Department of Mechanical Engineering
香港城市大學
City University of Hong Kong

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MNE Newsletter

Welcome from the Department Head

Our very first issue

Prof. PAN Chin
Department Head and CLP Power Chair Professor of Nuclear Engineering

Welcome to our very first issue of the MNE newsletter. On behalf of the department, I extend a warm welcome and thank you for choosing to stay abreast of our developments.

The departmental vision is "To be the best to educate the best." We are proud that two Global STEM Professors funded by the UGC, Prof. HIBIKI Takashi and Prof. LEE Tu-Chung, have joined us as chair professors in June 2021 and June 2022, respectively.

In this issue, we also share with you some of our exciting achievements, including publications in the prestigious journal ***Nature***, winning a Gold Medal with Congratulations of the Jury at the Inventions Geneva Evaluation Days (IGED) 2022, and awards of up to HK$ 1 million from the CityU HK Tech 300 Angel Fund secured by three startups (co-)founded by our faculty members, alumni and students.

IN THIS ISSUE

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People Stories

HKSAR Global STEM Professorship Scheme

Prof. HIBIKI Takashi

Prof. LEE Tu-Chung

We are pleased to introduce two of our outstanding professors, Prof. HIBIKI Takashi and Prof. LEE Tu-Chung, who have been working with us under the prestigious Global STEM Professorship Scheme.

Initiated by the HKSAR government, this scheme is aimed at attracting internationally renowned Innovation & Technology (I & T) researchers and their teams to work in Hong Kong by providing university resources and funding. For long-term impact, the scheme also aims to build up universities' capacities to commercialise their research, enabling universities to apply their newfound knowledge to spark I & T development in Hong Kong.

Prof. HIBIKI Takashi

Chair Professor

Thermal-Fluid Engineering

- Two-Phase Flow & Boiling Heat Transfer
- Reactor Thermal Hydraulics
- Computational Fluid Dynamics

> Students are a professor's legacy. Their success is my success. Technology transfer from senior professors to students and junior scientists is indispensable for sustainable research activity.

Prof. HIBIKI Takashi is an internationally renowned scholar in interdisciplinary two-phase flow research, which provides essential technology for various industries. He is among the best international scientists in two-phase flow theoretical modelling research. According to metrics compiled by Stanford University, Prof. HIBIKI is listed among the top 2% of the world's most highly cited scientists.

Prof. HIBIKI has developed more than 100 constitutive equations, including those for unsolved technical problems, for over 20 years. His equations, derived through innovative thinking, have significantly improved the accuracy and robustness of computational fluid dynamics coding. Thanks to his outstanding contributions to relevant research, Prof. HIBIKI has received eighteen academic awards from six academic societies and two educational awards from Purdue University. His worldwide network is immense and includes presidents and vice presidents of several top universities and executive officers of companies.

Prof. HIBIKI is also a passionate educator. His unique education philosophy has produced several junior faculties in top universities worldwide. Prof. HIBIKI further demonstrated his leadership capability through the successful foundation of the Mitsubishi Centre of Thermal-Hydraulics at Purdue University.

Prof. HIBIKI took early retirement from Purdue University in 2018, with the honorary title of Professor Emeritus, to pursue his long-term dreams. Currently, Prof. HIBIKI is devoting his time voluntarily to pursuing a mission to transfer his knowledge and experience by helping undergraduate and graduate students and junior faculties across Asia.

His outstanding educational, administrative and research track records are consistent with the objectives of the Global STEM Professorship Scheme. Moreover, Prof. HIBIKI has a passionate mind for advancing research and fostering younger generations. He is perhaps a unique professor in Hong Kong in that with his extensive academic network in Japan; he works as an ambassador to connect HK universities with their counterparts in Japan. The MNE department is unreservedly proud to have Prof. HIBIKI in the Global STEM Professorship position. He is a national treasure and will help bring the university's reputation to the next level.

Prof. LEE Tu-Chung

Chair Professor

Thermofluids and Smart Manufacturing

- Microscale heat and mass transfer
- Bioenergy
- Circular bioenconomy

Prof. LEE Tu-Chung is an internationally renowned scholar in bioengineering. In 2019, SciVal ranked Prof. LEE 4th globally for number of publications in "Bioengineering", and he was listed in the top 2% of scientists in Biotechnology by Stanford University. Prof. LEE also has an impressive grant record and numerous academia–industry research collaborations, completing 47 research projects with a total research budget of about 7.4M USD. He contributed to the Grand Industrial Collaboration Projects on Energy and Environment sponsored by National Science Council of Taiwan, with the industrial partners involved profiting by applying the technologies developed. He has worked with collaborators to develop new materials, such as supramolecular materials for energy storage and thin films for the next generation of semiconductors.

Prof. LEE has successfully supervised many graduate students to outstanding research outcomes, with many now working as faculty members at universities in Taiwan and overseas. Many prestigious awards and titles have recognized Prof. LEE's excellent performance, such as the Academic Award in Engineering (2014) and National Chair (2017) from the Ministry of Education in Taiwan, and being made a Fellow of both the Royal Society of Chemistry (2016) and International Bioprocessing Association (2011).

Prof. LEE has brilliant leadership experience. He was appointed Chair Professor and Dean of College of Engineering in 2013 and Vice President (2013–2017) of the National Taiwan University of Science and Technology, and has been the National Taiwan University Chair since 2017. Prof. LEE has also been very active in cross-university collaborations with world-class institutions such as CityU, PolyU, Nanyang Technology University, Kyoto University, and Hokkaido University. Prof. LEE was President of the Taiwan Institute of Chemical Engineers (2013–2014) and Chairman of the International Bioprocessing Association. Prof. LEE has also served as editor-in-chief for well-known journals, including the Journal of the Taiwan Institute of Chemical Engineers and Bioresource Technology Reports.

