



The Hong Kong Polytechnic University (PolyU), a university with the vision to excel in professional education, applied research and partnership for the betterment of Hong Kong, the nation and the world, with strong establishments on Chinese mainland and significant impact in internationalization.

Innovation and Technology Development Office (ITDO) serves to nurture platforms to boost high-impact research in collaboration locally and internationally with universities, industry and government. Our research strength includes healthcare, safety, aviation, aerospace, transportation, sustainable development, etc.

## Contribute strategic value to the national technology development

The approval of two Hong Kong Branches of Chinese National Engineering Research Centers (CNERC) and two Partner State Key Laboratories manifests recognition of the PolyU Research & Development capability of research teams and provides a high-level platform to strengthen the collaboration between the Mainland China and Hong Kong.



## At the forefront of safeguarding social welfare

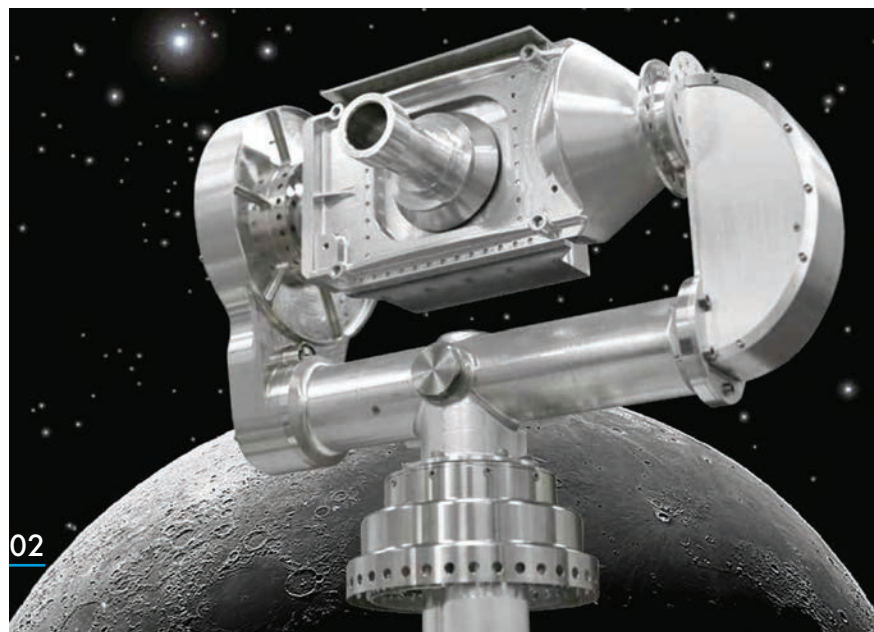
PolyU joins hands together with academic, government and industry for the cross-sector research platform. We discover Hong Kong's first anti-cancer drug granted with US FDA Investigational New Drug (IND); another US FDA granted drug is permitted to support cancer patients with all-oral chemotherapy regimen for cancer treatment. We also coordinate with different departments by initiating Food Safety Consortium, establishing research institute of sustainable urban development, as well as jointly established the respiratory virus research foundation, and Institute of Translational medicine, so as to benefit the whole community.



## Push the frontiers of major research and development initiatives with knowledge transfer potential

PolyU established an interdisciplinary research team to study the use of optical fibre and ultrasonic wave sensing technologies for monitoring the structural health and safety of the nation's fast-expanding high-speed rail, while expertise in precision engineering for space applications has been utilized

