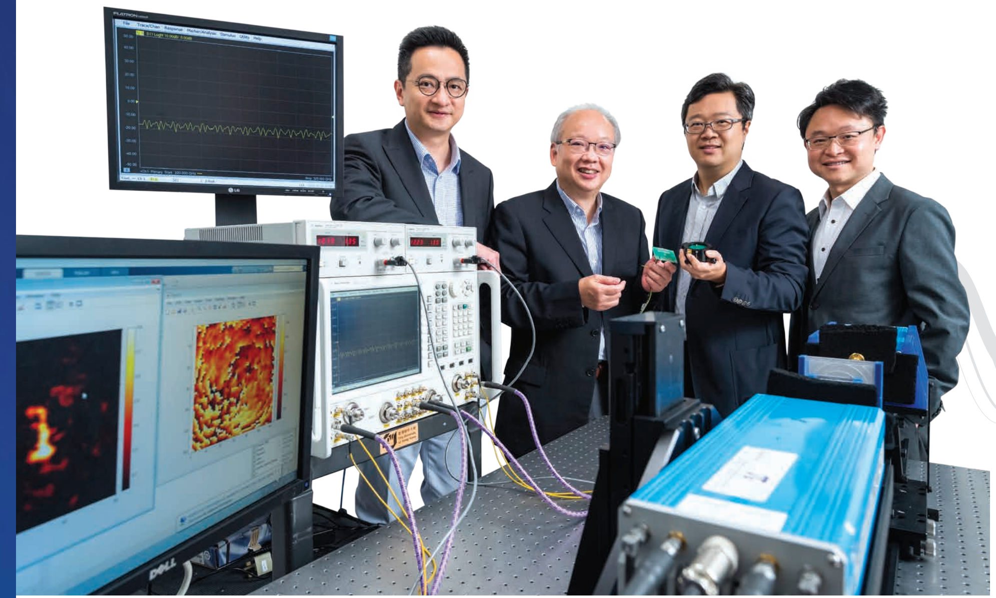
SMART CITY

Creating innovative solutions to address regional and global concerns, such as sustainable energy, climate change, environmental degradation, urban planning, government regulation and the law, through collaborative efforts among diverse disciplines and programmes.



(From left) Dr Steve Wong Hang, Professor Chan Chi-hou, Professor Johnny Ho Chung-yin, and Professor Kenneth Lo Kam-wing join hands to advance the development of terahertz (THz) technology.

Building a Compact System for Terahertz Technology and 6G Communications

With the arrival of fifth-generation (5G) wireless technology, which is set to provide massive, ultra-high speed connectivity in the next five to 10 years, the development of sixth-generation (6G) technology is already on its way. A team of multi-disciplinary experts, led by **Professor Chan Chi-hou**, Chair Professor in the Department of Electrical Engineering (EE) and Director of the State Key Laboratory of Terahertz and Millimeter Waves (SKLTMW) at CityU, has been working on advancing the development of terahertz (THz) technology for 6G communications, imaging and spectroscopy.

THz waves exist in the electro-magnetic spectrum between the conventional microwave and infrared regions. This is a broad frequency band with a wide range of applications. For example, THz technologies have been used to detect melamine in milk powder, antibiotics in food matrices, pesticides in vegetables, and foreign objects in drugs.

Developing highly-efficient THz sources

"However, the widespread application of THz technologies is hindered by bulky and expensive THz sources," said Professor Chan, who is leading a team of electronic engineers, materials scientists, biologists and chemists to work on the Theme-based Research Scheme project, whose aim is to develop high-power THz sources using integrated circuits and optoelectronic approaches, and exploring different applications of THz technology.

Professor Chan explained that THz radiation sources are usually generated in two ways: i) using integrated circuits (ICs) to generate up-conversion from the lower microwave frequency to THz radiation, and then transmit it via antennas; or ii) using the optoelectronic approach, which involves using materials science to generate down-conversion from the higher optical frequency. But both approaches face the same problem: the output power of the THz source is relatively low.

To enhance the radiation efficiency for both approaches, **Dr Steve Wong Hang**, Associate Professor in the EE Department, is developing high-performance antennas in the terahertz spectrum, while **Professor Johnny Ho Chung-yin**, in the Department of Materials Science and Engineering, is working with his team to synthesise high-quality nanowires to generate THz sources through down-conversion. "These nanowires have properties that are not found in the bulk size and exhibit good performance in enhancing the efficiency of converting visible light to THz," said Professor Ho. He is also synthesising high-quality monolayer graphene to explore its potential in generating THz radiation.

Active antennas for 6G communications

"With compact, low-cost THz sources available, we can apply them in different ways," said Professor Chan. "For instance, the antennas we developed can be used to generate THz and for 6G wireless communications."

Earlier, the International Telecommunication Union announced the frequency range for future 6G wireless communications, which exactly matches Dr Wong's research focus – developing antennas for a frequency range of 0.2 to 0.5 THz. After years of fundamental research by Dr Wong and the SKLTMW team, they are now developing a new technology of programmable antennas using functional materials, which can enable beam-forming techniques.

