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

Issue No.2
October 2022

MNE Newsletter

Welcome from the Department

The Research issue

Every issue, we try to pick some of our best news and share it with our audience. But the word 'best' here is a subjective idea. Instead, moving forward, every issue will have a theme. With the world transitioning to the endemic, we shall steer our attention and optimism again into the bright, exciting future. And what's a better way to celebrate that than by sharing some of our latest research - which enables emerging technologies such as virtual reality, advanced material for 3D/4D printing and nanogenerators. And so that is the central theme of this issue.

IN THIS ISSUE

1

People Stories

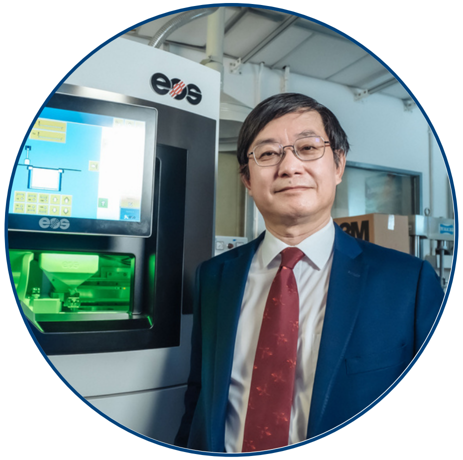
Prof. LU Jian

Prof. JING Xingjian

In this issue, we are pleased to introduce two of our outstanding professors. Prof. LU Jian - Chair Professor of Mechanical Engineering who enables the world's first 4D printing for ceramics.
And Prof. JING Xingjian - An expert on Nonlinear Dynamics, Vibration & Control, who is also the deputy major leader of BEng Aerospace Engineering.

Prof. LU Jian

Chair Professor



Mechanical Engineering

- 4D printing
- Experimental mechanics
- Mechanical properties of metallic and ceramic materials
- Metallurgy

> **At first, I looked around but couldn’t find the material I was dreaming of for achieving my design. So, I decided to fabricate it myself.**

Prof. LU's research interests lie in surface science/engineering, the mechanical properties and processing of nanomaterials and advanced materials, experimental mechanics, and residual stress. He has published more than 460 journal papers, including in Nature (as a cover article), Science, Science Advances, Nature Materials, Nature Communications, Materials Today, Advanced Materials, Physical Review Letters, Acta Materialia, and the Journal of the Mechanics and Physics of Solids. His publications have been cited more than 34,000 times. He is the inventor of over 67 granted patents registered in the United States (38), Europe (5), and China (24), with international extensions.

Prof. Lu has been granted two French honours: he was made a Knight of the National Order of Merit (Chevalier de l'Ordre National du Mérite) in 2006 and the Knight of the National Order of the Legion of Honour (Chevalier de la Legion d’honneur) in 2017. Moreover, in 2011, he was elected as an Academician of the National Academy of Technologies of France, and in 2018, he received the 12th Guanghua Engineering Science and Technology Award, which is widely regarded as the most prestigious award in China for engineering and technology achievements.

Prof. JING Xingjian

Professor

Mechanical Nonlinear Dynamics, Vibration & Control

- Nonlinear Vibration and Control / Nonlinear Dynamics and Control
- Robotics and Control
- Nonlinear Systems: Analysis, Design, and Identification
- Bio-inspired Approach

Prof. JING's research interests are nonlinear dynamics, vibration, control, and robotics. His work is focused on theory and methods for realising nonlinear benefits in engineering applications and methods, such as vibration control, robust control, sensing, energy harvesting, nonlinear fault diagnosis or signal processing, nonlinear system identification, bio-inspired systems and methods, bio-inspired robotics and control, and nonlinear frequency domain methods.

Prof. JING has developed a systematic parametric characteristic approach for analysing and designing nonlinear systems in the frequency domain. This approach yields an explicit analytical structure and expression of the output spectrum of nonlinear systems in terms of model parameters, frequency variables, and excitation amplitude, which are collectively denoted characteristic parameters and are difficult to obtain using other methods. This approach greatly facilitates the analysis, design, and understanding of a class of nonlinear dynamics (i.e., Volterra-type nonlinear systems), thereby opening up a new pathway that has led to a series of application studies in vibration control, fault detection, and energy harvesting, among others. In recognition of these efforts, Prof. JING was awarded the Senior Research Prize by the European Association of Structural Dynamics in 2017 and the Outstanding Paper Award by the Hong Kong Institution of Engineers in 2019.