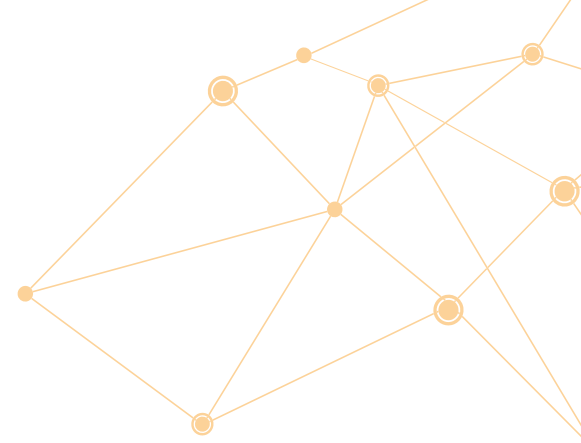
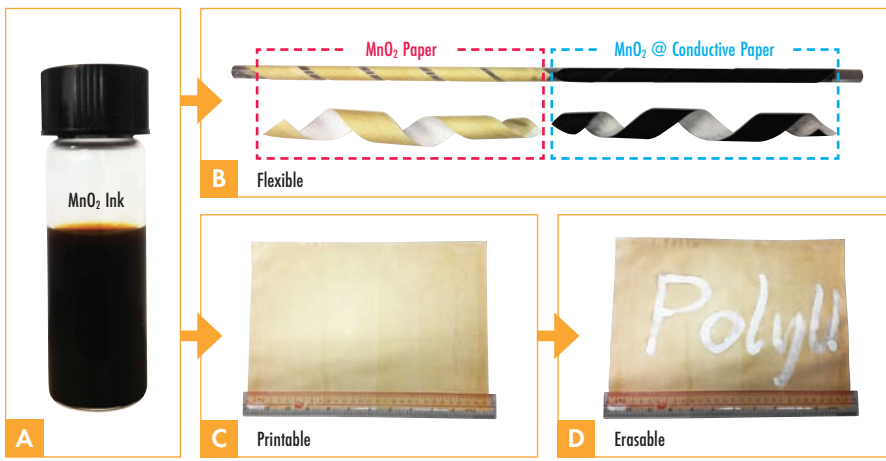
in China's lunar exploration programme. PolyU and The Boeing Company also jointly established Hong Kong's first Aviation Services Research Centre, deepening the University's commitment to the rapidly growing aviation industry.



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## Innovative Intellectual Property Management

PolyU highly values the protection of knowledge creation and breakthrough scientific researches by our staff members and students. With the establishment of the Intellectual Property Assessment Committee (IPAC) and the implementation of an Intellectual Property (IP) web-based system, we have significantly enhanced the University's IP management process. These enhancements are first of its kind among Hong Kong's higher education institutions, which contribute to our continuous strive to improve our IP management process.

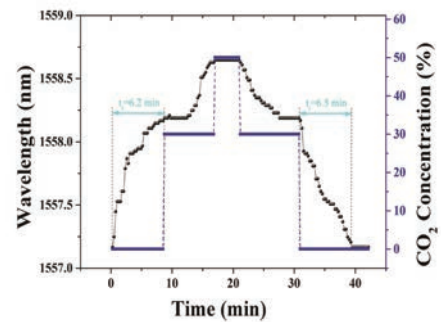


## High Performance Printable Energy Storage Devices

The conventional  $MnO_2$  electrodes are mainly prepared by two approaches: 1) nanostructured  $MnO_2$  or  $MnO_2$ -containing composite precipitates via wet chemical process; 2) direct electrodeposition or chemical deposition on various substrates (e.g. glass, quartz, copper or aluminum foil). These existing preparation methods suffer from higher cost, complicated processes and superfluous contaminations. On the other hand, during the coating process, the introduction of insulating binders would cause agglomeration in the inks, leading to the reduction of electrical conductivity.

By now, it still remains a great challenge to synthesize  $MnO_2$  inks with high reliability and versatility. Hence, the development of environmental-benign aqueous  $MnO_2$  inks is desirable for high-efficient and large-scale printable processes. Performance tests of inorganic  $MnO_2$  ink. (A) Optical picture of the  $MnO_2$  ink. (B)  $MnO_2$  ink coated flexible paper strips with (right) and without (left) MCNTs treatment. (C) A sheet of A4-sized paper coated by the  $MnO_2$  ink. (D) The  $MnO_2$  coated paper shown in C erased by oxalic acid with the erased area showing the word "PolyU".