The MNE department is delighted to welcome Professor LEE and anticipate that his contributions will help us scale new heights in teaching and research activities in the department.

2

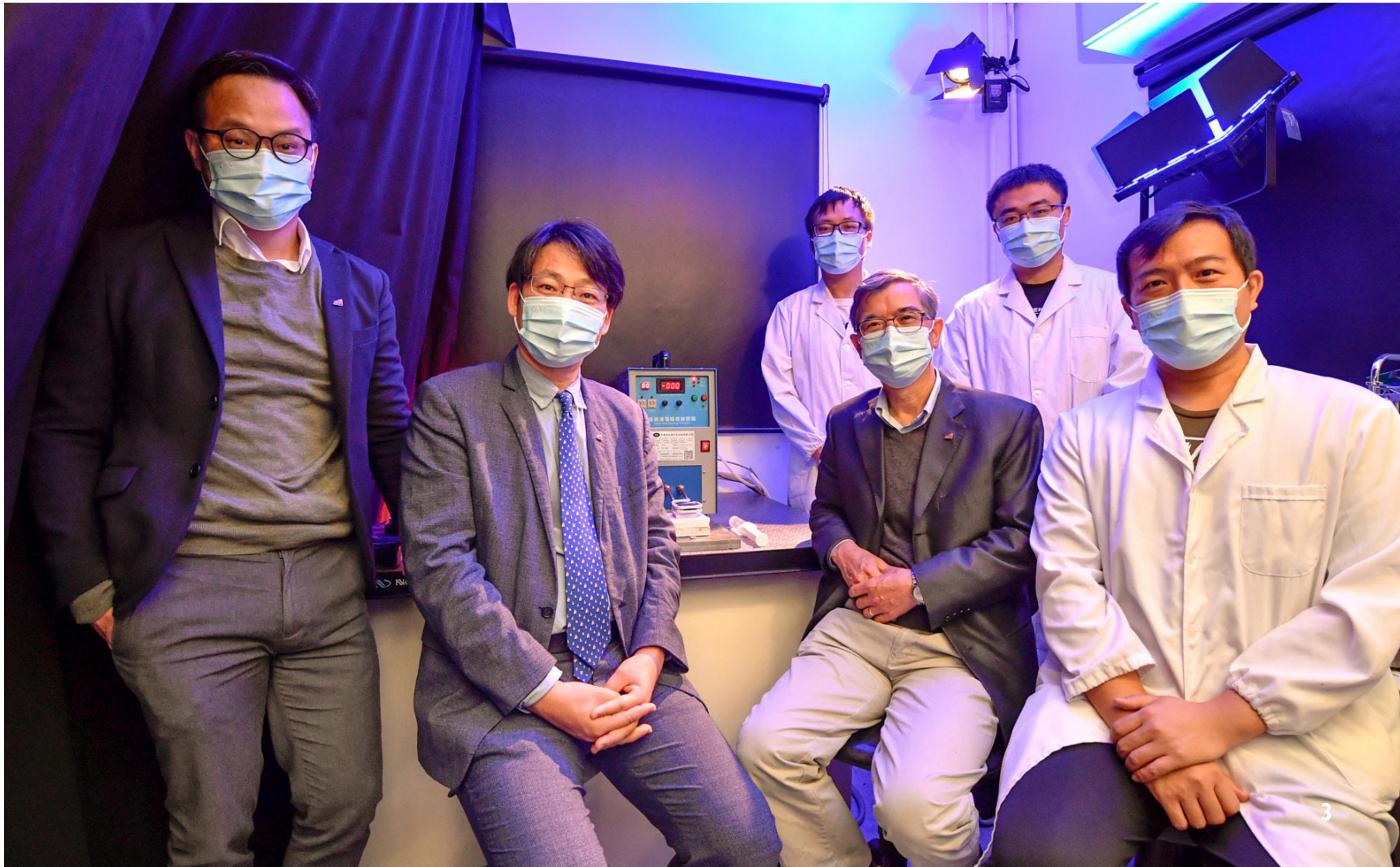
Recent *Nature* Publications

Inhibiting The Leidenforst Effect Above 1000 °C for Sustained Thermal Cooling

A Highly Distorted Ultraelastic Chemically Complex Elinvar Alloy

Inhibiting The Leidenforst Effect Above 1000 °C for Sustained Thermal Cooling

Tackling a challenge unsolved in science and engineering since 1756



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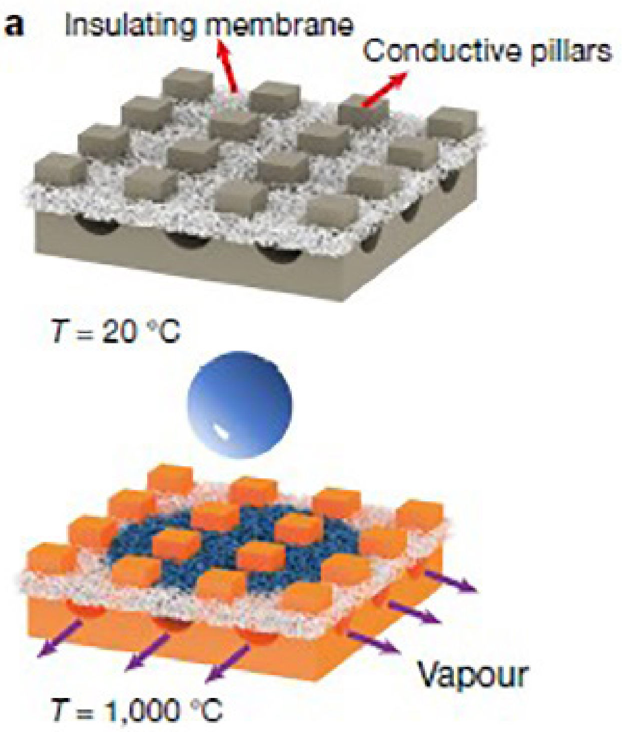
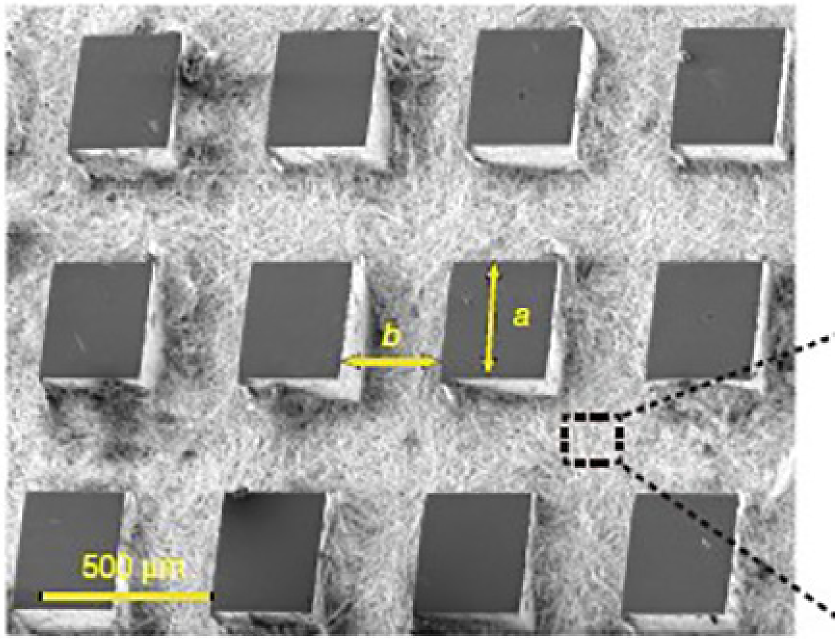


The Problem

Achieving liquid thermal cooling at extremely high temperatures is a challenge because it is limited by the Leidenfrost effect – a physical phenomenon discovered in 1756, which refers to the levitation of drops on a surface that is significantly hotter than the liquid's boiling