world over the past 40 years. The chart, consisting of values of highest conversion efficiencies for different types of solar cells since 1976, recently posted "Hong Kong UST" – an organic solar cell which yields efficiencies of up to 11.5 percent, as the latest world record for emerging organic solar cells. This research was also published in the prestigious journal *Nature Energy* in February 2016.

Shortly after the publication, Prof Yan's team achieved another important breakthrough by discovering a new material system that demonstrated ultrafast and efficient charge separation despite a nearly zero charge separation



Prof Henry He Yan (middle) and his research team (from right): Kui Jiang, Zhengke Li, Huawei Hu, Yuhang Liu, Jingbo Zhao and Haoran Lin



Best Research-Cell Efficiencies Chart by National Renewable Energy Laboratory of the United States

driving force, meaning that the more environmentally-friendly OSCs may be able to have performance as good as inorganic solar cells in future. This research work led to a "back-to-back" publication at *Nature Energy*. Historically, the charge separation in OSCs required a significant driving force – typically 0.3 eV or higher – which has been a fundamental limitation for OSC's development as the driving force inevitably resulted in a large voltage loss in OSC and limited its maximum achievable efficiency. Prof Yan's breakthrough is set to remap the future of OSC. Currently, the best-performing OSC only has an efficiency of between 12 and 13 percent. With the required driving force reduced to near zero however, OSC's maximum efficiency could be increased to between 20 and 25 percent, a level that is comparable to the most advanced inorganic solar cells nowadays.

Prof Yan graduated from Peking University and obtained his PhD at Northwestern University in 2004. Before joining HKUST in 2012, he led a research group at Polyera Corporation – a leading company in the organic electronics industry. His publication of the first high-mobility n-type polymeric semiconductor on *Nature* was highlighted on the cover as the "new transistor age". After joining HKUST, Prof Yan's research direction focuses more on emerging organic solar cells. His research results in OSCs attracted worldwide attention. In December 2014, Prof Yan published a milestone paper at *Nature Communications* which has now been cited over 1,250 times, making it by far the most cited paper among over 3,000 *Nature Communications* articles published in 2014.

During the past two years, Prof Yan's team has made major advances in emerging organic solar cells and is considered one of the leading groups in the field. Prof Yan was also elected the Chair of the 2016 Gordon Conference on Hybrid Electronic and Photonic Materials and Phenomena, and the Chair of 13th International Symposium on Functional Pi-Electron Systems in 2017 at HKUST. Besides having outstanding achievements in research and winning the Research Award in 2015, Prof Yan was awarded the School of Science Teaching Award in 2016, a recognition and appreciation to his outstanding teaching performance.

Our Renewable Future

Prof Tianshou Zhao
Director of HKUST Energy Institute
Chair Professor of Mechanical and Aerospace Engineering

Prototype model fuel cell car

Pollutant emissions are largely a byproduct of our need for energy generation and transportation, which today are usually powered by fossil fuels, namely oil, coal and gas. One major emission is carbon dioxide, a greenhouse gas that contributes directly to global warming when generated in quantities that outstrip nature's assimilative capacity. Others, such as particulate matter, are toxic to human health. Yet currently, only 2% of energy is derived from "clean air" renewables, such as wind and solar.

The key challenges for renewables include stability in generation, on-tap availability and cost-efficiency. Wind farms require large areas of land and highly efficient solar panels are often expensive to produce. Both face an "intermittent generation" problem and energy storage to cover such gaps remains a huge challenge.

Prof Tianshou Zhao has been advancing the potentials for wider use of clean energy for the past 15 years through his ground-breaking work on direct alcohol fuel cells and advanced battery technologies.

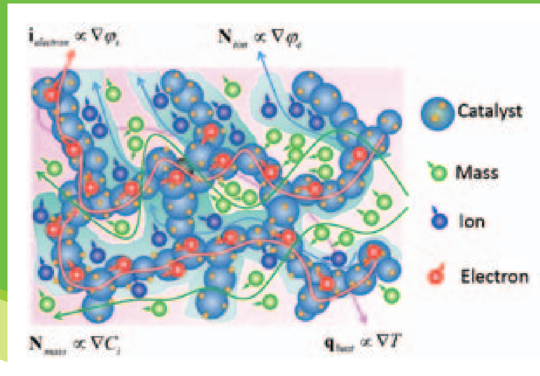
Prof Zhao sees immense potential in fuel cells as an alternative source of energy. Fuel cells generate electricity through converting the chemical energy of a fuel such as hydrogen, ethanol and methanol, all of which can be directly produced from renewable sources. Fuel cells have high efficiency of around 65%, compared with 30%-35% for traditional heat engines. In addition, they are scalable and can be applied to a wide range of modern lifestyle devices and needs, including cars, mobile phones, computers and buildings.

The main problem with alcohol fuel cells has been low power density, the amount of power produced in relation to the volume of the cell. Based on his seminal work on the underlying mechanism

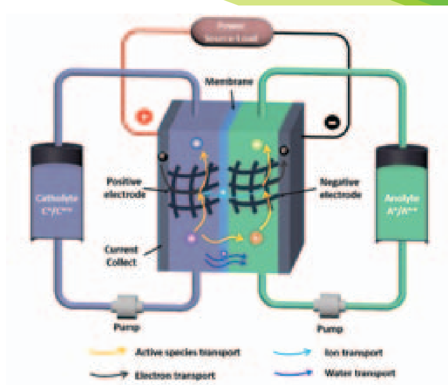
of couple heat/ mass energy transfer and electrochemical kinetics in fuel cells, Prof Zhao discovered that the issue lay in integrating the understanding of heat and mass transport, and electrochemistry.

With such insight, a new theoretical framework was developed, which led to a dramatic increase in the performance of direct methanol fuel cells by six times and that of direct ethanol fuel cells by four times. Prof Zhao has demonstrated a prototype model car that runs for 10 hours on 5cc of alcohol fuel. And an MP3 player that plays for 20 hours on 2cc of fuel. The researchers have also discovered that hydrogen can evolve spontaneously from a direct methanol fuel cell. This has given rise to a new technique for hydrogen production at room temperature minus the carbon monoxide species common to traditional methanol reformation.