Nonlinearity plays a critical role in engineering systems and thus cannot be ignored during structural design, dynamic response analysis, and parameter selection. Moreover, the analysis and design of potential nonlinearities introduced into or inherent to a system under study are key concerns in applications involving vibration control, energy harvesting, sensor systems, and robotics technologies.

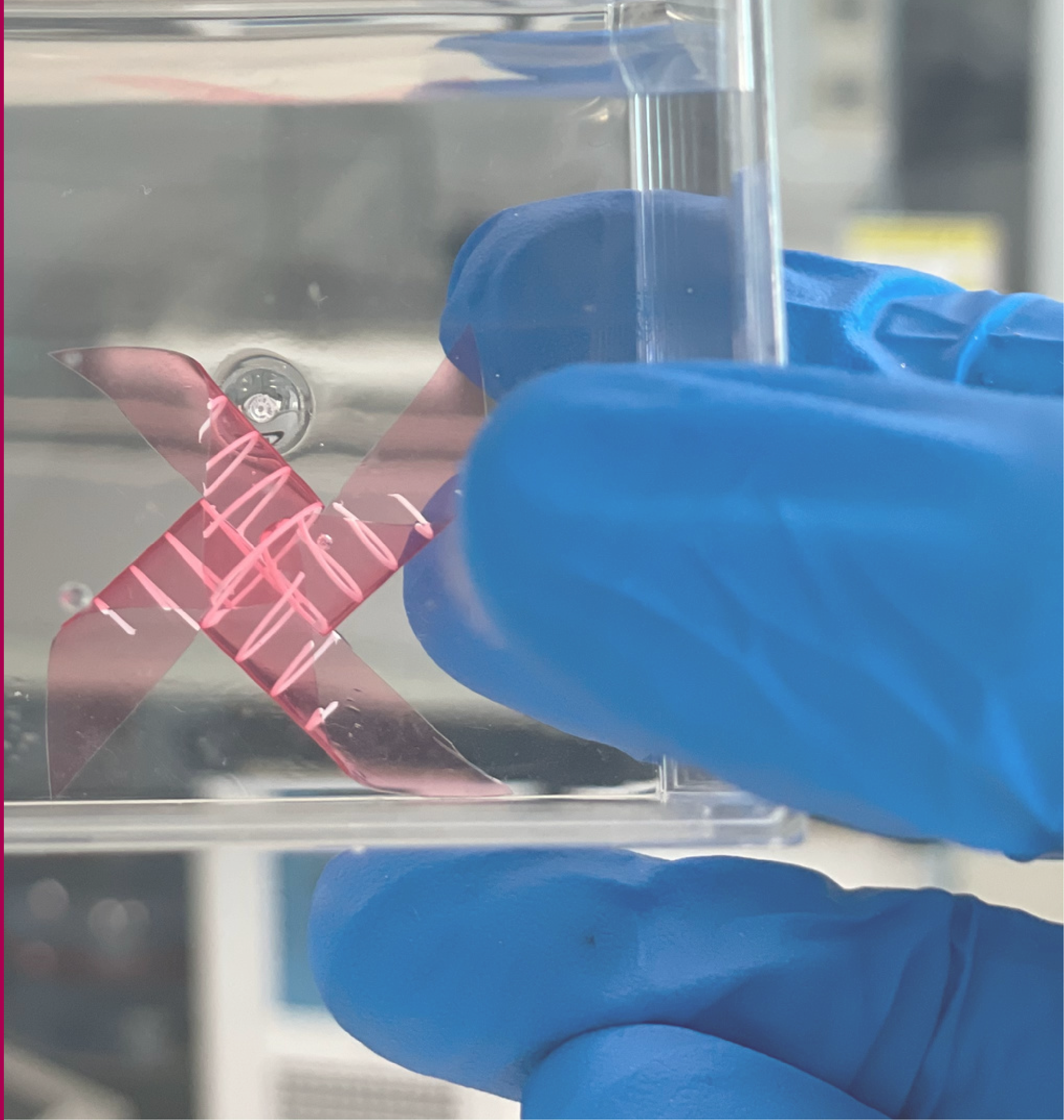
Prof. JING therefore proposed and established a bio-inspired X-shaped structure and mechanism that offers a new and effective design perspective on beneficial nonlinearity (in stiffness, damping, and inertia) in practical engineering systems, which enables its realisation via easy-to-implement structure and mechanism designs. These developments have led to a series of innovative applications in the aerospace, civil engineering, construction, and automobile industries. His X-shaped passive vibration control structure won the 2017 Global TechConnect Innovation Award[AE1] (USA), while his anti-vibration jackhammer technology[AE2] won First Prize in the Hong Kong Construction Industrial Council's Construction Innovation Award.