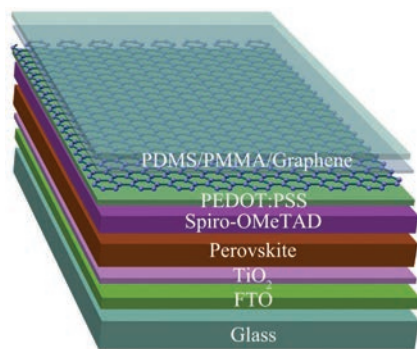
## Optical Fiber-Top Microcavity $CO_2$ Sensor



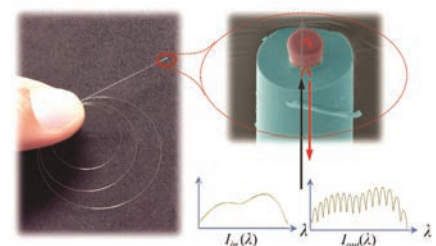
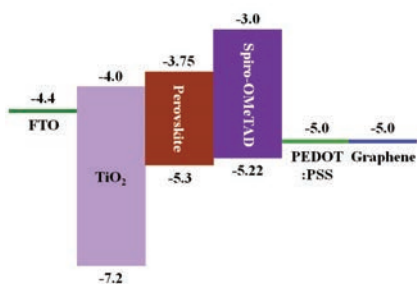
A new type of fiber-optic  $CO_2$  sensor based on a polymer Fabry-Pérot (FP) cavity fabricated on the end face of a standard single-mode optical fiber has been developed. A photo-crosslinkable poly (ionic liquid) (PIL) with strong  $CO_2$  adsorption ability was synthesized and then printed on the top of optical fiber by using an home-built in-situ optical printing technology to form an FP cavity for  $CO_2$  sensing. Experimental results show such a miniature fiber-optic sensor has wide detection range and relatively fast response time for  $CO_2$  detection.

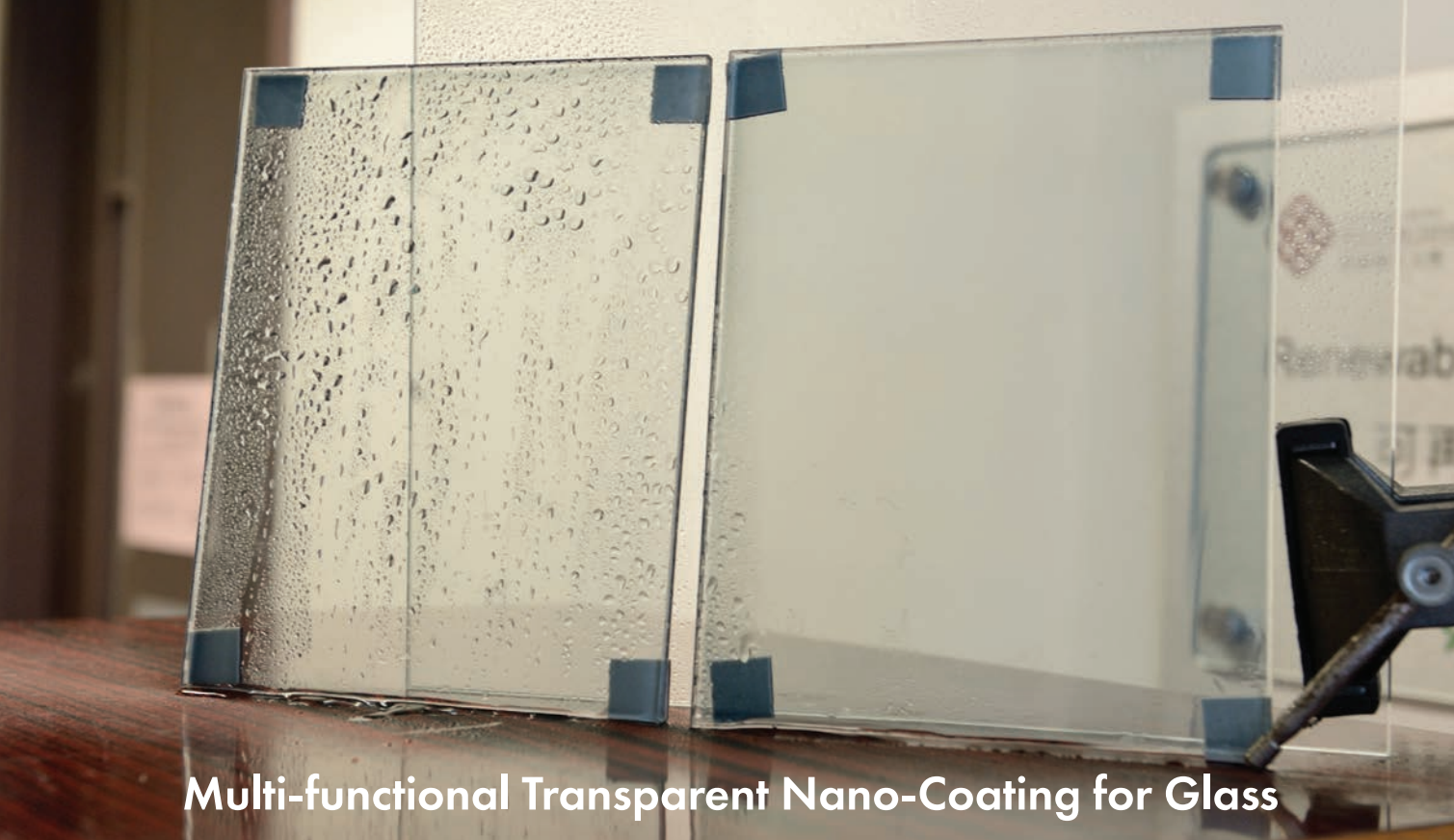
The result of a cycling test for characterization of the dynamic response of the fiber-optic  $CO_2$  microsensor shows that the response time of the  $CO_2$  microsensor is around 6.5 minutes, which is much faster than that previously reported PIL  $CO_2$  sensor (which is about 30 minutes). The fast response time of the  $CO_2$  microsensor is attributed to its small size achieved by optical microfabrication process.