"With functional materials, we can manipulate the properties of the generated waves, and control the beam formation and beam direction of THz waves. This means the direction of the beams emitted can be changed according to need. To put it simply, an active antenna system on a mobile device enables beam-searching and beam-forming technology, eliminating poor connection problems," explained Dr Wong. "This can greatly enhance communications quality and will be of great demand in the age of high-speed, high-volume 6G wireless communications."

Spectroscopy and imaging for cancer drug development

The team is also exploring THz applications in spectroscopy and imaging for addressing health-related issues. "Many studies have shown that the absorption of THz radiation by cancer and normal tissues is different. So we are interested in finding out how we can apply THz in cancer studies," said **Professor Kenneth Lo Kam-wing**, in the Department of Chemistry, who is also one of the members of the multi-disciplinary team.

In particular, he is investigating whether THz imaging can reveal the cancerous parts of tissues more precisely and the changes of the tumour cells for drug testing; and whether THz can be used as a spectroscopic tool for tracing compounds inside tissues for cancer drug development, as a supplemental approach to fluorescent biological probes to stain tissues.

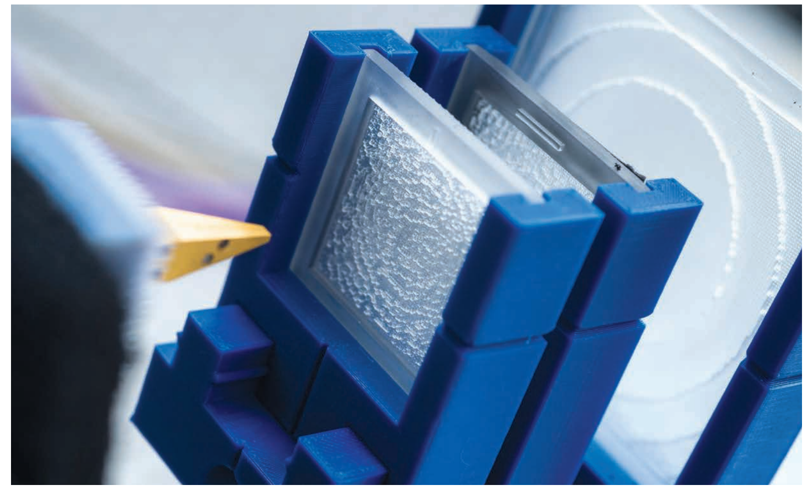
"We hope our project will improve the performance of the THz system and generate more new research ideas by integrating the input from experts from different disciplines, thus achieving wider benefits for society," said Professor Chan.

Major Awards

- **Professor Chan Chi-hou**
  - IEEE Antennas and Propagation Society Harrington-Mittra Computational Electromagnetics Award, 2019
  - Distinguished Alumni Award, Department of Electrical and Computer Engineering, University of Illinois at Urbana-Champaign, 2019
- **Professor Kenneth Lo Kam-wing**
  - Croucher Senior Research Fellowship 2015
- **Professor Johnny Ho Chung-yin**
  - RGC Research Fellow 2020
  - The President's Award 2020, CityU

Key Projects

- Theme-based Research Scheme: A Compact System for Terahertz Imaging and Spectroscopy
- Collaborative Research Fund: High-Resolution Antenna Measurement System with Robotic Arms for Millimeter-wave Frequencies