Prof. JING currently serves as an Associate Editor of several prestigious journals, including IEEE Transactions on Systems, Man, and Cybernetics; IEEE Transactions on Industrial Electronics; Mechanical Systems and Signal Processing (MSSP); and IEEE/ASME Transactions on Mechatronics. He has also been the lead editor of several special issues on nonlinear vibration controls published in MSSP. His research results have won him the 2016 IEEE SMC Best Transaction Award and the 2021 ASME Journal of Vibration and Acoustics Best Paper Award. Since 2020, Prof. JING has been in the "Top 2% Most Highly Cited Scientists" list, which is published by Stanford University and ranks scientists in different fields from around the world.

2

Research Highlight

- World's first 4D printing of ceramics
- Bubble Energy Generator
- Lightweight, ultra-tough, 3D-architected hybrid carbon microlattices
- Super-resolution wearable electrotactile rendering system

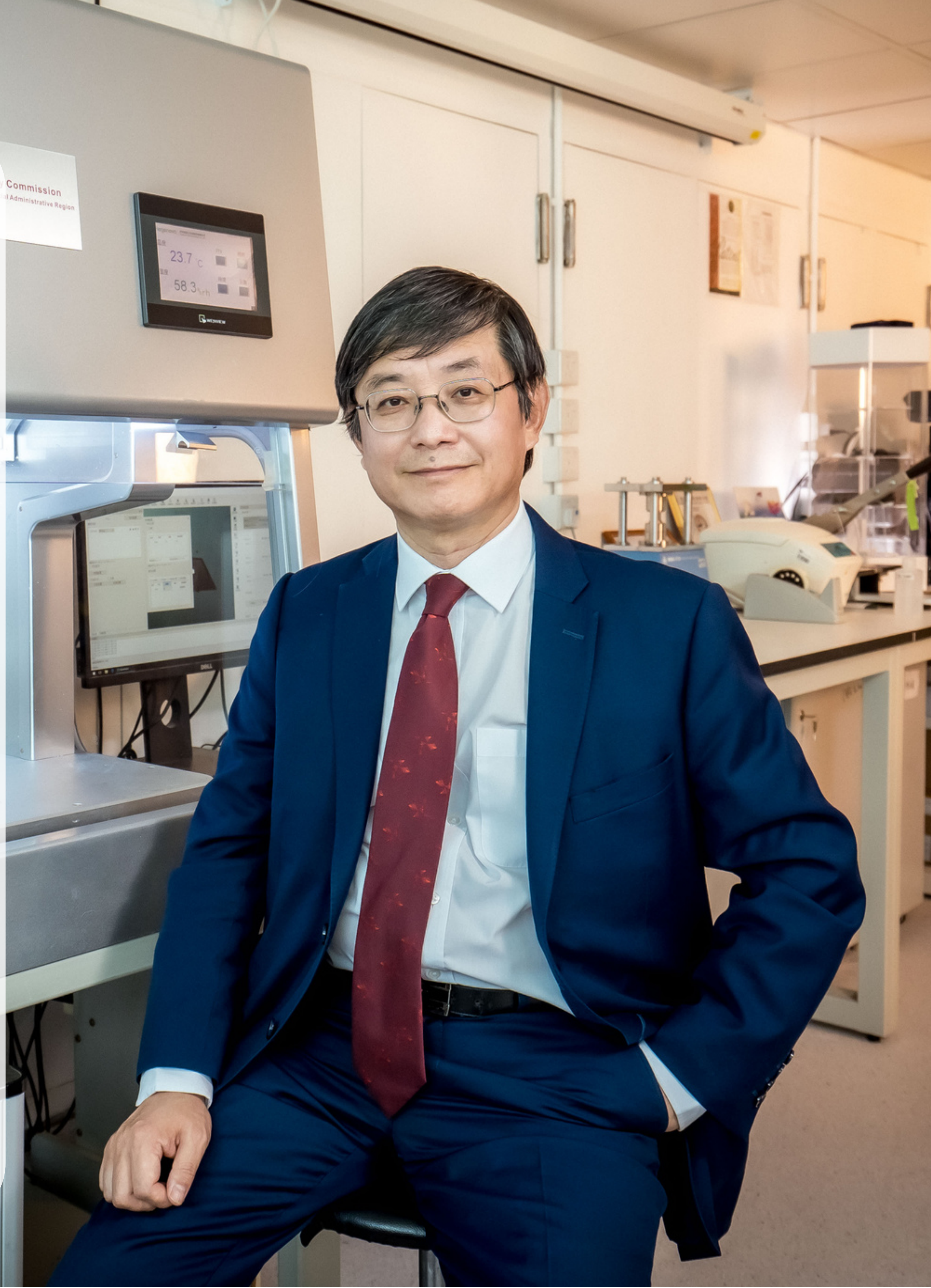


4D Printing of Structural Materials

Giving life to lifeless objects

Pushing the boundaries

In theoretical physics, describing where an object requires 4 dimensions of information – that is: the usual left-right, back-forth and up-down; there is also the 4th dimension - the dimension of time. **4D printing is conventional 3D printing combined with the additional element of Time and Motion as the fourth dimension.