## High Efficient Semitransparent Perovskite Solar Cells



Developing transparent or semitransparent solar cells with high efficiency and low cost has become increasingly important due to the increasing demands of the building integrated photovoltaics (BIPVs) systems. An efficient and low-cost semitransparent perovskite solar cells with graphene electrodes have been successfully developed. The power conversion efficiencies (PCEs) of this novel invention are around 12% when they are illuminated from fluorine-doped tin oxide (FTO) bottom electrodes or the graphene top electrodes, compared with 7% of conventional semitransparent solar cells. In addition, the semitransparent feature enables it to absorb light from both sides, and can be widely used in windows, facades, louvers and rooftops of buildings for converting solar energy into electricity, thus increasing the surface area for collecting solar energy substantially.





## Multi-functional Transparent Nano-Coating for Glass

A novel long-term glass multi-functional layer is developed by uniform coating nanoscale  $\text{TiO}_2$  and Antimony doped tin oxide (ATO) mixture particles as the main material on various glasses. The  $\text{TiO}_2$  nano-particles are synthesized by low-cost hydrothermal method while the ATO by high-temperature calcination technique.

This coating is featured by super-hydrophilic self-cleaning property, thermal insulation

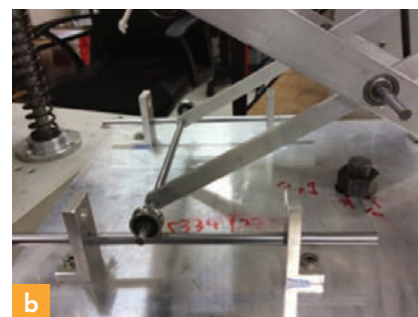
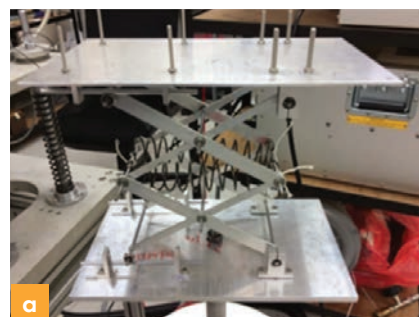
property and photocatalysis property. With contact angle of less than  $5^\circ$ , the coating can block over 70% IR/90% UV light but transmits more than 70% of visible light. It can also break down organic pollutants.