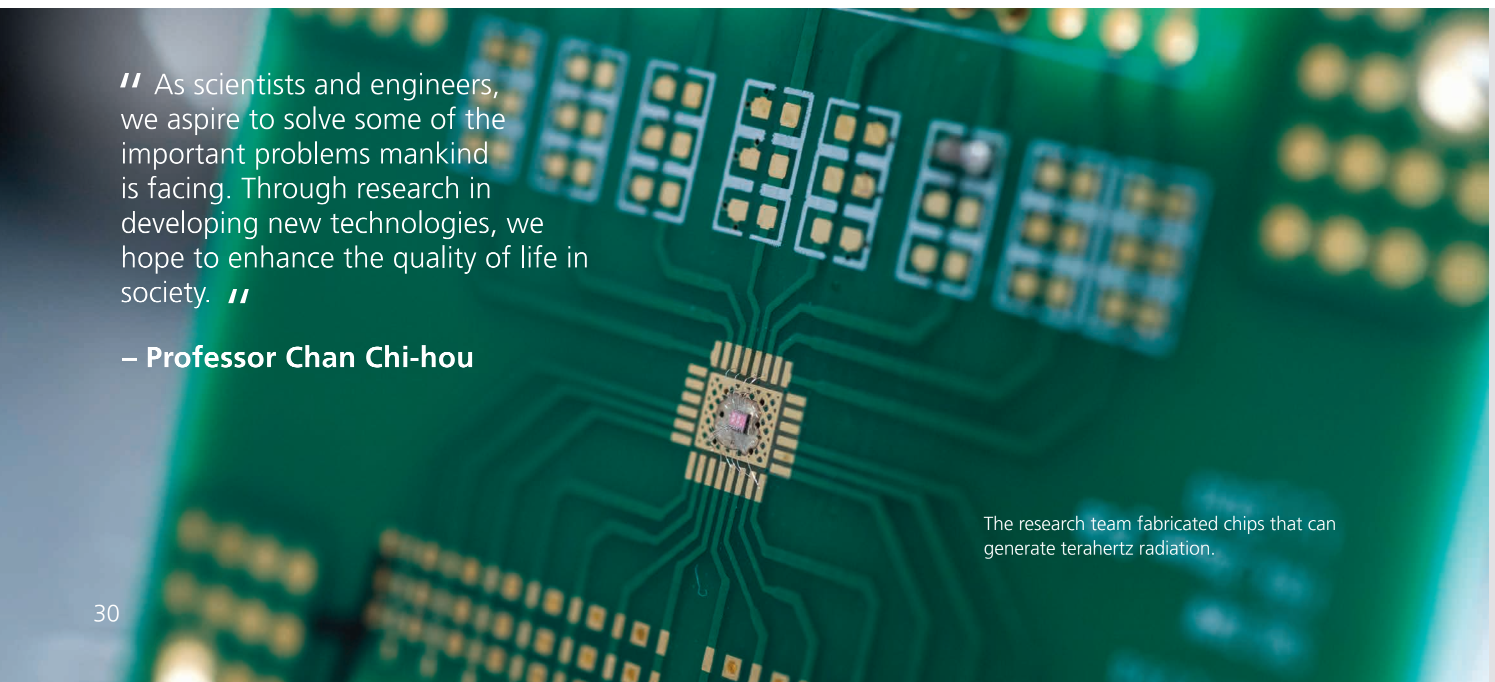


Antenna measurement system developed by the team.

Integrating an antenna measurement system on their own

Performance characterisations of antennas for different application scenarios are essential for exploiting the benefits of the THz frequency band. However, the SKLTMW team has found that there are no antenna measurement facilities for higher millimetre and THz wave bands that meet their needs available in the market. "Therefore, we are trying to build a high-resolution antenna measurement system for millimetre and THz research on our own with bought components to support research and development activities in both academia and industry," said Dr Wong, who is the Project Coordinator of an equipment grant project supported by the Collaborative Research Fund (CRF).

In collaboration with a team from the University of Hong Kong, they will build a world-class antenna measurement facility that can conduct near-field and far-field radiation measurements through the help of robotic arms. "We hope the new facility will drive high-frequency electronic development to a new level of excellence and promote more collaboration with other institutes in southern China, with CityU playing a leading role, contributing to Hong Kong's role as an international hub for innovation," said Dr Wong.



"As scientists and engineers, we aspire to solve some of the important problems mankind is facing. Through research in developing new technologies, we hope to enhance the quality of life in society."

– Professor Chan Chi-hou

The research team fabricated chips that can generate terahertz radiation.

Selected Publications & Patents

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- **Lo, K.K.-W.** 2020, "Molecular design of bioorthogonal probes and imaging reagents derived from photofunctional transition metal complexes", *Accounts of Chemical Research*, vol. 53, no. 1, pp. 32-44.
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- Yip, A.M.-H. & **Lo, K.K.-W.** 2018, "Luminescent rhenium(I), ruthenium(II), and iridium(III) polypyridine complexes containing a poly(ethylene glycol) pendant or bioorthogonal reaction group as biological probes and photocytotoxic agents", *Coordination Chemistry Reviews*, vol. 361, pp. 138-163.
- Zhou, H., Shum, K.M. & **Chan, C.H.**, "A wide locking range injection locked frequency tripler based on a dual-band voltage controlled oscillator", US Patent 16/931,790, filed 2020.
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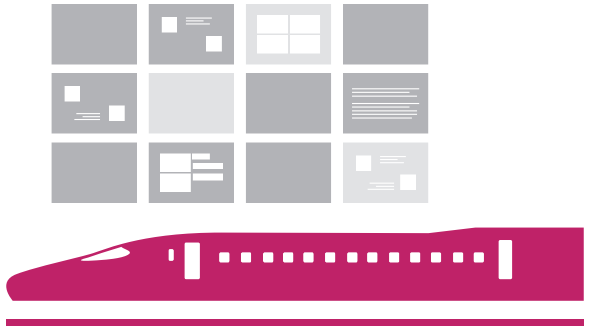
Data-driven Management for Safe and Reliable Railway Systems



As high-speed rail and metro systems are rapidly developing in speed and complexity in many cities and regions, identifying effective ways to ensure their safe, reliable and efficient operation has become more pertinent. A multi-disciplinary research project, led by CityU, has developed a platform of tools to improve safety and reliability in railway system health monitoring, crowd safety and disruption management.

"As with other large-scale technologies, there have been major accidents around the world related to high-speed rail and metro systems. These systems require continual improvement in condition monitoring, safety and reliability engineering, operation and maintenance, and decision systems to prevent accidents," said **Professor Tsui Kwok-leung**, Chair Professor of Industrial Engineering and Adjunct Professor in the School of Data Science at CityU. He was the former project coordinator of the five-year Theme-based Research Scheme (TRS) project, with team members from CityU and other local and overseas institutions. The aim of the project was to innovate and advance rail system technologies to ensure safety, avoid and managing disruptions, and ensure operational efficiency.