point. **It produces an insulating vapour layer and dramatically reduces heat transfer performance at high temperature,** rendering liquid cooling on the hot surface ineffective. This effect is most often detrimental, and to suppress this effect has remained a historic challenge.

b



The Innovation

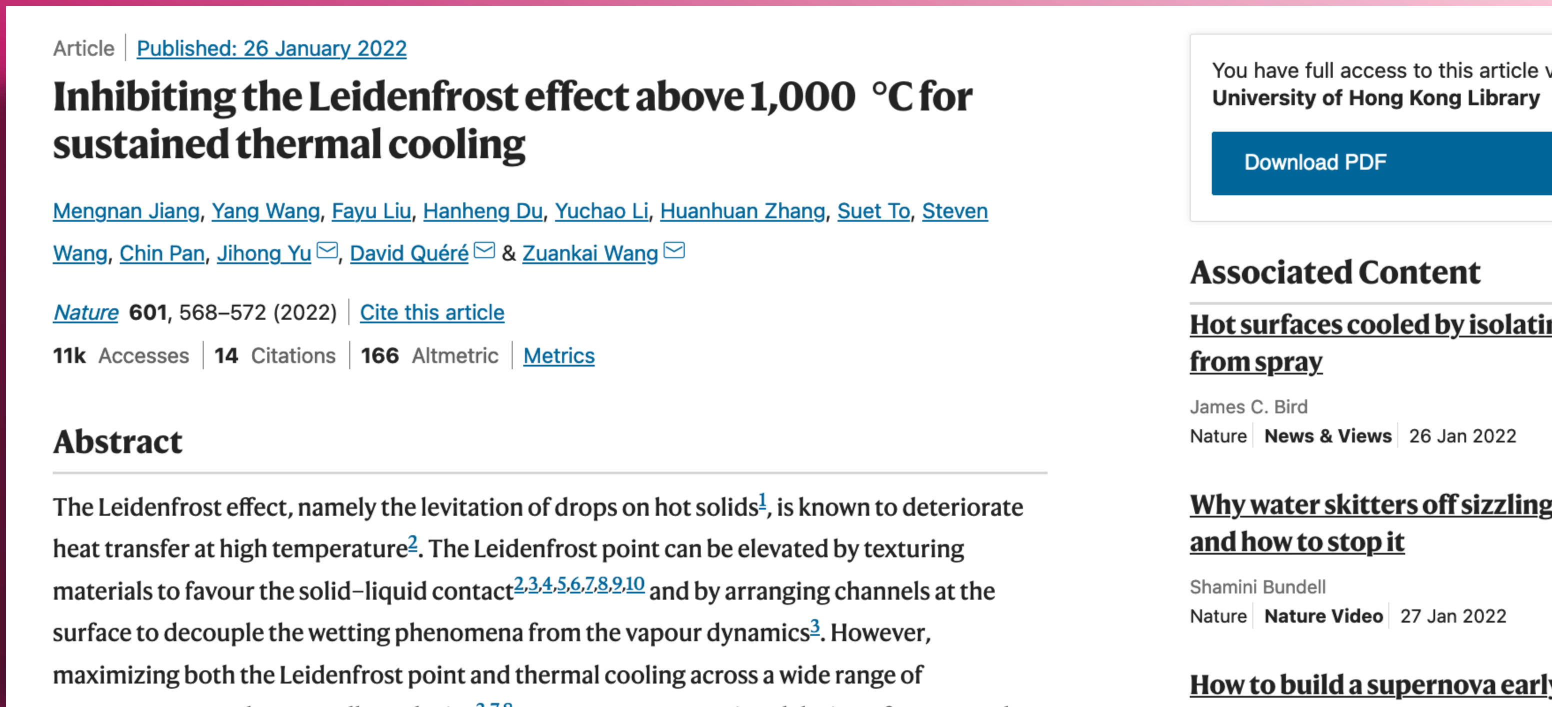
A new multi-textured material (Structured Thermal Armour – STA) was engineered with key elements that have contrasting thermal and geometrical properties. The design for the STA superimposes **robust**, **conductive, protruding pillars** that serve as thermal bridges to promote heat transfer; an embedded thermally **insulating membrane** designed to suck and evaporate the liquid; and **underground U-shaped channels** to evacuate the vapour. Thus, the STA successfully inhibits the occurrence of the Leidenfrost effect up to 1,150 °C, achieving efficient and controllable cooling across the temperature range of 100°C to over 1,150°C.