The innovation proposes a special formula from which water could be used as the dispersion medium of the precursor that could realize the good effect of no harm to human beings.



## High Performance X-shaped Passive Control Anti-vibration Structure

The X-shaped bio-inspired structures are novel designs of passive vibration isolation systems by using only linear spring and damping components to achieve superior nonlinear vibration isolation. The technology provides excellent passive quasi-zero stiffness of high loading capacity, and nonlinear high damping at resonant frequencies but low at others, without unstable nonlinear equilibrium. The structure can provide flexible and adjustable stiffness up to zero and adjustable nonlinear damping characteristic. The stiffness is decreasing with the increase of compression or extension of the structure, different from existing spring systems which have higher stiffness subject to more compression or extension. The technology is easy to implement and flexible in usage of low cost. The systems can be with n-layers of X-shaped

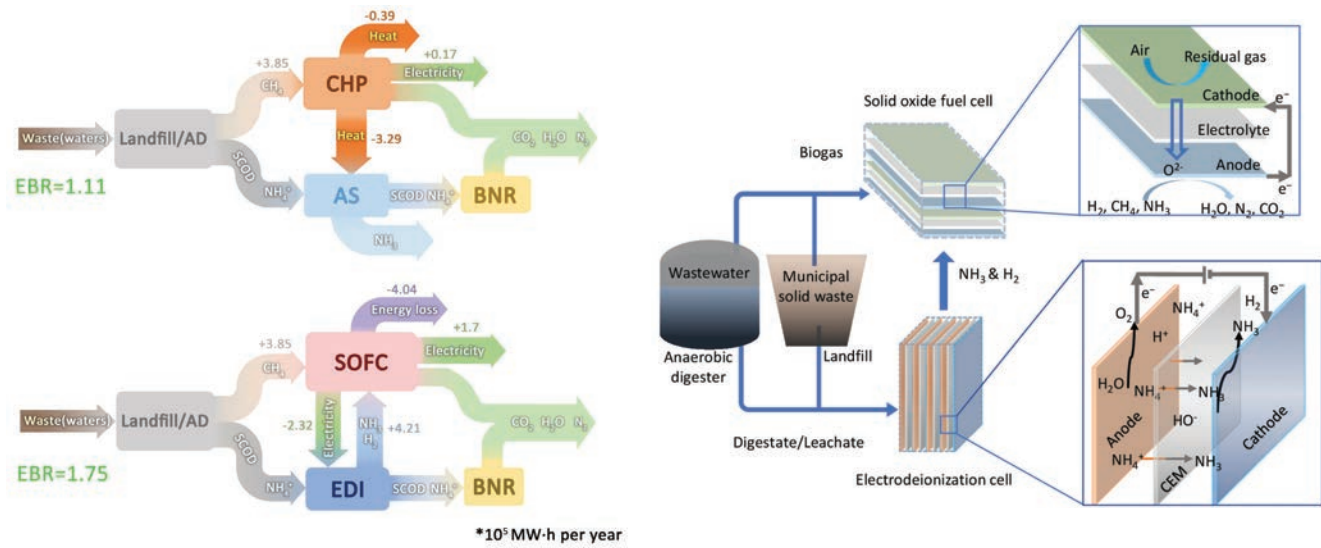


A prototype of the SLS platform: the prototype (a) and rollers in a horizontal track and bearings in rotational joints assembled in the system (b).

structures to suit different applications, such as leg/joint design of robots, limb-like structured suspension for mobile robots with track, protection of high-precision machinery, space launch and on-orbit applications.