"We are striving to fill at least two unique niches in high-speed rail and metro systems research," said **Professor Xie Min**, Chair Professor in the School of Data Science and Department of Systems Engineering and Engineering Management (SEEM) at CityU, who is the current coordinator of the TRS project. "One is to develop new knowledge in self-cognisant fault detection and prognostics and health management of railway systems by synergising prominent sensor-based data management technologies and sophisticated modelling expertise. Another is to allow dynamic train deployment in response to abrupt events, accidents or disruptions using real-time transportation network data."

Sensor-based monitoring of suspension systems

One of their key studies is the design of a novel domain-knowledge-guided data-driven framework to monitor and predict the health status of high-speed rail suspension systems by measuring real-time train vibration signals from sensors installed in multiple locations. "Suspension systems play a major role in high speed railways. The failure of springs and dampers may lead to accelerated wear of wheels and rails. Suspension damage may even increase derailment risk," said **Dr Li Lishuai**, Assistant Professor in SEEM, who led the study.

Existing methods rely mainly on sophisticated dynamic models or simulations that require precise suspension and inertial parameter values. They are difficult to use in different rail systems, and the results can be distorted if the parameter values are inaccurate.

To overcome these limitations, the team proposed a model that can be trained quickly and adapted easily to different rail systems. It includes a feature extraction method, based on a simple dynamics model, to select the relevant information in the multi-location vibration data. Also, it introduces a novel way to generate training datasets via a simple dynamic model and impact analysis.

Having evaluated and tested the proposed method with 10 months of tracking data in a railway system operating in mainland China, as well as simulation data from different laboratories, the team found that it performed well. While more field tests are needed to prove its effectiveness and reliability, Dr Li believes the proposed method will be implemented in parallel with existing tools in the near future.

Analysing alighting and boarding behaviour

Applying an agent-based computer simulation model, **Professor Lo Siu-ming**, in the Department of Architecture and Civil Engineering, and his team conducted a study on passengers' alighting and boarding movements in metro stations and the effects of passengers' non-compliant behaviour. Different alighting and boarding rules in different passenger volume conditions were recommended to increase alighting and boarding efficiency.

Riding on the achievements of the TRS project, Professor Tsui said that several research projects with industry and university collaborators from Hong Kong, Taiwan and mainland China are ongoing, including establishing an escalator health condition analytics model, monitoring the wear of high-speed train wheels based on wheel profile data and multi-location vibration data, passenger flow forecasting for disruption management, traffic scheduling, and maintenance planning.

The research team expects the leading-edge technologies developed to not only contribute to safety and revenue management for inter- and intra-city rail systems, but also serve as a prototype that can be transferred to other complex network systems, such as shipping, air traffic, electricity transmission, health care systems, supply chain management, internet connectivity and finance.

Professor Tsui Kwok-leung (front row, centre), Professor Xie Min (back row, second from right), Professor Lo Siu-ming (back row, first from left) and other CityU team members.

Key Projects

- Theme-based Research Scheme: Safety, Reliability, and Disruption Management of High Speed Rail and Metro Systems
- Research Impact Fund: Enhancing Safety, Punctuality and Ride Comfort of Railway Transportation: From Local Metro System to Global High-speed Rail Network
- National Natural Science Foundation of China (NSFC): Evaluation Models of Railway Emergency Plan Considering the Prioritization and Synergy of Action Alternatives

Selected Publications

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- Li, Z., Lo, S.M., Ma, J. & **Luo, X.W.** 2020, "A study on passengers' alighting and boarding process at metro platform by computer simulation", *Transportation Research Part A: Policy and Practice*, vol. 132, pp. 840-854.
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Professor Michael Leung Kwok-hi

Turning Waste Heat from Air-conditioners into Electricity

As the world gets hotter, the use of air-conditioners is bound to increase. But powering air-conditioning (AC) units requires energy, and the cooling process ejects heat into the surroundings, which has an adverse impact on the environment. To achieve energy-efficient cool air supply, **Professor Michael Leung Kwok-hi**, Shun Hing Education and Charity Fund Professor of Energy and Environment, is developing a novel technology which efficiently converts the waste heat from AC systems into useful electricity.

"AC is often the largest energy consumer in urban cities, and demand will continue to grow because of the global urbanisation trend," said Professor Leung, who is also the Director of the Ability R&D Energy Research Centre at CityU. "AC systems produce an enormous amount of waste energy in the form of heat and wind, resulting in the ineffective utilisation of energy resources."

Recycling the waste heat into power is nothing new. But Professor Leung explained that the commonly used Organic Rankine Cycle (ORC) technology can work only with heat at temperatures of 200°C or above, so it cannot be applied to the heat from AC systems, which is usually 50°C to 80°C. Also, fouling contamination commonly found in AC systems results in poor indoor air quality and indirectly increases energy consumption, he added.

Recycling energy from low-temperature waste heat

Therefore, Professor Leung is developing a new generation of AC systems to recover the thermal energy from low-temperature waste heat and convert it into electricity, which can then be used by the AC unit itself, or for lighting or other electrical appliances.

The new system features the integration of thermoscience and nanotechnology, namely thermal nano technologies (TNT), to achieve high energy efficiency and clean air supply. Modelling and experimental results have shown that this TNT solution can raise the coefficient of performance (COP) of an AC system and reduce energy use up to 20%.