The Impact

This breakthrough can be applied in aerospace engines and to improve the safety and reliability of next-generation nuclear reactors.

"Searching for novel strategies to address the liquid cooling of high-temperature surfaces has been one of the holy grails in thermal engineering since 1756. We are fortunate to fundamentally suppress the occurrence of the Leidenfrost effect and thereby provide a paradigm shift in liquid thermal cooling at extremely high temperatures, a mission that has remained uncharted to date," said Prof. WANG Zuankai.

Read the full article in our *Nature* publication



Article | Published: 26 January 2022

Inhibiting the Leidenfrost effect above 1,000 °C for sustained thermal cooling

Mengnan Jiang, Yang Wang, Fayu Liu, Hanheng Du, Yuchao Li, Huanhuan Zhang, Suet To, Steven Wang, Chin Pan, Jihong Yu, David Quéré & Zuankai Wang

Nature **601**, 568–572 (2022) | Cite this article

11k Accesses | **14** Citations | **166** Altmetric | Metrics

Abstract

The Leidenfrost effect, namely the levitation of drops on hot solids[1], is known to deteriorate heat transfer at high temperature[2]. The Leidenfrost point can be elevated by texturing materials to favour the solid–liquid contact[2,3,4,5,6,7,8,9,10] and by arranging channels at the surface to decouple the wetting phenomena from the vapour dynamics[3]. However, maximizing both the Leidenfrost point and thermal cooling across a wide range of

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Hot surfaces cooled by isolati… from spray