** 4D printed objects can re-shape or self-assemble themselves over time with external stimuli – such as light, humidity or temperature. Ceramics, elastomers, and hydrogels are excellent materials for 4D printing. However, each with its own challenges and limitation to overcome. And Prof. LU Jian with his team has been making numerous progress in addressing these issues.



The Innovation

Ceramics: The high melting point and the non-deformable nature of current 3D-printed ceramic precursors hinder the additive manufacturing of complexly shaped ceramics.

A novel “ceramic ink” that combines polymers and ceramic nanoparticles have been developed. 3D-printed ceramic precursors printed with this ink are soft and can be stretched to over three times their initial length. With heat treatment in specific conditions, these flexible and stretchable ceramic precursors enable the printing complexly shaped ceramics. This innovation is the world's first 4D printing technology for ceramics and opens a new chapter in the high-resolution printing of complex, mechanically robust, and cost-efficient ceramics.

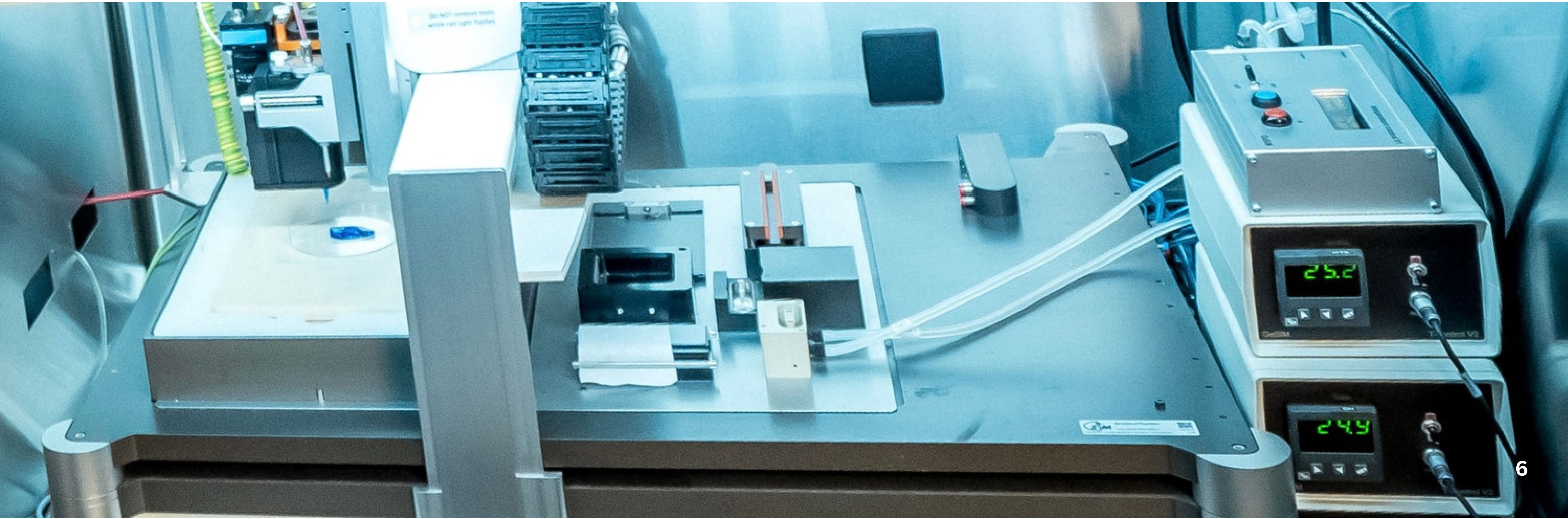
Light Stimuli Polymers: Flexible light-responsive polymers with complex geometries and multi-level functions have not yet been achieved.

Three biomimetic actuators with programmable actuation have been developed, together with a monopolar antenna designed to enable the light-controlled regulation of three states. Prof. Lu and his team have developed a simple technique to fabricate light-controlled reconfigurable structures with complex kirigami geometries and multi-level functions.