Professor Leung introduced that the TNT solution, which involves a number of key technologies, described as follows:

i) **Ultra-low-temperature integrated organic Rankine cycle**
The thermodynamics of the ORC is highly feasible for the recovery of low-temperature waste heat to generate kinetic energy. A novel refrigeration cycle, based on the integration of ORC into the conventional AC cycle, maximises the overall energy efficiency of the system.

ii) **Direct thermal-charging cell**
A thermo-electrochemical capacitor, made of graphene oxide based electrodes, can store thermal energy in the form of electricity. The mechanism features low-temperature heat-to-electricity conversion.

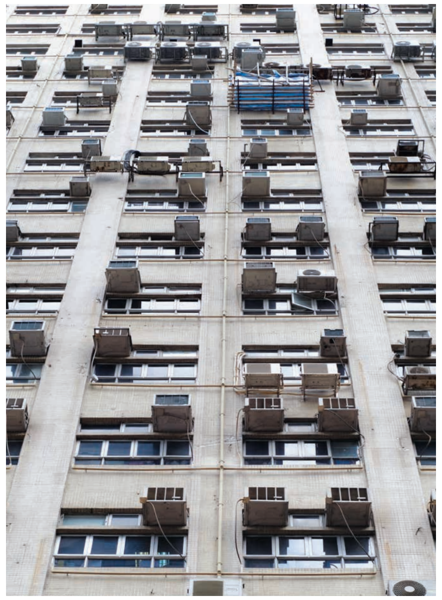
iii) **Waste-heat-recovery adsorption cooling system**
Innovative metal-organic framework (MOF) adsorbent materials have been developed for a modified adsorption cooling system. The application involves recovering the heat rejected by the AC system for an additional cooling effect.

iv) **Nanostructured biphilic heat exchanger**
A nanostructured biphilic surface is composed of superhydrophobic substrate and hydrophilic sites. As water vapour cools and condenses onto the biphilic surface, jumping droplets occur, resulting in enhanced heat transfer. This technology is applied to improve low-temperature heat recovery.

v) **Forward-backward-swept vertical-axis wind turbine**
For air-cooled condensers, cooling towers and exhaust air fans, the air leaving the unit at high speed is a form of waste energy. Vertical-axis wind turbines built with specially designed forward-backward-swept blades effectively capture this wind and use it to generate electricity.

The five technologies can be applied separately or they can be integrated for a synergistic effect. Professor Leung and his team are working to push the practical efficiency towards the theoretical maximum value.

"In addition to the increase in energy efficiency, the benefits include reduced greenhouse gas emissions and the reduction of unwanted waste heat rejection," said Professor Leung. "The revolutionary technological breakthrough anticipated in this project has the potential to not only contribute to enhanced sustainability, but also generate many new business opportunities worldwide."



The advanced TNT solutions can convert the low-temperature waste heat from AC units into electricity and reduce the energy use of an AC system.

Major Awards

- Shun Hing Education and Charity Fund Professorship in Energy and Environment
- Highly Cited Researcher (Engineering), Clarivate, 2018

Key Projects

- General Research Fund: Rational Design of MoS_2 Electrocatalyst for pH-universal Hydrogen Evolution: Mechanisms, Kinetics and Optimization
- Innovation and Technology Fund:
  - Integrated System of Advanced Thermal Nano Technologies (TNT) for Energy-Efficient Air-Conditioning and Clean Indoor Air: Part 1 - Energy Efficiency
  - High-efficacy, Environmental- And Eco-friendly Nano-photocatalytic Marine Antifouling Paint

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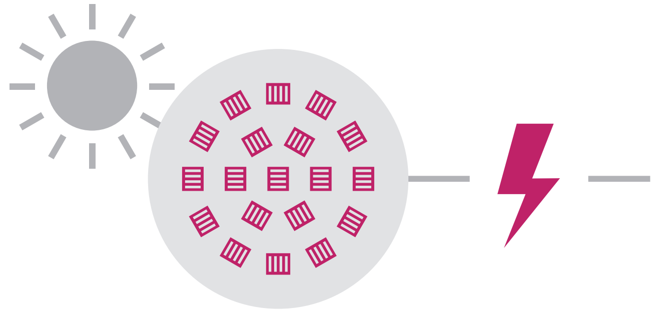
More Stable and Environmentally Friendly Solar Cells



Solar energy is the fastest-growing electricity source. But the commonly used silicon-based solar cells are close to their theoretical maximum efficiency and cost-reduction limit. At CityU, **Professor Alex Jen Kwan-yue**, Lee Shau Kee Chair Professor of Materials Science, has been working on developing more stable and environmental friendly perovskite and organic solar cells, which are believed to offer more promising and diverse applications to replace silicon as the future of photovoltaic technology.

Hybrid perovskites are a class of new materials that display many exciting properties, such as remarkable efficiency in absorbing light and converting it into electric currents in photovoltaic solar cells. They have become a buzzword in the field of solar cells.

Printable solar cells

As a leading expert and highly cited scholar in the field of perovskite and solar cell research, Professor Jen pointed out that research on perovskite solar cells started just about a decade ago, but their power conversion efficiency has greatly improved from 3.8% to 25.5%, rivalling that of their silicon-based counterparts, which were developed more than 50 years ago.