James C. Bird

Nature | **News & Views** | 26 Jan 2022

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Shamini Bundell

Nature | **Nature Video** | 27 Jan 2022

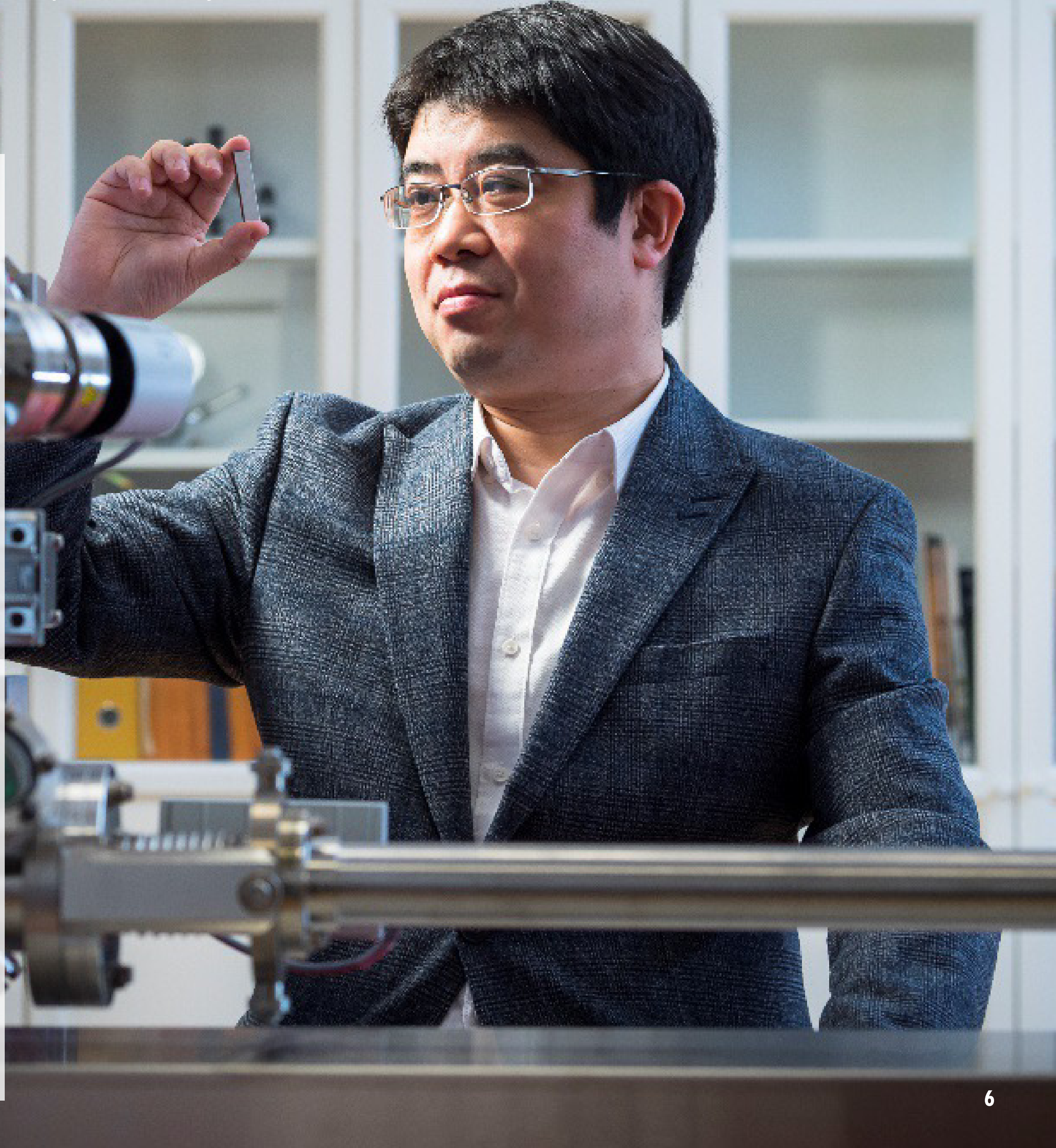
How to build a supernova earl…

A Highly Distorted Ultraelastic Chemically Complex Elinvar Alloy

Maintaining near-constant elastic modulus between room temperature and 627 °C

The Problem

Metals expand and soften under thermal load (heat), which decreases their mechanical performance; the resistance to this behaviour defines the elastic modulus (stiffness) of a material. Usually, all alloys exhibit this behaviour, preventing their application in certain scenarios, such as applications requiring high precision (extreme tolerance) and those with large temperature variations.



The Innovation / Discovery

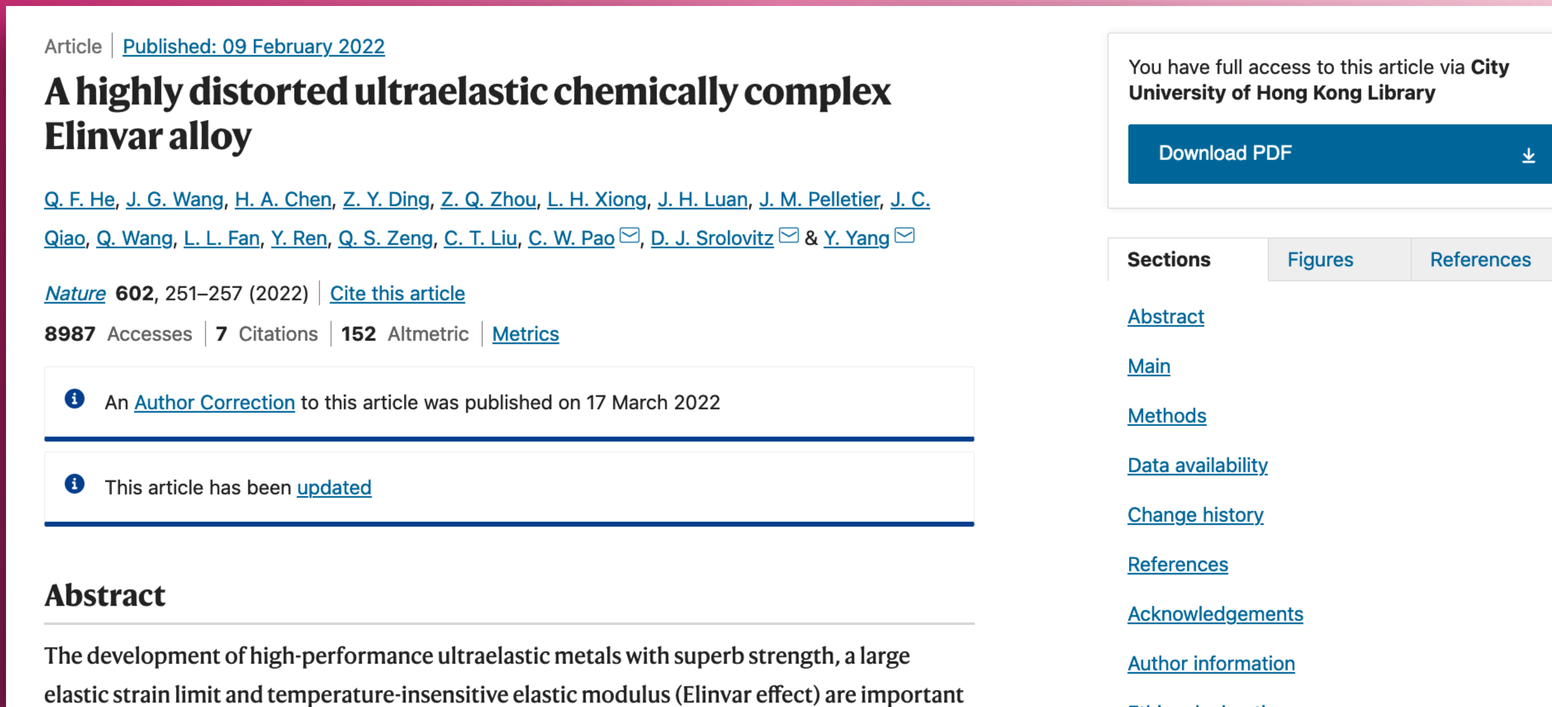
Prof. YANG Yong, together with his team and collaborators, discovered a high-entropy alloy ($Co_{25}Ni_{25}(HfTiZr)_{50}$) that can retain its stiffness even after being heated to 1,000 K (~727 °C) or above, with nearly zero energy dissipation. The high-entropy Elinvar alloy exhibits the Elinvar effect: the alloy retains its elastic modulus over a wide range of temperature changes. Through various experiments on the alloy's atomic structure, the team discovered that the new alloy's properties are due to its unique, highly distorted lattice structure combined with its complex chemical composition. Because of these unique structural features, the high-entropy Elinvar alloy has a very high energy barrier against dislocation movements. Consequently, it displays an impressive elastic strain limit and nearly 100% energy storage capacity.