Such theory and discoveries have helped Prof Zhao's research group to tackle further related issues through electrode design improvements for large-scale redox flow battery technologies that can help solve the "intermittent generation" problem for renewables such as solar and wind by raising power density. In contrast to solid state batteries that integrate energy storage and power pack together, a flow battery separates the storage component from the power pack, meaning that power and capacity can be independently sized, making the technology scalable. The battery lifespan is also increased.



Vanadium redox flow battery



Coupling of heat and mass transfer with electrochemistry

Prof Zhao's unusual blend of electrochemistry and thermos-fluid science is indicative of the non-traditional approach encouraged by HKUST. His team comprises expertise ranging from materials and modeling to fluid sciences and electro-chemistry.

Prof Zhao and his research team

CRF Research on Cooling Effect for Smart Green Buildings Awarded HK$7.33M

Prof Christopher Chao
Chair Professor and Head of Mechanical and Aerospace Engineering

A research team led by Prof Christopher Chao, Chair Professor of Mechanical and Aerospace Engineering (MAE), has been awarded HK$6.18 million by the Collaborative Research Fund (CRF) of the Research Grants Council (RGC), together with an equipment matching of HK$ 1.15 million from the University for a three-year project "Study of Cooling Effect by Surface Treatment and its Application to Smart Green Buildings".

In many countries and areas including Hong Kong, more than 30% of electricity consumption in the residential and commercial sectors is for space conditioning. Reducing energy consumed in space conditioning is thus an essential requirement for a smart green building. This is especially important to Hong Kong where the abundance of sunlight in the tropics results in buildings experiencing significant solar heat gain, leading to extensive use of air-conditioning (AC) to ensure comfort, health and productivity of occupants.

The project aims to design and develop a smart green wall panel (SGWP) for buildings, providing a solution for building thermal management – an Indoor Thermal Environment Control (ITEC) System. The ITEC system controls the solar heat gain to the buildings, thus reducing indoor air temperature, HVAC energy consumption and the electricity demand.

The proposed ITEC system is built using SGWP, a panel that combines two different technologies: a plasmonic structured passive radiative cooler and a hydrophobic-based vanadium oxide (VO2) thermochromic smart window.

The problem with existing technology is that, to realize net radiative cooling below ambient air temperature, a strong reflection of sunlight and a strong emission of thermal radiation with a wavelength within the atmospheric window (8–13μm) must be achieved simultaneously. This is extremely difficult to realize using conventional optical coatings.

The project seeks to develop a passive radiative cooler based on plasmonics technology. By changing the plasmonic pattern, the optical properties of photonic devices can be tailored for different spectral regimes, providing great potential to enhance radiative cooling.

However, even with passive radiative coolers on SGWPs to cool the indoor air, substantial energy is still received or lost through the windows. To deal with this, a thermochromic smart window will be further developed which automatically changes the intensity of the light passing through it to reduce the energy demand for heating, cooling and lighting. A nano-structured, self-cleaning and hydrophobic material will be coated on top of the smart windows to enhance its visible transmittance. Such coatings have been explored for photovoltaic cells, but never for smart windows.

Lastly, the project will evaluate the effectiveness of the ITEC system on thermal management in a combined system setting. The impact of the ITEC system on indoor thermal comfort will also be studied by monitoring a suite of thermal comfort parameters, such as indoor air temperature, relative humidity, mean radiant temperature, air velocity, air flow distribution and location of ventilation units.

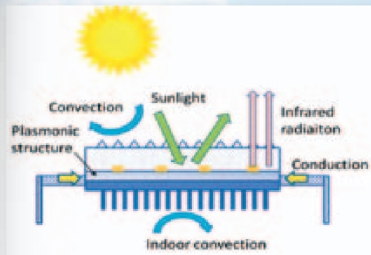
The project boasts the benefits of being environmentally friendly. The passive radiative cooler belongs to a technology of sustainability; it is a "green" cooling strategy which requires no electricity nor refrigerants and is therefore one of the most environmentally-friendly options among various space cooling techniques available. The thermochromic smart window can smartly control the amount of solar heat to the buildings.

Together, they mean reduced air-conditioning and heating loads and a better indoor thermal environment. The combination will provide a thermal management solution—an ITEC system. In summer, there is reduction in transmitted solar heat gain. In winter, infrared radiation is allowed into the buildings to maintain a warm indoor environment.

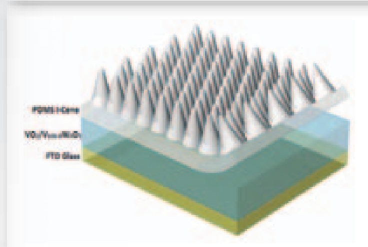
The resultant SGWPs not only have energy-saving potential, but will also enhance health and comfort, making buildings both greener and smarter. They can be retrofitted to existing buildings as well as installed in new ones.

The outcomes of this project will dramatically change building styles and constitute a breakthrough in research on built environments and building technology.

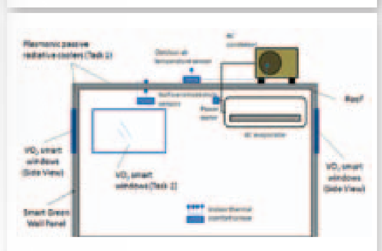
From left to right: Baoling Huang, Huihe Qiu, Chiyan Tso, Christopher Chao, and Shuhuai Yao.



Design of a plasmonic based passive radiative cooler



Structure of VO2 thermochromic smart window with PDMS



Graphical illustration of an ITEC system and system test bed

With Prof Christopher Chao as the Principal Investigator, team members include HKUST MAE's Prof Baoling Huang, Prof Shuhuai Yao, Prof Huihe Qiu and Prof Edwin Tso, Prof Kin-Man Yu from the Department of Physics and Materials Science of City University of Hong Kong, and Prof Man-Pun Wan from the School of Mechanical and Aerospace Engineering of Nanyang Technological University, Singapore. Prof Chao, as Head and Chair Professor of MAE, has over 20 years of R&D experience in thermal and environmental engineering covering indoor air science, energy-efficient building technology and energy engineering and with proven record in thermofluids, energy and the built environment.

THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

Joint HKUST-MIT Team Develops Advanced Smart HVAC Control System for Energy-efficient Building

Prof Yi-Kuen Lee
Associate Professor of Mechanical and Aerospace Engineering

A multidisciplinary team consisting of world-leading researchers from HKUST and MIT, led by Prof Yi-Kuen Lee, Associate Professor of Mechanical and Aerospace Engineering (MAE), has been awarded HK$10 million by the Innovation and Technology Fund under the HKUST-MIT Research Scheme for a two-year project "Smart Adaptive Control/Monitoring System for Energy Efficient Buildings with Low Carbon Footprint and CMOS MEMS Sensors and Smart Actuators", renewable for another two years with deliverables achieved.

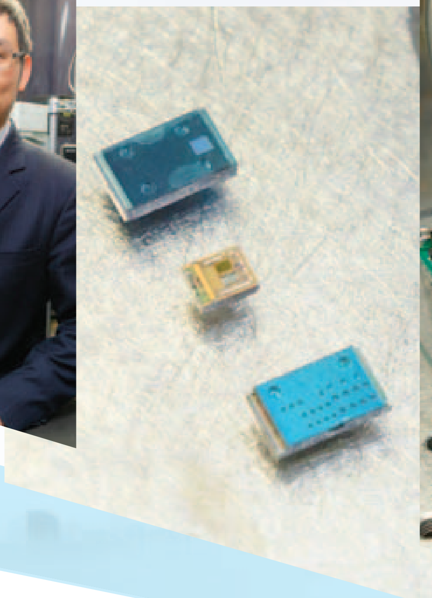
This project is to develop a smart heating, ventilation and air conditioning (HVAC) control system to enable energy-efficient building in view of the world's pressing energy resources and emission problems.

With the world's population reaching 7.3 billion in 2015 and 11.2 billion in 2100, and with over 70% of the population living in cities by 2050, it is forecasted that the earth's limited energy resources will be depleted in the near future. In addition, the global increase of carbon dioxide emission is gradually resulting in extreme climate change around the world.

To address the issue, it is extremely critical to develop a new energy-efficient building technology with low carbon footprint. Two Gt of carbon dioxide needs to be saved by 2050, according to the technology roadmap of OECA/IEA. This is especially important to the expanding population in the urban area.

On the other hand, the advance of semiconductor industry in the past several decades has enabled low-cost high-performance computers following Moore's law, data storage devices and the internet. The Internet of Things (IoT), with more low-cost MEMS sensors and actuators, will be the next emerging technology. Sensors are one of the five pillars for IoT, according to the chief economist of Consumer Electronics Association Dr Shawn DuBravac.

In Hong Kong which has the world's second highest carbon footprint per capita, operating buildings account for more than 50% of total energy consumption. In most other countries, operating buildings account for 30-40% of total energy consumption and carbon dioxide emissions. There is great potential for significantly reducing these



figures and the associated carbon footprint. HVAC systems, in particular, account for almost 40% of the major sources of energy use in buildings.

In this joint HKUST-MIT project, the team will conduct collaborative research to develop key IoT technologies, techniques and tools for energy-efficient building with low carbon footprint. It will also provide outreach to Hong Kong's building industry to upgrade the existing technology, as well as educate the next generation of scientists and engineers to work on highly interdisciplinary research in energy-efficient building.

The team will integrate smart sensors, actuators and artificial intelligence algorithms to develop a new smart HVAC control system to significantly reduce energy consumption in commercial buildings. The smart sensors to be developed include low-cost CMOS MEMS thermal flow sensor/temperature sensor/energy sensor with integrated microelectronics using commercial CMOS MEMS foundry. The actuators include low-cost smart windows, personalized ventilation (PV) systems with integrated sensors. The smart HVAC controller will incorporate the advanced building modeling and artificial intelligence algorithms.

The team is working with HKUST's Facility Management Office (FMO) to develop a working prototype of the proposed system in a demo room of the University towards the end of the project. In addition, they plan to promote the technology to government office buildings and industries in Hong Kong and Mainland China.

The HKUST-MIT multidisciplinary team consists of world-leading researchers in Mechanical and Aerospace Engineering, namely HKUST's Prof Christopher Chao and Prof Yi-Kuen Lee, and MIT's Prof Nicholas Fang; Electrical and Computer Science Engineering, namely HKUST's Prof Lei Chen, MIT's Prof Gregory Wornell and Prof Lizhong Zheng; Building Technology and Architecture Engineering, namely Prof Jane Weizhen Lu and MIT's Prof Leon Glicksman.

Research Project

HK2.99M Awarded to Research on High Performance Cathode Materials for Lithium-ion Batteries

Prof Minhua Shao

Associate Professor of Chemical and Biomolecular Engineering
Associate Director of HKUST Energy Institute