Perovskites are efficient and can be made via low cost solution processing. They can be made inexpensively from solutions. "Like the ink used in newspaper printing, the solution can be 'printed' on plastic films as flexible solar cells, or it can be coated on a window, looking like tinted glass but generating power," said Professor Jen. "The application potential is huge."

But the problems of instability and potential environmental impact of perovskite solar cells have yet to be overcome. One of the main concerns is the potential environmental contamination from the lead-containing component of perovskites. "As solar cells age, the lead component can potentially leak from the cells and leach into the soil through rainwater, for example," he explained.

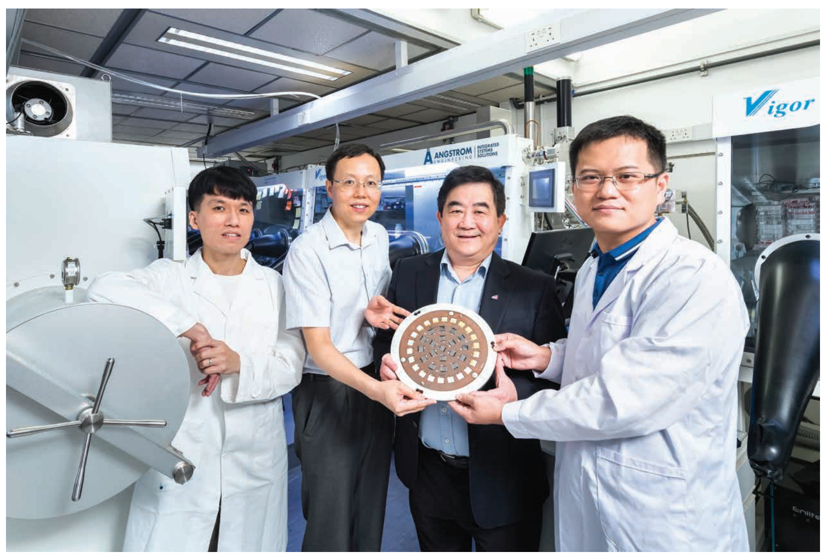
Together with **Professor Xu Zhengtao** and **Dr Zhu Zonglong**, from the Department of Chemistry, Professor Jen led the team to overcome these challenges by applying two-dimensional (2D) metal-organic frameworks (MOFs) to perovskite solar cells.

Protective layer mitigates lead leakage

The MOF layer is a multi-functional honeycomb-like structure. It has semiconducting properties and can "capture" heavy metal ions to form water-insoluble complexes, mitigating lead leakage. It can also act as a protective layer against moisture and oxygen, while maintaining high efficiency. Both the power conversion efficiency (over 22%) and the open-circuit voltage recorded were among the highest values reported for planar inverted perovskite solar cells.

Moreover, the MOF layer provides superior long-term operational stability. The device retains 92% of its initial efficiency after operating for 1,000 hours under continuous light irradiation at 85°C, meeting the commercialisation standard set by the International Electrotechnical Commission (IEC).

"Our findings offer an integrated solution to address both the stability and environmental issues, the two main hurdles before large-scale applications of perovskite solar cells," said Professor Jen. The team is working to further enhance the power conversion efficiency and explore ways to lower the production cost.



Key members of the research team: (from left) Dr Wu Shengfan, postdoc fellow, Professor Xu Zhengtao, Professor Alex Jen Kwan-yue, and Dr Zhu Zonglong.

Highest efficiency organic solar cell

Professor Jen and Dr Zhu have also designed various organic, inorganic and hybrid materials for applications in different types of solar cells and photonic devices. In September 2020, their organic solar cell, developed in collaboration with the University of Washington, was recognised by the National Renewable Energy Laboratory (NREL) in the US, a benchmark testing lab in the renewable energy research field, in its "Best Research-Cell Efficiency Chart". Its power conversion efficiency of 17.5%, certified by NREL, was the highest among organic solar cells at that time.

Though the power conversion efficiency of organic solar cells is not as high as that of perovskite solar cells, Professor Jen pointed out that the production process for organic solar cells is even more environmentally friendly and consumes less energy than that for perovskite solar cells. The semi-transparent organic solar cells can also be applied to building-integrated photovoltaics, the glass roof panels of greenhouses and other buildings, enabling power self-sufficiency. And the foldable flexibility of organic solar cells definitely has huge potential for applications in new-generation wearable electronic devices.

"Solar energy is no longer limited to bulky and hard panels on rooftops," said Professor Jen. "These new materials can be installed everywhere, from coatings on buildings and windows to mobile devices and even clothing, composing an integrated system of sustainable energy."

The perovskite solar cells developed by CityU team.