Fabricate responsive soft actuators: The team’s findings show that the stripe-film structure and the high modulus ratio of chitin and polydimethylsiloxane lead to a fast response to stimuli. The high strength of a chitin film results in robust and stable deformation. This research paves the way for the fabrication of responsive actuators with complex shape-morphing capabilities, which promise a wide range of applications.

Hydrogels: The low modulus and slow diffusion of water in hydrogels make it hard to create responsive or adaptive actuators capable of complex and robust deformation.

To fabricate stimuli-responsive hydrogels for 4D printing, the bilayer of a hydrogel is printed with the ionomer of poly(acrylamide-r-sodium 4-styrene sulfonate) (PAS) to serve as the matrix for both the passive and active layers containing tetra-(4-pyridylphenyl)ethylene (TPE-4Py). At low pH, the protonation of TPE-4Py leads to changes in the fluorescence colour and brightness. At the same time, the electrostatic interactions between the protonated TPE-4Py and benzenesulfonate groups of the PAS chains cause the printed materials to deform.

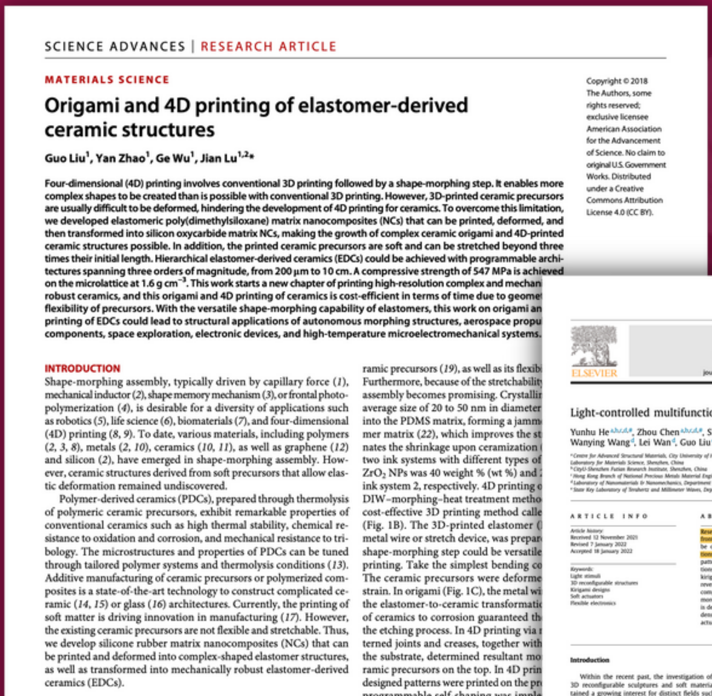


The Impact

Shape-morphing materials could apply to various applications across domains, including biomedical, biomimetic actuators, aerospace propulsion/antenna components, electronics, high-temperature microelectromechanical systems, soft robots, smart wearable devices, and tissue engineering.

Prof. LU Jian and his team have published six papers in renowned international journals, such as Science Advances, and have been granted seven invention patents. **In 2019, the European Commission highlighted the 4D printing of ceramics as one of the 100 Radical Innovation Breakthroughs for the future.** Moreover, the Innovation and Technology Commission (Hong Kong), the Research Grants Council (Hong Kong), the National Natural Science Foundation of China, and other provincial and ministerial governments of the Mainland have granted Prof. LU Jian and his team funding totalling approximately HK$27 million for five 4D-printing-related research projects.

Read the full papers

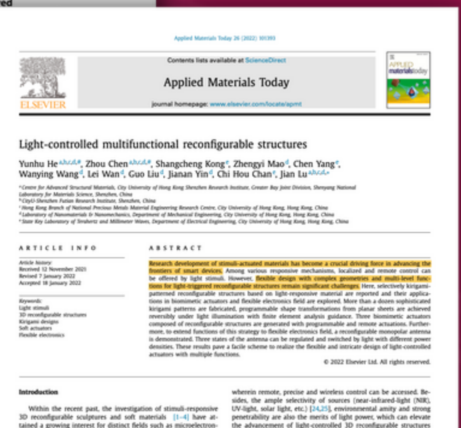


SCIENCE ADVANCES | RESEARCH ARTICLE

MATERIALS SCIENCE

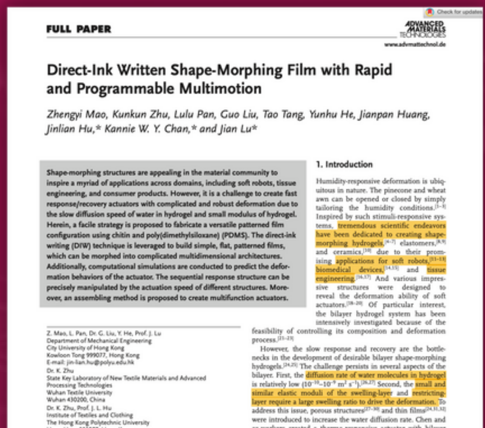
Origami and 4D printing of elastomer-derived ceramic structures