The Impact

The team found that the alloy is "very springy" and can store a large amount of elastic energy. Prof. YANG highlighted that the alloy could be used for energy storage for subsequent energy conversion. "Since elasticity does not dissipate energy and therefore will not generate heat, which can cause devices to malfunction, this super-elastic alloy will be useful in high-precision devices, such as watches and chronometers," he explained.

The research team envisions many applications for the alloy, particularly in aerospace engineering, in which devices and machinery are subjected to drastic temperature changes. "We know that the temperature ranges from 122°C to −232°C on the moon's surface, for example. This alloy will remain strong and intact in an extreme environment and vacuum of space. So it would fit very well with future mechanical chronometers operating within a wide range of temperatures during space missions," said Prof. YANG.

Read the full article in our *Nature* publication



Article | Published: 09 February 2022

A highly distorted ultraelastic chemically complex Elinvar alloy

Q. F. He, J. G. Wang, H. A. Chen, Z. Y. Ding, Z. Q. Zhou, L. H. Xiong, J. H. Luan, J. M. Pelletier, J. C. Qiao, Q. Wang, L. L. Fan, Y. Ren, Q. S. Zeng, C. T. Liu, C. W. Pao, D. J. Srolovitz & Y. Yang

Nature **602**, 251–257 (2022) | Cite this article

8987 Accesses | **7** Citations | **152** Altmetric | Metrics

An Author Correction to this article was published on 17 March 2022

This article has been updated

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Abstract
Main
Methods
Data availability
Change history
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Acknowledgements
Author information

Abstract

The development of high-performance ultraelastic metals with superb strength, a large elastic strain limit and temperature-insensitive elastic modulus (Elinvar effect) are important

3

Feature Awards

Inventions Geneva Evaluation Days 2022

3.1 Gold Medal with Congratulations of the Jury

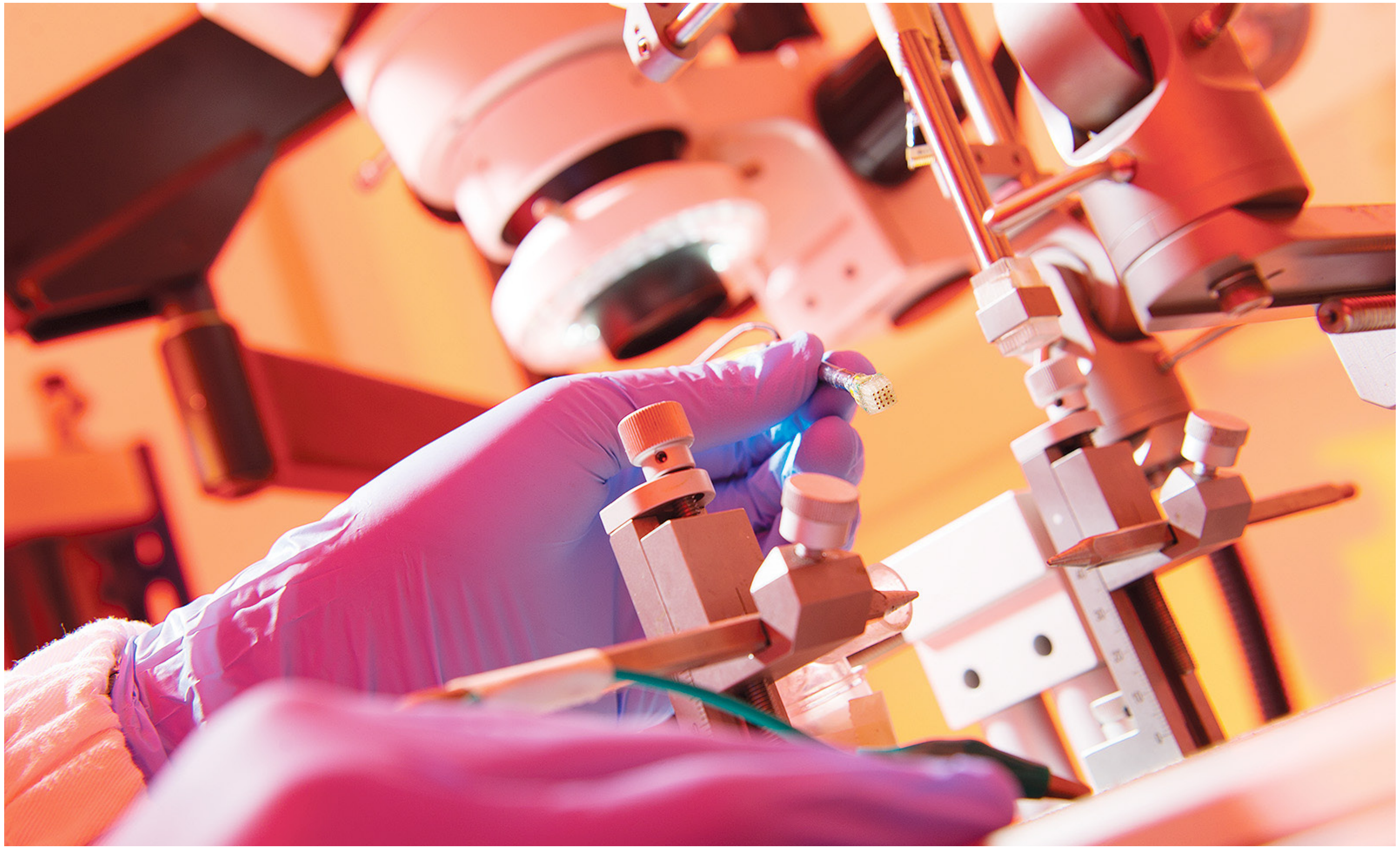
Project "Fog-to-Electricity Generator with Ultra-High Power Density"