Major Awards

- Highly Cited Researcher (Materials Science), Clarivate, 2014-2020
- Top 10 Researchers in Perovskite Solar Cell Research, Times Higher Education, 2018
- World's Most Influential Scientific Minds (Materials Science), Thomson Reuters, 2015 & 2016
- Fellow, European Academy of Sciences and Washington State Academy of Sciences
- Fellow, American Association for the Advancement of Science

Key Projects

- Collaborative Research Fund: Developing Non-fullerene Organic Solar Cells with Small Photovoltage Loss
- Innovation and Technology Fund:
  - Rational Design of Efficient and Stable Transporting Materials for High Efficiency Metal Halide Perovskite Solar Cells and Large-Scale Fabrication
  - Development of Highly Efficient Perovskite/Polymer Hybrid Solar Cells

Selected Publications & Patent

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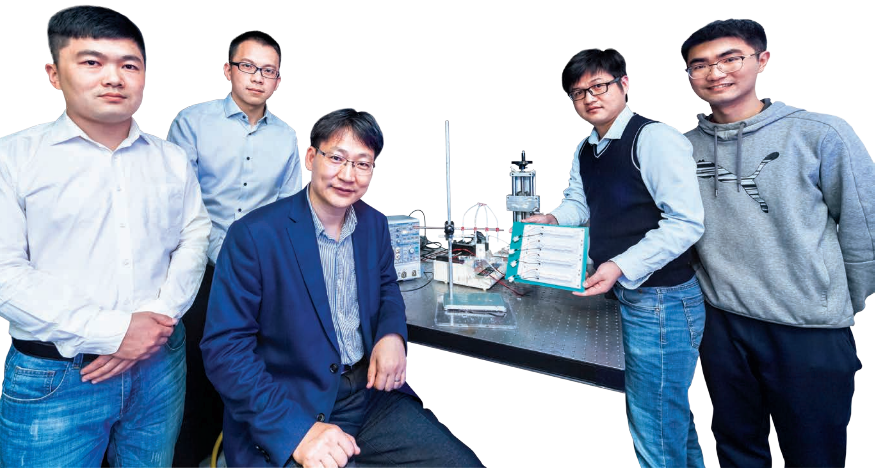
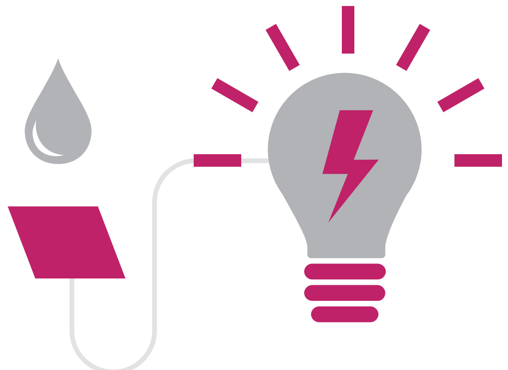


Professor Wang Zuankai (centre) and his CityU team: (from left) Zheng Huanxi, Xu Wanghuai, Dr Zhang Chao and Song Yuxin.



Harvesting Water Droplets for Sustainable Energy

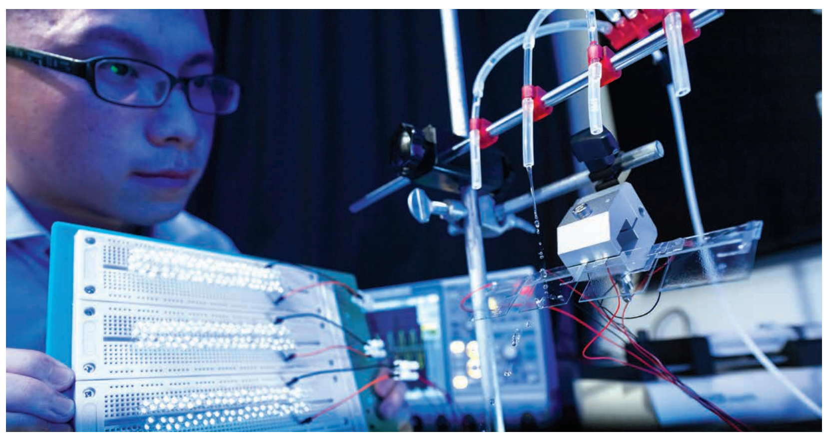
Energy needs have skyrocketed in the past two centuries or more. The main energy sources, fossil fuels, are not only polluting, but also finite. Developing sustainable energy sources has long been a key global challenge. **Professor Wang Zuankai**, Associate Dean (Internationalisation and Industry Engagement) in the College of Engineering and Professor in the Department of Mechanical Engineering, has achieved research breakthroughs in efficiently converting the kinetic energy in water droplets into electrical energy, advancing research in water-based energy harvesting.

"Harvesting water energy can help solve the global problem of renewable energy shortage," said Professor Wang. "Although droplets are small and ordinary, their power and impact can be large and far-reaching if we can efficiently harvest the kinetic energy from falling droplets." His distinguished research on water energy harvesting earned him the 2020 Xplorer Prize presented by the Tencent Foundation.

Droplet-based electricity generator with transistor-like structure

The conventional droplet-based electricity generator (DEG) is based on the triboelectric effect – a type of contact electrification in which two materials, a droplet and a surface, contact and separate. However, the electrical energy generated through it is limited to the amount of charges generated on the surface. Hence, the energy conversion efficiency is relatively low.

To enhance the energy conversion efficiency of the DEG, Professor Wang proposed a design similar to a field effect transistor, which includes two electrodes, one of which is deposited with polytetrafluoroethylene (PTFE), an electret material with a quasi-permanent electric charge. When the water droplets continuously hit the PTFE surface, the surface charges generated accumulate and gradually reach saturation. This helps to overcome the bottleneck of low charge density encountered in conventional generators.