Guo Liu[1], Yan Zhao[1], Ge Wu[1], Jian Lu[1,2]*



Applied Materials Today

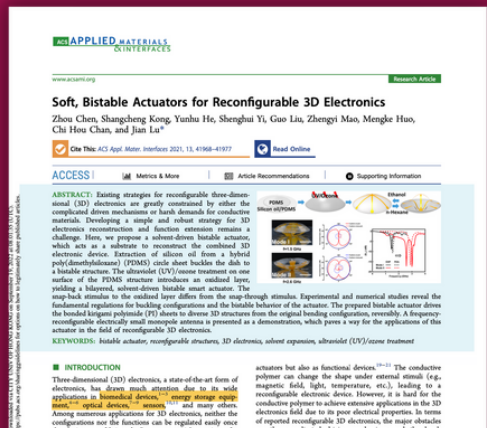
Light-controlled multifunctional reconfigurable structures



FULL PAPER

Direct-Ink Written Shape-Morphing Film with Rapid and Programmable Multimotion

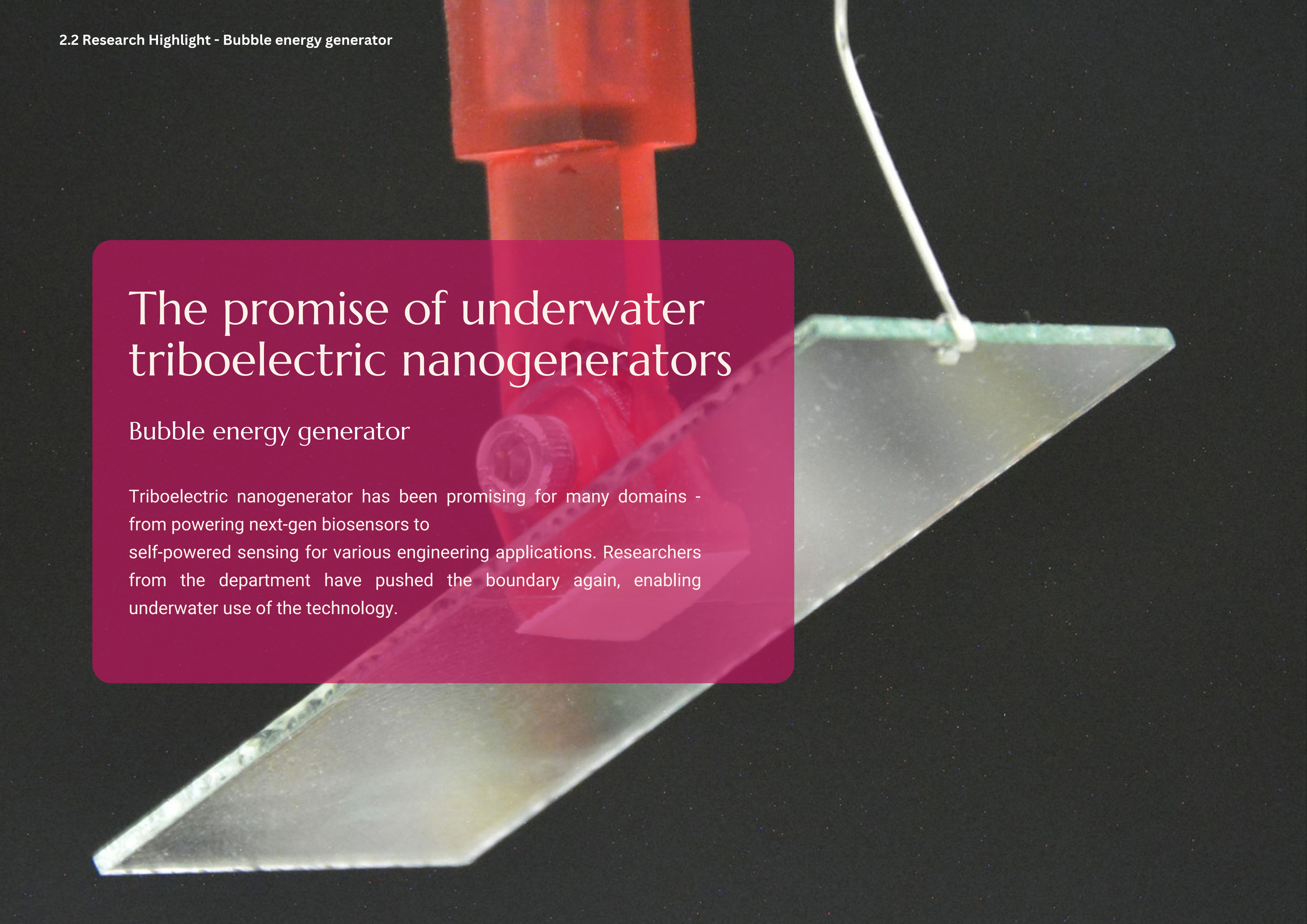
Zhengyi Mao, Kunkun Zhu, Lulu Pan, Guo Liu, Tao Tang, Yunhu He, Jianpan Huang, Jinlian Hu,* Kannie W. Y. Chan,* and Jian Lu*