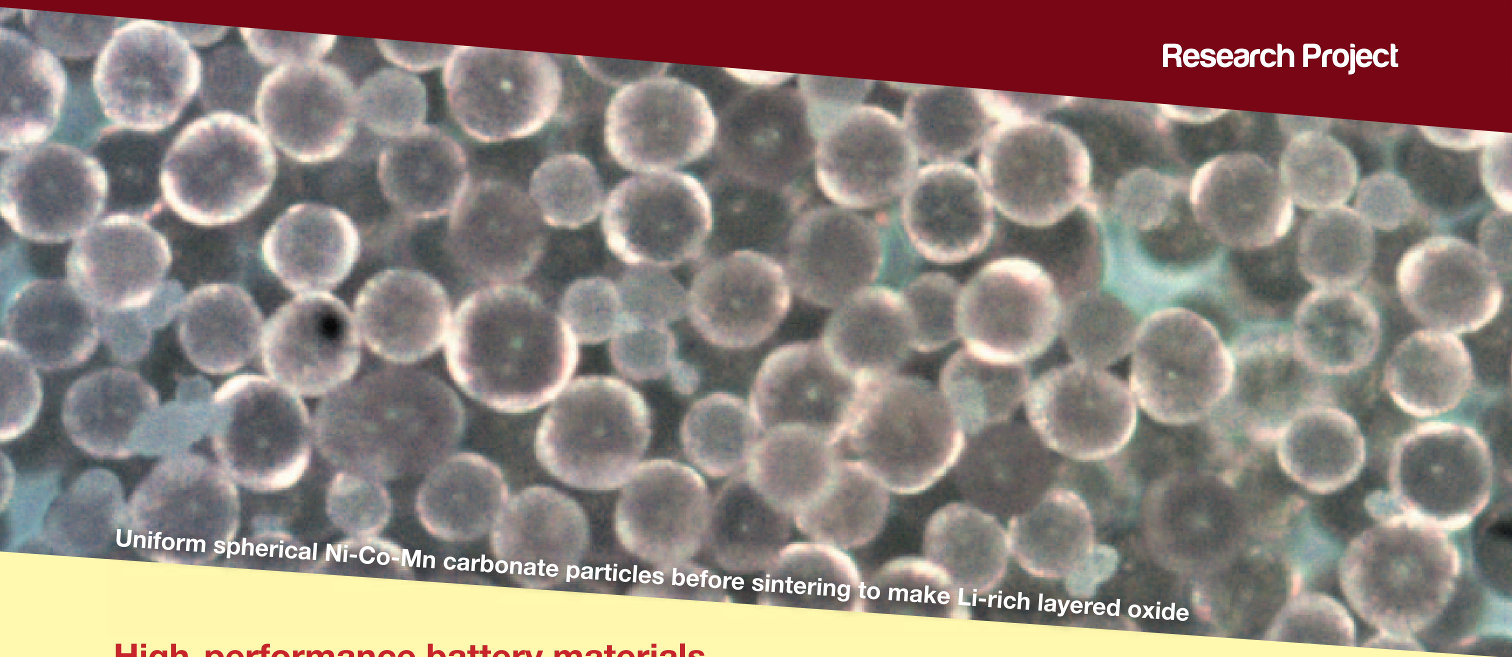
A team led by Prof Minhua Shao, Associate Professor of Chemical and Biomolecular Engineering and Associate Director of the HKUST Energy Institute, has recently been awarded HK$2.99 million by the Innovation and Technology Fund (ITF) to develop high-performance materials for lithium-ion batteries.

Lithium-ion battery

Since their first commercialization in the 1990s, lithium-ion batteries (LIBs) have become the dominant power sources for various electronic devices and energy storage solutions. In recent years, LIBs have been applied to electric vehicles (EVs) as the main power source due to their high energy density, low maintenance, and long calendar life, to replace lead acid and nickel-metal hydride batteries. The wide adoption of EVs will significantly reduce air pollution and CO_2 emission arising from conventional combustion engine cars.

A rechargeable LIB is typically made up of a cathode and an anode, which are separated by a porous membrane in a non-aqueous electrolyte. Performance of LIB is strongly dependent on intrinsic properties of the active materials at the anode and cathode. Energy density of LIB is mainly limited by cathode materials since the capacity of graphite (370 mA h g^{-1}) at the anode is much higher than that of common cathode materials, such as LiCoO2 (140 mA h g^{-1}). For this reason, tremendous efforts have been made to develop more advanced cathode materials.

Among cathode materials, the layer-structured oxides LiMO2 (M = Ni, Co, Mn) can provide a relatively higher theoretical capacity (>270 mAh g^{-1}) and operating voltage (>3.6 V vs. Li/Li^+). Layered $LiCoO_2$ which has been impressively successful in small LIBs is not the preferred choice for those in EVs partially due to its safety issues and a relatively small capacity. During the past decade, great efforts have been devoted to Li-rich layered oxides (LLO), $x Li_2MnO_3 \cdot (1-x) LiMO_2$ ($0<x<1$, M=transition metals) and Ni-rich layered oxides ($LiNi_{0.8}Co_{0.1}Mn_{0.1}O_2$, NCM) due to their high capacity. These materials, however, have poor cyclability and rate capability due to structural changes and side reactions on surfaces.



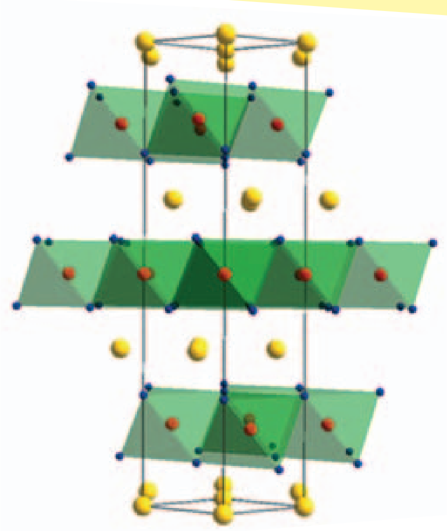
Uniform spherical Ni-Co-Mn carbonate particles before sintering to make Li-rich layered oxide

High-performance battery materials

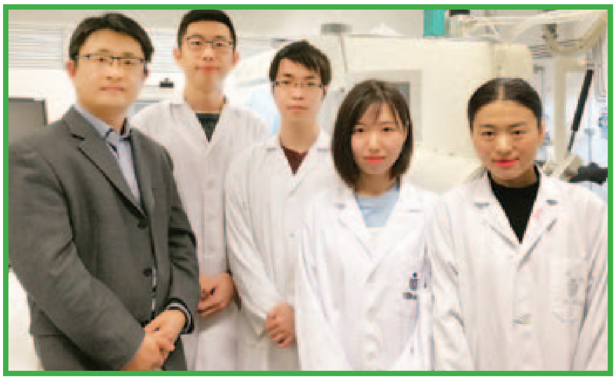
This project aims to synthesize spherical hierarchical microstructure LLO and NCM consisting of hundreds of primary nanostructures. The microsized spherical secondary particles can provide a high tap density resulting in a more compact electrode layer, which helps attain high volumetric energy and power densities. In addition, spherical assemblies can provide excellent structural stability and reduce side reactions of electrolytes, and thus guarantees better cycle performance. On the other hand, the nanosized primary particle provides a short diffusion length for Li ions and is key to enhancing electrochemical reaction kinetics and rate capability. LLO materials with spherical hierarchical microstructures are vital to achieve good electrochemical performance.