3.2 Gold Medal

Project "Structured Thermal Armour"

3.3 Silver Medal

Project "Fast-Track Vented Enclosure System for COVID-19 Patient Wards"



MNE faculty received three awards at Inventions Geneva Evaluation Days (IGED) 2022

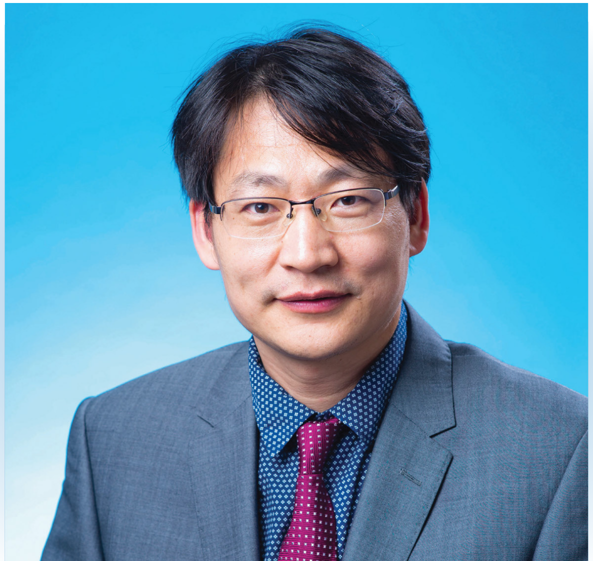
Taking home one Gold Medal with Congratulations of the Jury, one Gold Medal and one Silver Medal

Fog-to-Electricity Generator with Ultra-High Power Density

The research team was led by Prof. WANG Zuankai and supported by MNE Assistant Prof. Dr. WANG Steven and three PhD students LING Chen, YAO Xiaoxue and WANG Hongbo. The project was first founded as a start-up under the CityU's flagship entrepreneurship programme HK Tech 300, aiming to transfer the university technologies into practical applications.

The project has introduced the first-ever fog-powered green generator to harvest energy and freshwater from moisture. It combines a newly developed high-power density Droplet-based Energy Generator (DEG) with a nature-inspired, superhydrophobic fog harvesting mesh. This dual-purpose electricity generator and fog harvester has the highest fog-based energy-conversion efficiency to date, producing record-high power (300 V) alongside a water collection rate of approximately 250 litres per square metre per day. This new technology provides a sustainable, stable, low-cost, portable, and eco-friendly power solution while tackling the freshwater crisis in many major cities and areas. Read more

3.2 / Project "Structured Thermal Armour



Structured Thermal Armour

The thermal armour developed by Prof. WANG Zuankai can be attached to different shaped substrates to remove heat from surfaces at temperatures of 1,200°C or higher. A fast and a controlled temperature drop of more than 1,000°C can be achieved within several to tens of seconds.

This liquid-cooling technology can be used to prevent thermal crisis in ultra-high thermal- fluxed electric devices. It also enables the traditionally impossible efficient-liquid-cooling of extremely high temperature system. Read more

Fast-Track Vented Enclosure System for COVID-19 Patient Wards

Developed by Dr. WANG Steven and his team, the ventilation system can thoroughly filter viral particles and quickly stop the spread of COVID-19 at low cost. This system aims to relieve the demand for negative pressure wards at scale during this challenging time.

The system is currently under clinical trial at the Clinical Simulation Centre at the University of Hong Kong School of Nursing. Furthermore, it has already been undergoing clinical testing in the 24-hour Outpatient and Emergency Department of Gleneagles Hospital Hong Kong since February this year. As the system design is simple and can be set up quickly, the system has the potential to be widely adopted in high-risk venues such as hospitals and residential care homes to effectively reduce the risk of virus transmission. Read more

"

This highly efficient, low-cost filtering system with simple installation can provide sufficient protection for healthcare workers.

Dr. WANG Steven

HK TECH 300 Startup Stories

Three companies founded / (co-)founded by MNE faculty members have been awarded up to HK$ 1 million from the CityU HK Tech 300 Angel Fund:

Super Bamboo Limited

Leidenford Limited

LUMAT-SERS Limited

HK TECH 300 – Nurturing future leaders, one at a time

"HK Tech 300 is an innovation and entrepreneurship accelerator programme launched by the City University of Hong Kong. Aspiring to be the No.1 university-based entrepreneurship platform in Asia, It aims to support 300 future in Hong Kong for the next three years - to pioneer technology development and translate university research results into real-world applications..." Read more on HK Tech 300 Website

Three companies founded / (co-)founded by MNE faculty members have been awarded up to HK$ 1 million from CityU HK Tech 300 Angel Fund