ACS APPLIED MATERIALS & INTERFACES

Soft, Bistable Actuators for Reconfigurable 3D Electronics

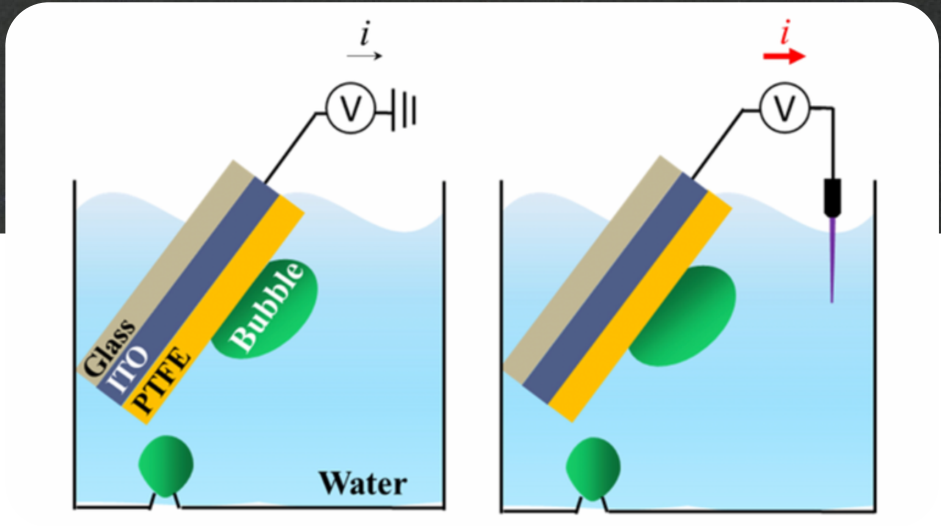
Zhou Chen, Shangcheng Kong, Yunhu He, Shenghui Yi, Guo Liu, Zhengyi Mao, Mengke Huo, Chi Hou Chan, and Jian Lu*



The promise of underwater triboelectric nanogenerators

Bubble energy generator

Triboelectric nanogenerator has been promising for many domains - from powering next-gen biosensors to
self-powered sensing for various engineering applications. Researchers from the department have pushed the boundary again, enabling underwater use of the technology.



Meet the team

Department of Mechanical Engineering, CityU:
Xiantong YAN, Wanghuai XU, Yajun DENG, Chao ZHANG, Huanxi ZHENG, Siyan YANG, Yuxin SONG, Pengyu LI, Xiaote XU, Dr. Zhengbao YANG(MNE Associate Professor),
Dr. Steven WANG (MNE Assistant Professor), Prof. Zuankai WANG (MNE Chair Professor)

Department of Engineering Mechanics,Shanghai Jiao Tong University:
Yue HU, Luwen ZHANG

Overview

Potential use cases | Bubble energy generator

Much of our life relies on offshore underwater infrastructure. From the basic needs of telecommunication to solving some of the most pressing problems in ecology and climate change. Indeed, subsea cables carry 99% of international communications traffic, which includes webpages, data and your Zoom calls. Ensuring the serviceability of these underwater infrastructures required emphasis on structural health monitoring - for intelligent self-sensing diagnostics, prognostics, damage tolerance and failure analysis. And sustainably powering these networks of sensors in underwater environments is a challenge.

Current off-grid power supplies, such as long-distance electric wires or disposable batteries, are cost-ineffective, resource-dependent, and eco-unfriendly.

That is why researchers in the Department of Mechanical Engineering have developed a way to generate electricity by converting kinetic energy stored in buoyant bubbles.