# Sustainable Waste-water Derived Energy Generation System



The development of wastewater-derived energy system (EDI-SOFC) is feasible to fit into existing anaerobic treatment plants. The optimization of the system and its net energy balance assessment with different strength of wastewaters. The present groups AD, EDI and SOFC to convert energy in organics and nitrogen pollutants to electric energy. In this invention, the microorganism community of AD process

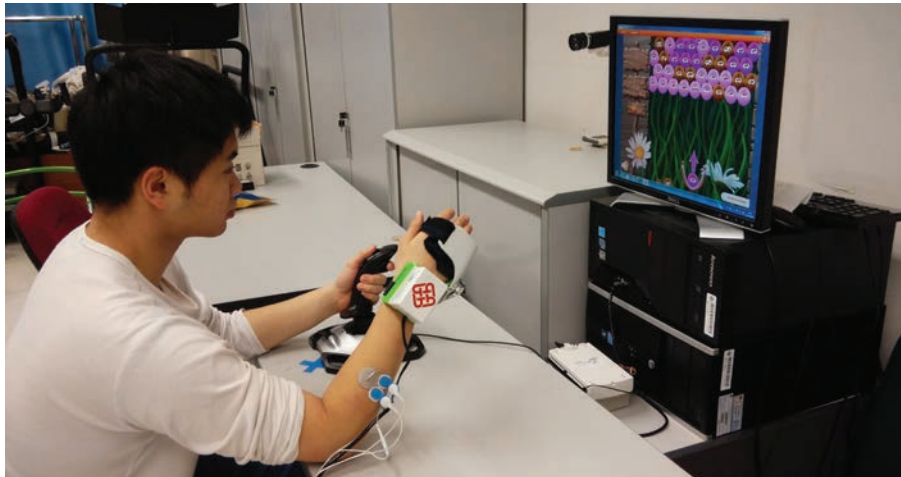
metabolizes complicated organics to biogas and digestate containing NH<sub>4</sub><sup>+</sup>. Biogas collected and NH<sub>3</sub> gas converted into NH<sub>4</sub><sup>+</sup> collected yield electricity. O<sub>2</sub> is not a need for NH<sub>4</sub><sup>+</sup> removal from wastewater input for aeration of the nitrification and denitrification, but also produces less sludge yield. The effluent of EDI cathode recycles to AD and neutralizes H<sup>+</sup>, which can prevent

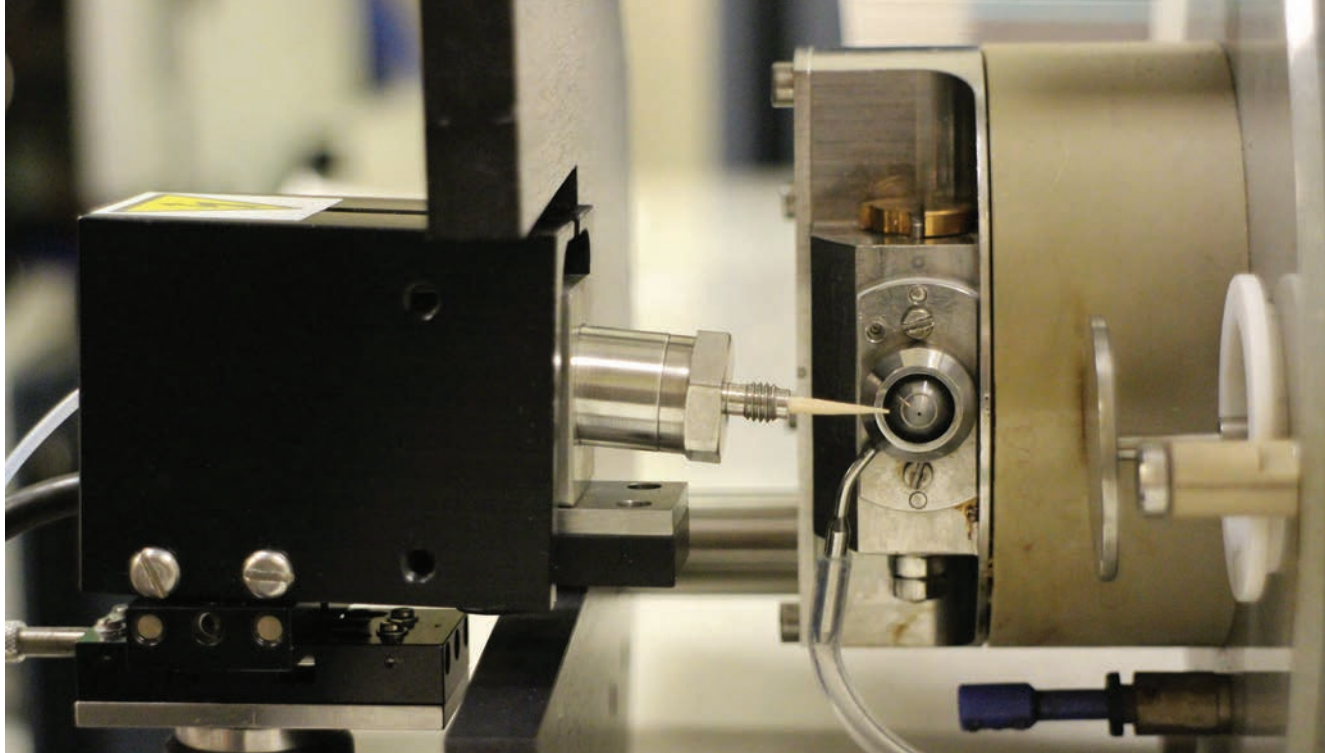
from the inhibition of low pH and increase biogas yield. Conservative 50% electricity conversion efficiency can be obtained by SOFC fed with a mixed gas of biogas and NH<sub>3</sub>-H<sub>2</sub> and 20% higher electricity conversion efficiency than 30% of gas fired turbine. This invention can help handling landfill leachate, digestate, wastewaters, sludge and positively net energy output can be realized.