Besides morphology of active materials, this project will also try to develop a scalable surface coating method to improve the volumetric energy densities, rate capabilities and long-term cyclic stability of LLO and NCM battery materials. A thin (a few nm) carbon-based layer doped with heteroatoms will be coated on the pristine LLO and NCM particles. This carbon layer will reduce side reactions of electrolytes, improve electric conductivity and enhance stability of active materials.

This project is supported by several industrial partners including Hong Kong Fortune Green Engineering Technologies, Shenzhen BAK Battery, Guangzhou Great Power & Energy Technology, and Hangzhou LIAO Technology.



Crystal structure of layered oxides (yellow balls are Li)



Prof Minhua Shao and his research team

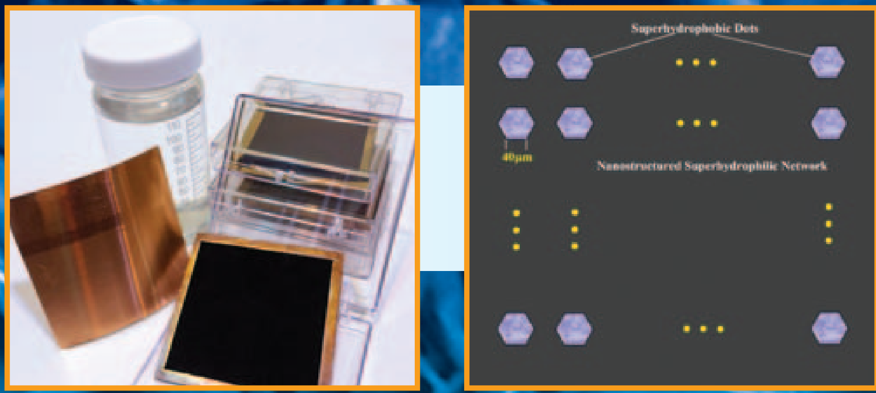
Ultrathin Flexible Heat Spreader for High Power Electronics

Prof Huihe Qiu
Professor of Mechanical and Aerospace Engineering

From left: Yingzhuan Yang, Research Assistant; Prof Huihe Qiu; Minghao He, PhD candidate (MAE)

A team led by Prof Huihe Qiu, Professor of Mechanical and Aerospace Engineering, has been awarded HK$2.88 million by the Innovation and Technology Fund (ITF) to develop an ultrathin, flexible heat spreader for thermal management of light-emitting diodes (LEDs), power electronics, flexible displays, smart phones, and more. To prolong the lifecycle and increase reliability of these devices, thermal management or heat removal has become increasingly important. It has become a crucial issue in the further development of high-power electronics, such as high power energy-efficient LEDs, ultrathin smartphones and flat display panels, lithium ion battery packs and notebook computers, due to the high operating current densities causing hot spots and heat dissipation. Furthermore, new-generation ultrathin flexible smartphones and display panels require flexible and thin heat spreaders for high efficient heat removal. The availability of flexible, low-cost, high-heat transfer coefficient and high critical heat flux technology could profoundly transform thermal management of those devices.

Previous studies show that phase change liquid cooling has great potential in providing heat removal solution, in comparison with the conventional air-cooling system. Phase change cooling technique is a promising technique to meet the requirements of high heat flux, high heat transfer coefficient, low noise and small scale. It has been known that surface characteristics have significant impact on heat transfer performance in phase change cooling technique. A superhydrophobic surface can significantly enhance the heat transfer coefficient (HTC), whereas liquid wetting on the surface will result in high critical heat flux (CHF) when a hydrophilic surface is used. Although HTC can be improved when the surface is superhydrophobic, all hydrophobic surfaces have a common problem: as the surface hydrophobicity increases, the bubble emission frequency decreases while the bubble departure diameter increases. As a result, the CHF will be reduced and will become easily dried out. This drawback has a significant effect on designing ultrathin flexible heat spreader because the working fluid is very limited in microspace.



Key components of ultrathin flexible heat spreader, chemical pattern schematics and nanostructured superhydrophilic surface

Novel design and technologies

The key technologies used in this project are based on the team's recent findings that utilize ultrathin biphilic multiscale chemically patterned micro/nano wick structures and hydrophobic/ superhydrophobic dots to control and optimize nucleation sites in a microscale. The nucleation site density and evaporation rate can be increased significantly. The biphilic chemical pattern design and micro/nano multiscale structure fabrication techniques are crucial to improve effective thermal conductivity of the ultrathin flexible heat spreader. Asymmetrical arrangement in micro/nano structure and chemical patterns will be used to manipulate capillary flows and optimize evaporation and condensation in order to achieve a very high HTC and high CTF in ultrathin flexible heat spreaders.

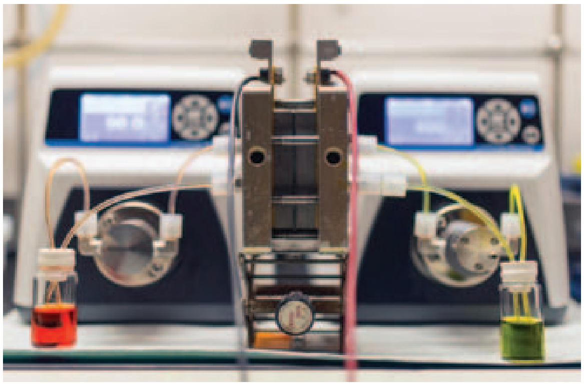
The total thickness of the ultrathin flexible heat spreader will be less than 200μm; its in-plane effective thermal conductivity will be larger than 1,600 W/(mK), which is about four times higher than that of a copper heat spreader. Its density will be less than 2.5 g/cm_3, which is less than the density of aluminum (2.7 g/cm_3). Due to very low material cost, the price of the flexible heat spreader will be extremely low.