With the new droplet-based electricity generator, a drop of water can generate a voltage of over 140V, lighting up 100 small LED bulbs.

A drop of water could light up 100 LED bulbs

More importantly, the two electrodes play a role similar to that of a field effect transistor. When a water droplet hits and spreads on the surface, it "bridges" the aluminium electrode and the PTFE/indium tin oxide (ITO) electrode, forming a closed-loop circuit. All the stored charges on the PTFE are then fully released and generate an electric current. This phenomenon contributes to the remarkably high instantaneous power density and energy conversion efficiency.

In collaboration with **Professor Zeng Xiao Cheng**, from the University of Nebraska-Lincoln, and **Professor Wang Zhong Lin**, Founding Director and Chief Scientist at the Beijing Institute of Nanoenergy and Nanosystems of the Chinese Academy of Sciences, the DEG developed by Professor Wang showed instantaneous power density of up to 50.1 W/m^2 in experiments, thousands of times higher than that of similar devices without the FET-like design. In their experiments, a drop of 100 microlitres of water released from a height of 15 cm generated a voltage of over 140V, which could light up 100 small LED light bulbs. Their DEG findings were published in *Nature* in 2020.

A specialist in nature-inspired engineering

In his research, Professor Wang loves to get inspiration from nature, which has all the characteristics that scientists and engineers dream of including in their technologies: it is adaptive, dynamic, multi-functional, energy efficient and interconnected.

One breakthrough piece of research conducted by Professor Wang and his team relating to nature-inspired engineering involves shaping drops of liquid in such a way that they can shed from a surface faster, thus creating super dry surfaces. Potential applications include preventing ice from forming on metal surfaces, like aircraft wings and engines.

In another inspiration from nature, Professor Wang worked together with **Dr Shen Yajing** from the Department of Biomedical Engineering to develop a tiny, soft robot with caterpillar-like legs, which is capable of carrying heavy loads and adaptable to adverse environments, and can be used for the accurate delivery of drugs into the human body.

"Through billion years of evolution, nature has developed extraordinary principles, which are characterised by green energy and resilience, such as how lotus leaves repel water and how certain beetles in the desert gain access to water. We can always look to principles in nature for inspiration in developing technologies," said Professor Wang. "It will never disappoint us."

Major Awards

- Xplorer Prize, Tencent Foundation, 2020
- Fellow of International Society of Bionic Engineering, 2019
- World Cultural Council Special Recognition, 2018
- Chang Jiang Chair Professor, Ministry of Education, China, 2017
- Outstanding Research Award 2017, CityU
- The President's Award 2016 & 2017, CityU

Key Projects

- Collaborative Research Fund: Bio-inspired Surface Engineering for Phase Change Heat Transfer: From Fundamental Understanding to Practical Applications
- General Research Fund: Developing Transistor-like Water Energy Generator with High Peak Power Density and High Durability
- Innovation and Technology Fund: Developing Liquid Diode Based Medical Tube

Selected Publications & Patents

- Xu, W., Zheng, H., Liu, Y., Zhou, X., Zhang, C., Song, Y., Deng, X., Leung, M., Yang, Z., Xu, R.X., Wang, Z.L., Zeng, X.C. & **Wang, Z.** 2020, "A droplet-based electricity generator with high instantaneous power density", *Nature*, vol. 578, no. 7795, pp. 392-396.
- Wang, D., Sun, Q., Hokkanen, M.J., Zhang, C., Lin, F.-Y., Liu, Q., Zhu, S.-P., Zhou, T., Chang, Q., He, B., Zhou, Q., Chen, L., **Wang, Z.**, Ras, R.H.A. & Deng, X. 2020, "Design of robust superhydrophobic surfaces", *Nature*, vol. 582, no. 7810, pp. 55-59.
- Feng, S., Delannoy, J., Malod, A., Zheng, H., Quéré, D. & **Wang, Z.** 2020, "Tip-induced flipping of droplets on Janus pillars: From local reconfiguration to global transport", *Science Advances*, vol. 6, no. 28.
- Li, J., Hou, Y., Liu, Y., Hao, C., Li, M., Chaudhury, M.K., Yao, S. & **Wang, Z.** 2016, "Directional transport of high-temperature Janus droplets mediated by structural topography", *Nature Physics*, vol. 12, no. 6, pp. 606-612.
- Liu, Y., Moevius, L., Xu, X., Qian, T., Yeomans, J.M. & **Wang, Z.** 2014, "Pancake bouncing on superhydrophobic surfaces", *Nature Physics*, vol. 10, no. 7, pp. 515-519.
- **Wang, Z.**, Jiang, M. & Wang, Y., "Highly effective heat dissipation architecture even on the ultrahigh temperature of more than 1000 celsius", US patent 63/072,995, filed 2020.
- **Wang, Z.**, Zhou, X. & Li, J., "Unidirectional liquid transport systems and methods of manufacture thereof", US patent US10,590,967, granted 2020.
- **Wang, Z.** & Liu, Y., "Superhydrophobic surface arrangement, article comprising same, and method of manufacture thereof", US patent 16/233,325, filed 2018.