## Voluntary Intention Driven Hybrid FES-robotic Exoskeleton

An electromyography (EMG)-driven electromechanical robotic exoskeleton integrated with functional electrical stimulation (FES) was developed for multi-joint upper limb rehabilitation after stroke. This hybrid system successfully combines the advantages of EMG-driven robot and FES and can achieve much more prominent recovery than using either technology alone in pilot clinical trials.

The treatment effects achieved by the technology is more effective than the traditional training by human therapist on subjects with subacute stroke, and the recovery progress is much faster than the traditional robotic training. The new system is a wearable, portable and comfort-to-wear exoskeleton, not only can be used in hospitals and clinics, but also suitable for home-based rehabilitation.



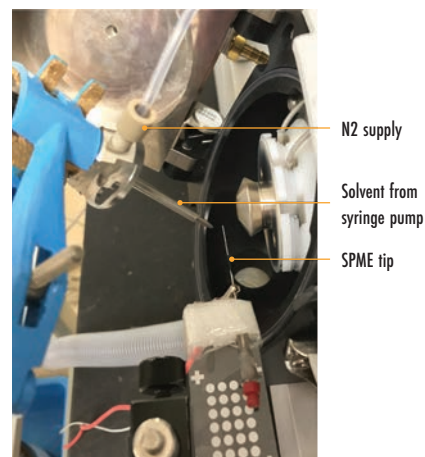


## Rapid Detection of Drug-abuse by Mass Spectrometry

Conventional drug analysis typically involves preliminary screening, followed by confirmatory analysis. However, the preliminary screening has the problem of producing false positive or false negative results, while the confirmatory analysis is time-consuming and laborious.

To solve these problems, two techniques have been developed, i.e., wooden-tip electrospray ionization mass spectrometry (WT-ESI-MS)

and solid phase microextraction coupled with electrospray ionization mass spectrometry (SPEM-ESI-MS), for rapid and reliable detection of drugs-of-abuse. WT-ESI-MS allowed detection of common drugs-of-abuse in urine and oral fluid with analysis of one sample within minutes, while SPME-ESI-MS allowed detection of drugs-of-abuse in urine and oral fluid with higher sensitivity within reasonable time.



## Rapid Authentication of Edible Oils by MALDI-MS Technology



Target pre-deposited with matrix



Direct oil sample loading

Authentication of edible oils has been an important issue in food safety. A direct analysis of edible oils using matrix-assisted laser desorption/ionization mass spectrometry (MALDI-MS) have been developed and a preliminary spectral database of edible oils have been established. Since different types of edible oils have different MALDI-MS spectral patterns, the authenticity of an edible oil sample can be determined by comparing its MALDI-MS spectrum with those of its labeled oil in the established database.