Prof Qiu graduated from Tianjin University and received his PhD degree from Institute of Fluid Mechanics *(LSTM)* at the University of Erlangen, Germany in 1994. His research interests focused on fluid dynamics, heat transfer, microscale multiphase flow and bioinspired flights. Prof Qiu is Editor-in-Chief/Editor/Associate Editor of four international journals. Prof Qiu is the General Chair 10th International Symposium on Measurement Techniques for Multiphase Flow (2017), General Chair of Asian Symposium on Computational Heat Transfer and Fluid Flow (2013), Co-Chairman of 8th Asian Computational Fluid Dynamics Conference (2010), and Vice Chairman of 9th Asian Symposium of Visualization (2007). He is the recipient of the Best Paper Award of Institute of Physics (IOP) in 1994, Philips Outstanding Paper Award in the International Conference on Electronic Packaging Technology and High Density Packaging (2012), ASME Best Poster Award (2010), Best Paper Award, 2nd World Congress on Mechanical, Chemical, Material Engineering (2016), The State Scientific and Technological Progress Award (SSTPA) and the Scientific and Technological Achievement Award from the State Education Commission. In addition, Prof Qiu is dedicated to education and has been awarded twice the School of Engineering Teaching Award in 1996 and 2010 respectively.

Prof Qing Chen Joins MAE with Expertise in Energy Materials

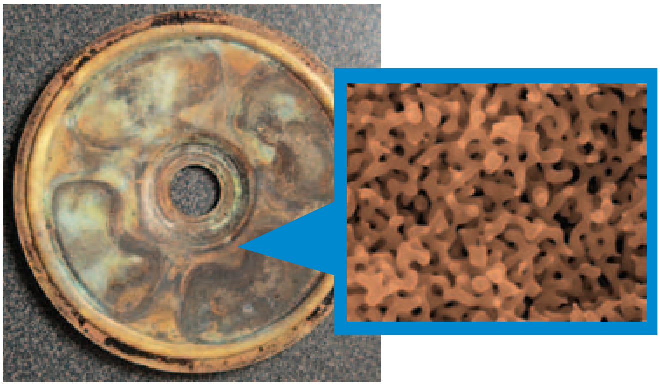
Prof Qing Chen
Assistant Professor of Mechanical and Aerospace Engineering

Prof Qing Chen joined HKUST in August 2016. He is primarily affiliated to the Department of Mechanical and Aerospace Engineering, while jointly appointed to the Department of Chemistry. Such a joint position manifests the multidisciplinary nature of his research concerning materials electrochemistry and energy storage. He currently conducts research in the Energy Central Research Lab as a core faculty member of the HKUST Energy Institute.



Organic redox flow battery

A lab-scale flow battery that stores energy in colorful electrolytes of active organic molecules. When scaled up for grid applications, the electrolytes will be much bigger than the cell so as to store energy for longer duration.



Nanoporous Metal by Dealloying

A dezincified brass is a dealloyed alloy that may contain nanometer size pores and metal ligaments. This type of intriguing nanostructures has excelled in many energy applications, including catalysis and energy storage.

Prof Chen (second from left) discussing with students in the lab

Nanoporous metal

Prof Chen currently divides his group's focus into two areas. The first one deals with nano-structure formation via selective dissolution, the best example of which is dealloying, i.e. the selective dissolution of alloys. A common phenomenon constantly occurring around us, dealloying is behind many detrimental corrosion and stress corrosion processes. Prof Chen's group is trying to turn this around, by applying the process in the fabrication of metallic foam of pores as small as a few nanometers. When such foam is made of noble metal like gold or silver, it stands out as a high-performance catalyst for reactions including oxygen reduction and carbon monoxide oxidation. When the foam comprises base metal like zinc or lead, a metal-battery can use it as an electrode of large specific area, high dimensional stability, high conductivity and short ionic diffusion distance. More importantly, Prof Chen's group is developing protocols based on abundant compounds instead of alloys to eliminate the costly and laborious step of alloy manufacturing. This will greatly simplify the fabrication of porous metal and pave the path towards more nanoporous materials.

Organic molecules for energy storage

The other research area of Prof Chen's group targets grid-scale energy storage. With the dropping cost of solar and wind energy, cost-effective energy storage has become the biggest technical obstacle on the path towards energy sustainability. Both solar and wind energy are intermittent and requires storage for hours of discharging when the sun is not shining and wind is not blowing. The key requirement in this type of energy storage is low cost, so that the renewable energy can compete with the dirt-cheap fossil fuels. Prof Chen's group believes that highly abundant organic molecules can be the solution. The team draws inspiration from nature, where redox-active molecules function as cofactors and promoters in biochemical processes. When tailored to the right molecular structures, they can dissolve in aqueous electrolytes to power redox flow batteries, a type of battery designed for long discharge duration at a fraction of the cost of lithium-ion batteries. The molecules can also crystalize to serve as intercalation electrodes of sodium ions in a saltwater battery. Combining organic synthesis with electrochemistry, Prof Chen's group aims to revamp batteries from the smallest scale possible for the diverse needs of future energy storage.

Prior to joining HKUST, Prof Chen was a postdoc at the John A. Paulson School of Engineering and Applied Science at Harvard University, after receiving his PhD in materials science from Arizona State University and his bachelor in polymer science from Zhejiang University. He was originally from Wenzhou in the Zhejiang province but he has yet shown any interest in starting his own business.

HKUST-Argonne Workshop Shedding Light on Energy Storage

THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

Argonne NATIONAL LABORATORY

HKUST Energy Institute and US' Argonne National Laboratory held a joint workshop on Energy Storage Systems at HKUST in January to kick-off collaborations. Renowned international speakers from Argonne and Stanford University joined hands with prominent local speakers to share research findings and explore collaboration potentials.

Energy shortage is one of the world's pressing issues. Renewable resources such as solar and wind energy, though being clean and eco-friendly alternatives to non-renewable energies, have problems of unpredictability and intermittency which hinder their widespread adoption. The Workshop is dedicated to the need for actionable and cost-effective solutions to energy storage for renewable energies.