Sustainable Structural Bamboo Materials with High Strength and Multi-function

> Stronger than titanium and greener than wood

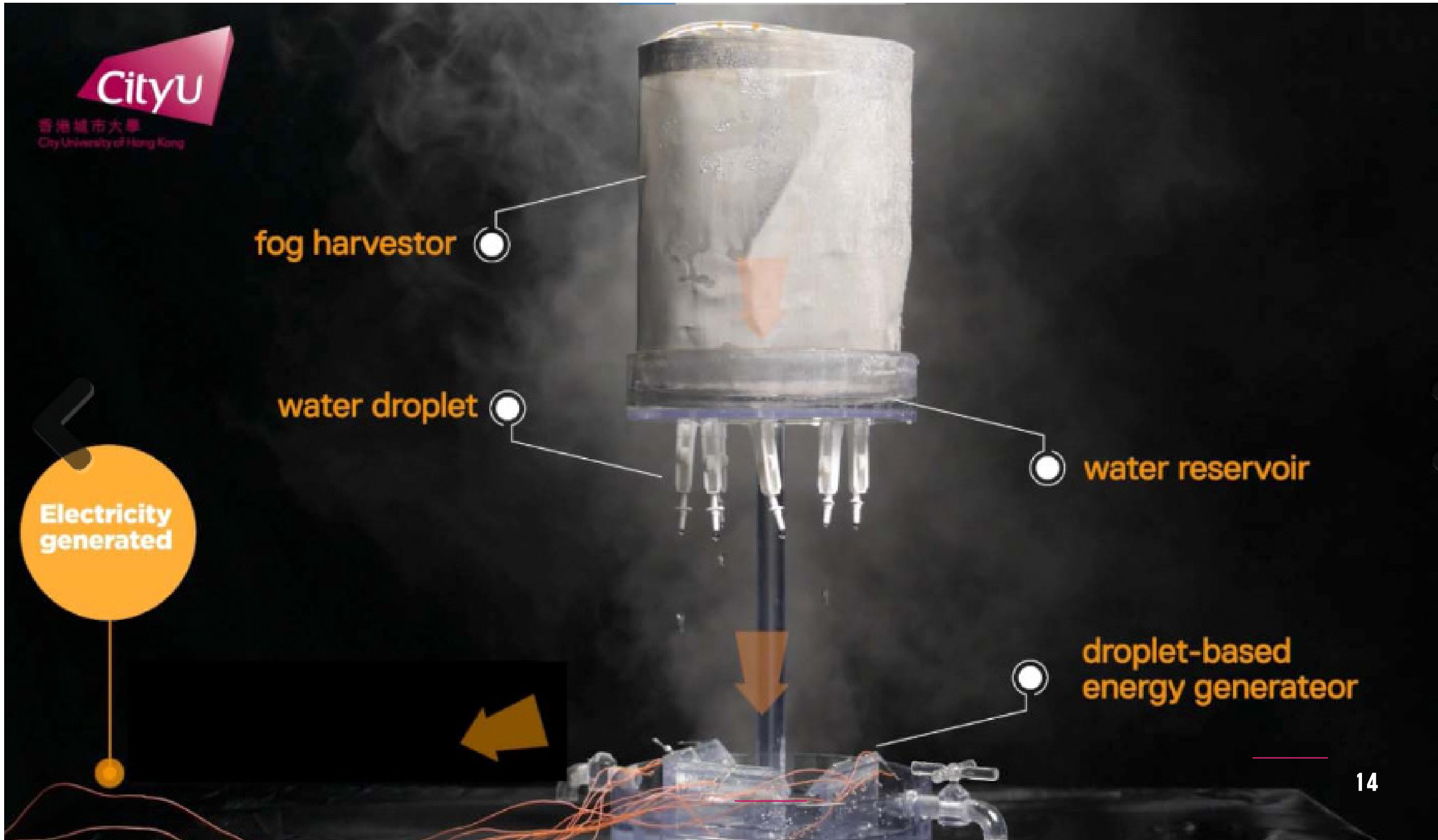
Super Bamboo Limited – co-founded by our department researchers Mr. Andy ONG (Alumnus of BEng Machanical Engineering), Prof. LU Yang (Professor), Dr. FAN Rong (Visiting Assistant Professor), and Dr. SURJADI James Utama (Postdoc). The company aims to provide an alternate material over traditional alloy to contribute to the net-zero carbon emission goal by 2050. Their award-winning augmented material, Super Bamboo, combines the eco-friendliness of natural material with engineering. "We utilise bamboo's special carbon sequestration capabilities and turn them into advanced materials that can replace less sustainable traditional materials like low carbon steel," said Mr. ONG (Founder). The result is an affordable "natural composite material" that has better mechanical properties, water-resistance and fire-retardance than normal bamboo, low carbon steel and titanium alloys. Bamboo is the fastest growing plant on Earth – it can grow more than 1 metre per day. By enhancing its already amazing mechanical properties, Super Bamboo has great potential for building a greener future can be appropriately harnessed. Read more

Fog-to-Electricity Generator with Ultra-High Power Density

Leidenford Limited - co-founded by Prof. WANG Zuankai (Chair Professor), Dr. WANG Steven (Assistant Professor), LING Chen and YAO Xiaoxue (PhD Students).

The mission of Leidenford is to solve the freshwater problem in remote areas. The company's product, Leidenford Water Generator (LWG), harvests water vapour from the atmosphere by combining a high-performance composite sorbent and an energy-efficient technique to achieve multiple cycles of fast adsorption and desorption kinetics per day to produce fresh and clean water. A network of LWGs could produce at least 100 litres of freshwater per day in a decentralised, modularised, low-cost and low energy consuming manner. Read more

"A network of the system can produce at least 100 litres of freshwater per day"



Low-Cost SERS Chips as Consumables for Food and Drug Safety

LUMAT-SERS limited – founded by Mr. SHEN Junda (PhD student of CityU, Department of Materials Science and Engineering (MSE)) and supported by Dr. ZHOU Binbin (Postdoc, MNE) Prof. LU Jian (Chair Professor, MNE), and Dr. LI Yangyang (Associate Professor of MSE & joint Associate Professor of MNE).

The company has developed patented SERS chips that are at least half the cost of current chips and can be mass-produced. These chips also perform 10–100 times better than current commercial offerings. SERS technology has a wide range of applications, such as food safety testing, dangerous goods testing and early disease screening, and thus has the potential to benefit millions of people. Read more

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