Compared to conventional techniques for analysis of edible oils, using MALDI-MS is much faster which allows direct analysis of edible oils, without the need of sample extraction, derivatization, sample cleanup and separation. It takes only several minutes for the technique to analyze one edible oil sample which can greatly reduce cost. The technique can be used by the industry to authenticate edible oils and screen out mixed edible oils and recycled edible oils.



MALDI\_MS analysis

# High Performance Video Quality Denoising by Deep Learning

The deep learning based video denoising method without motion estimation. We first stack the patches at the same spatial location across adjacent frames as a patch group, and learn a patch group prior model from a set of clean training videos. The patch group prior exploits the local temporal redundancy of video to remove noise. A deep convolutional neural network is

learned to exploit video spatial redundancy, as well as global temporal redundancy of video. The proposed algorithm exhibits better visual quality as well as quantitative measure than state-of-the-art video denoising methods and can be largely accelerated with GPU, provides a powerful tool for practical video denoising.

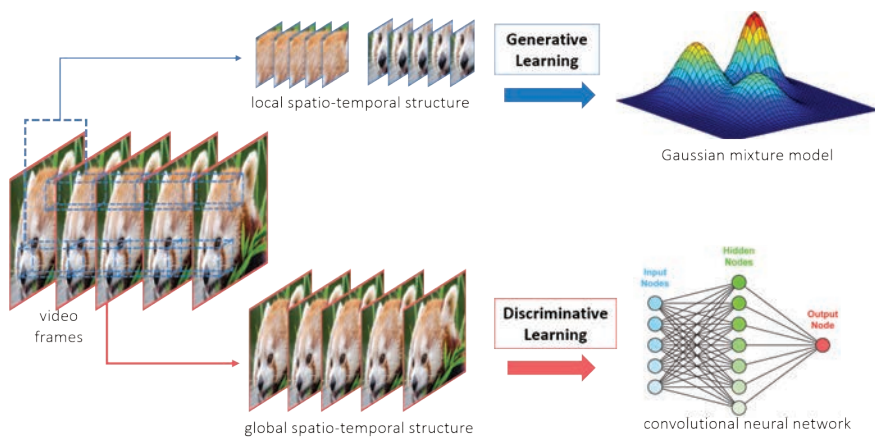


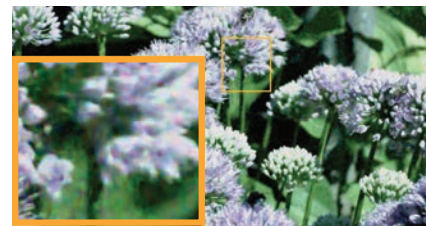
Fig.1 Our video denoising framework



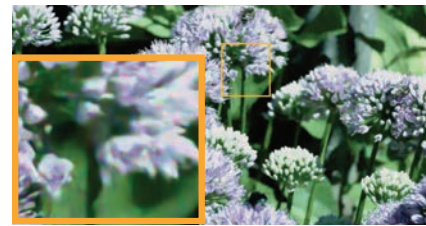
Clean video frame



Noisy video frame



Denoised video frame by VBM4D



Denoised video frame by our method

# Personalized Thermal-Comfort Platform for Smart Building

Heating, ventilation and air-conditioning (HVAC) system accounts for more than half of building energy consumption and leads to huge energy wastes. A Scalable Personalized Thermal-comfort (SPET) platform, which includes standardized data schema and SDK with adapters to harvest data of smart hardware and proactively guide building automation systems temperature setting services, analytic framework that optimize thermal comfort and energy conservation and visualization software package to show the thermal comfort of buildings, has been developed to quantitatively estimate the thermal comfort of any individual occupants or groups in daily operations. The research results have shown a preliminary version of the model can save energy for 18%

and improve thermal comfort for 33.8%. SPET can benefit three industry sectors: 1) smart energy systems for buildings and homes; 2) provides new meanings of data to smart personal devices and smart hardware; and 3) provides top up services for building automation and services.



System Deployment Experience





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