The Argonne National Laboratory has been significantly contributing to energy innovations and construction of scientific disciplines, thriving on collaborations with universities, industry and other national laboratories.

The Joint HKUST-Argonne National Laboratory Workshop on Energy Storage Systems featured Argonne's Dr Khalil Amine giving an overview of the Lab and speaking on advanced high energy chemistries for automotive batteries. Prof Yi Cui from Stanford explored ways to revive lithium metal anode through materials design.

As a host of the workshop, HKUST's Tony F Chan, President, and Prof Tianshou Zhao, Director of HKUST Energy Institute, delivered welcoming remarks.

Speakers from Hong Kong included Prof Kwong-Yu Chan from the University of Hong Kong, Prof Haitao Huang from the Hong Kong Polytechnic University, Prof Yi-Chun Lu from the Chinese University of Hong Kong, Prof Kaili Zhang from the City University of Hong Kong, and Prof Guohua Chen, Prof Qing Chen and Prof Minhua Shao from HKUST.

Roundtable on Clean and Low Carbon Transport Solutions

Bioethanol as a Source of Clean Fuel

Whereas Hong Kong's public transportation network has the reputation of being one of the world's most connected and well-maintained systems, the local street-level pollution and smog from transport systems, especially from motor vehicles, has also been one of the major air quality challenges in Hong Kong. In response to the HKSAR government's efforts to reduce emissions, HKUST Energy Institute and HKU SPACE co-hosted the High Level Roundtable on Clean and Low Carbon Transport Solutions this February, sponsored by Scania, to explore clean and low carbon fuel for motor vehicles.

The Roundtable provided a great platform for stakeholders from government, institutions and industry to tackle the pollution issues, particularly street-level pollution in relation to diesel vehicles, trucks, buses and light buses, and to explore potential solutions. The Roundtable focused on the essentials for a truly clean and low carbon transport system; the future of bio-renewables, especially bioethanol, from business and environmental perspectives; and the development of sustainable transport systems for Hong Kong and mainland China.

Welcome remarks were given by Ms Anissa Wong, former Permanent Secretary for Environment, Prof Nora Tam from City University's Department of Biology and Chemistry, and Prof Tianshou Zhao, Director of HKUST Energy Institute.

Ms Helena Storm, Consul General of Sweden in Hong Kong, presented the case of sustainable public transport system in Sweden which Hong Kong may take as reference.

Professors, researchers, government officials and industry professionals went on to discuss the possibility of using bioethanol as an alternative fuel. Bioethanol not only can achieve up to 90% carbon reduction, but also attain effective road-side emission control in comparison to Euro VI diesel. The main sources used to produce bioethanol are crops that contain sugar and starch, such as sugar cane, corn, and sweet sorghum. Therefore, the use of bioethanol buses would become a promising technology trend due to the raising demand of a clean and low carbon transportation.

Representatives from HKUST included Prof Tianshou Zhao, Director of HKUST Energy Institute and Chair Professor of Mechanical and Aerospace Engineering (MAE), Prof Minhua Shao, Associate Director of HKUST Energy Institute and Associate Professor of Chemical and Biomolecular Engineering (CBME), Prof Christopher Chao, Head and Chair Professor of MAE, as well as Prof Li Shi Zhong who is the Energy Institute's Visiting Professor from Tsinghua University.

HKUST Co-hosts Energy and Environment Forums under 10-Thousand-Talent Program

Prof Joseph H W Lee, HKUST Vice-President, and Prof Wang Cheng, President of Lanzhou University delivered opening remarks

HKUST Energy Institute, dedicated to excellent energy research and education, advance learning and knowledge locally, regionally and internationally. In view of China's 10-Thousand-Talent Program under the Ministry of Education (MoE) which thrives on exchange of students and researchers of tertiary institutions in Macau and Hong Kong with Mainland China, HKUST joins hands with leading Mainland universities to facilitate knowledge creation, academic and research collaborations.

The University collaborated with Wuhan University and Lanzhou University in June and October last year respectively to co-host energy and environment forums and youth camps. They created precious collaborative platforms among professors, researchers and students.

The forums cum youth camps aimed to create synergy among Mainland and Hong Kong's academia as well as postgraduate students in energy and environmental engineering in anticipation of potential collaborations and R&D opportunities. Facilitating scholarly research, academic visits and practicum with a special focus on professional, technical and cultural exchange, they enabled the experts and students in innovation and education to engage in fruitful knowledge and insights sharing.

Wuhan and the Three Gorges

The HKUST-Wuhan University Joint Environment and Hydraulics Research Collaboration Workshop cum Innovation Youth Camp were held in Wuhan last October. Professors and young researchers from the two universities engaged in meaningful discussions on the theme of energy and environment, especially hydraulics, water ecological environment, urban air quality and climate change during the workshop on the first day, followed by a visit to Wuhan University's environmental laboratory.

Participants then engaged in a one-day technical visit to the Changjiang Water Resources Commission (CWRC), the Hubei and Wuhan Environment Monitoring Center and the Key Laboratory of Geotechnical Mechanics and Engineering of Ministry of Water Resources of China, followed by a two-day technical field trip to the Three Gorges. The field trip to the Three Gorges, where participants acquired first-hand understanding of the milestone project on the Yangtze River, brought the five-day exchange to a meaningful finale.

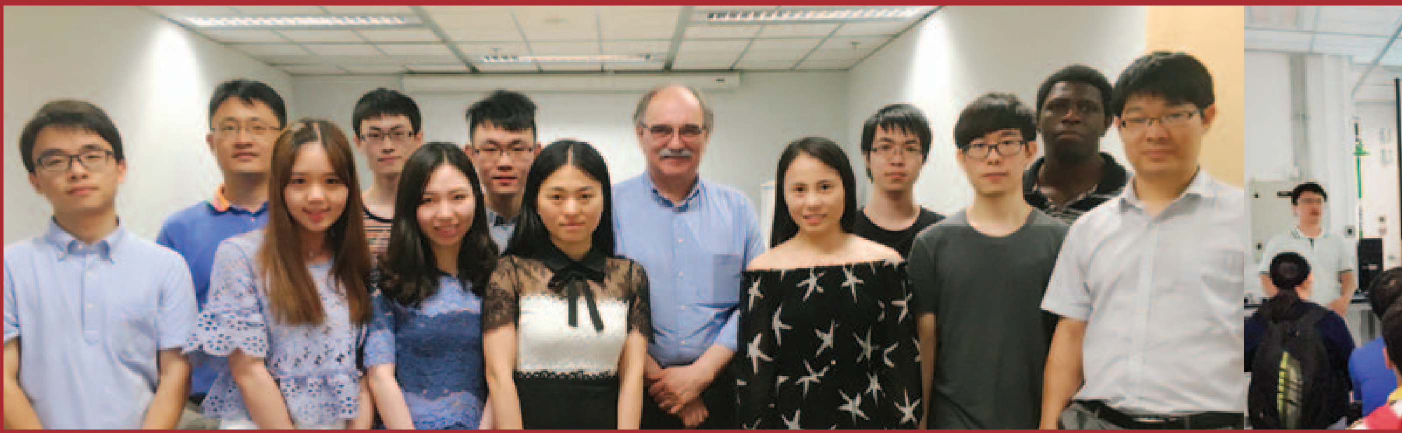
Lanzhou and the Silk Road

The HKUST-Lanzhou University Joint Energy and Environment Symposium cum Innovation Youth Camp were held in Lanzhou last June with the theme of energy and environmental technologies. The program consisted of one-and-a-half days of academic symposium, during which presentations on solar panel, air, purification, energy-efficient integrated circuits and environmental analysis etc were given.

During the subsequent one-and-a-half days of facility and technical visit, attendees visited the energy and environment laboratories and facilities of Lanzhou University which boasts two national state key laboratories, six MoE key laboratories as well as research centers under MoE and the National Natural Science Foundation of China (NSFC).

As a historical city on the Silk Road, Lanzhou has more to offer. Participants thus enjoyed a two-day cultural trip, visiting Dunhuang's world-renowned Buddhist remnants and the 600-year-old strategic pass and fortress of Jiayuguan to appreciate ancient China's bustling commercial and cultural activities as well as self-defense.

The in-depth academic, scientific and cultural activities have been successful in providing the academia and scientists with a comprehensive understanding of China's technological advancement and cultural heritage, as well as fostering collaborations among the experts in mainland China and Hong Kong.



Prof Scherson met with Student Chapter members

Electrochemical Society's First Student Chapter in Greater China Founded at HKUST

HKUST is pleased to have founded the first and only Student Chapter of the Electrochemical Society (ECS) in Greater China in June last year, and in so doing the University has joined the other 63 active ECS Student Chapters around the world to advance theory, practice, research and knowledge dissemination in the field.

ECS, a century-old international non-profit educational organization, has notable members including Intel co-founder Gordon Moore, the 'Father of Modern Electrochemistry' Allen Bard, and Esther Takeuchi who invented the battery for pacemakers.

The ECS HKUST Student Chapter, advised by Prof Minhua Shao, Associate Professor of Chemical and Biomolecular Engineering (CBME) and Associate Director of the HKUST Energy Institute (EI), and Prof Francesco Ciucci, Assistant Professor of Mechanical and Aerospace Engineering (MAE) and CBME, and chaired by PhD student Lulu Zhang (CBME), has members of postgraduate students from various departments including CBME, MAE and Electrical and Computer Engineering (ECE).

The Student Chapter was honored to have Prof Daniel A Scherson, ECS' immediate past President, to witness its establishment. Prof Scherson is the world-renowned electrochemist and Frank Hovorka Professor of Chemistry from the US' Case Western Reserve University. He received many prestigious awards including the IBM Faculty Development Award and the David C Grahame Award of the Physical Electrochemistry Division of ECS, just to name a few.

At the kick-off at HKUST, Prof Scherson gave a seminar about the oxidation dynamics of well-defined CO on Pt surfaces which attracted enthusiastic response from audiences. The Professor, specializing in linear and nonlinear spectroscopic and structural techniques for the *in situ* monitoring of interfacial electrochemical reactions, met student members and gave advice on research and career development in related fields.

Since its founding, the Student Chapter has organized many seminars for HKUST students as well as workshops for secondary school students.

The Student Chapter volunteered in several fuel cell vehicle workshops for secondary school students with Prof Minhua Shao's guidance

Students assembled the fuel cell vehicle, generate hydrogen and run the fuel cell by themselves in the Workshop

Prof Guohua Chen, former Department Head of CBME, was invited as the speaker at a lecture on communications skills for postgraduate students. Sharing personal experiences and citing examples from many of his previous lectures, Prof Chen elaborated on his insights on effective presentations. Highlighted tips included articulated pronunciations and projected voice accompanied by gestures and facial expressions, as well as preparation of concise slides with highlights, etc.

The Student Chapter also volunteered to organize several fuel cell vehicle workshops for secondary school students with Prof Minhua Shao's guidance, such as the Engineering Summer Camp, WISE Camp, JA Engineering Discovery Day, and the Academy for Bright Future Young Engineers.

The goal of these Workshops was to spark high-school students' enthusiasm in engineering, in the hope that they will pursue related studies in future. For example, one of these workshops introduced four technologies (fuel cell, electrolyzer, solar cell and battery) which play significant roles in renewable and clean energy systems. In the Workshop, battery and solar cell were used to power electrolyzer to spit water in order to generate hydrogen, which was then collected as fuel in a fuel cell to power a small vehicle. Students were requested to assemble fuel cell vehicle, generate hydrogen and run fuel cells on their own. Through these Workshops, they also learned about the importance of renewable energy technologies in environmental protection and sustainable development.

Looking forward, the Student Chapter plans to organize more activities including distinguished lectures, annual poster/seminar gatherings, workshops etc. It aims to become a main platform for social and idea exchange for all students in the fields of electrochemistry and electrochemical engineering.

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