The Problem

How it works | But there's a catch

Simply put. The newly developed Bubble Energy Generator works in the principle of triboelectric nanogenerators (TENG). But it can work even when immersed underwater.

The TENG generates electricity from the triboelectric effect. When two different materials contact through relative motion or friction, it becomes electrically charged. A common example of this phenomenon is the trick of rubbing a balloon on your head to make your hair stand up. And a TENG is the technology that effectively collects energy from these built-up charges.

However, typical TENG doesn't work underwater.

> 'Current techniques for droplet energy harvesting, such as reverse electrowetting, triboelectric nanogenerators (TENG), hydrovolcanic and other water-related energy harvesting techniques cannot be directly translated for bubble applications. In particular, the dielectric materials (Used to store the build-up of electrostatic charges) in TENG that operate in the air will break down underwater, owing to the presence of a ubiquitous phase: water. The water film also screens surface charges stored on the dielectric layer, making it difficult to generate energy from moving bubbles.'
>
> **Yan, et al, Bubble Energy Generator,**
> *Science Advances*, 2022

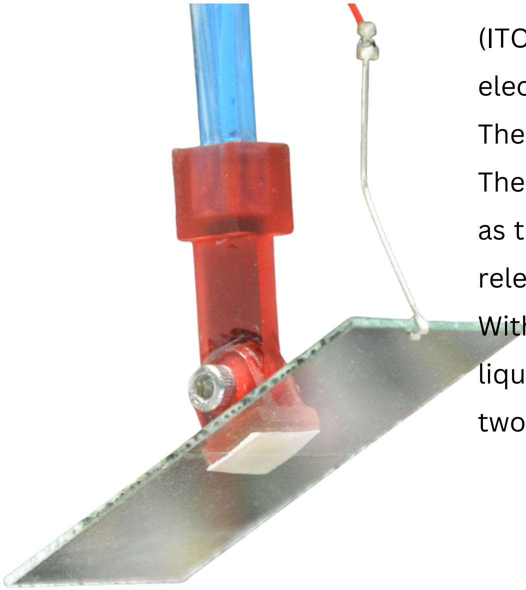
The innovation

Engineering the right surface for rapid bubble movement

The research team highlighted in the paper - 'The key innovation of the research lies in 1. tailoring the surface wettability of dielectric material for preferential bubble mobility and transport that suppresses the unwanted screening effect.' PTFE (Polytetrafluoroethylene) is used to achieve this objective - 'In our design, the electret PTFE is treated with high surface charge density to serve as the charge reservoir, while imparting ingenious surface wettability to promote preferential bubble motion.'

And 2. designing transistor-inspired electrode configurations for efficient charge transfer even in a water environment. The TBENG (Bubble energy generator features a two-electrode design - an indium tin oxide (ITO) electrode sandwiched between a glass plate and an electret PTFE. Also, an underwater platinum (Pt) electrode has been placed.

The design is inspired by a Field Effect Transistor, which consists of a source, gate, and drain terminals. The team mentioned, 'The electret layer in conjunction with the underlying ITO electrode can be treated as the source terminal, the second electrode (Pt) placed in water behaves like a drain terminal for charge releasing, and the moving bubble that mediates the charge release from the PTFE surface serves as a gate. With such a configuration, we expect that when a bubble impinges on the surface of TBENG, the original liquid/solid interface can be translated into a gas/solid interface, which will drive charge transfer between two electrodes for the boosted output.'



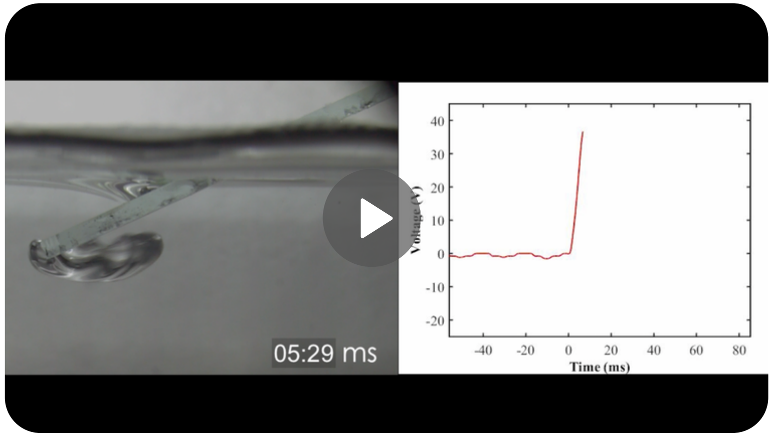
The Result

Continues power generation

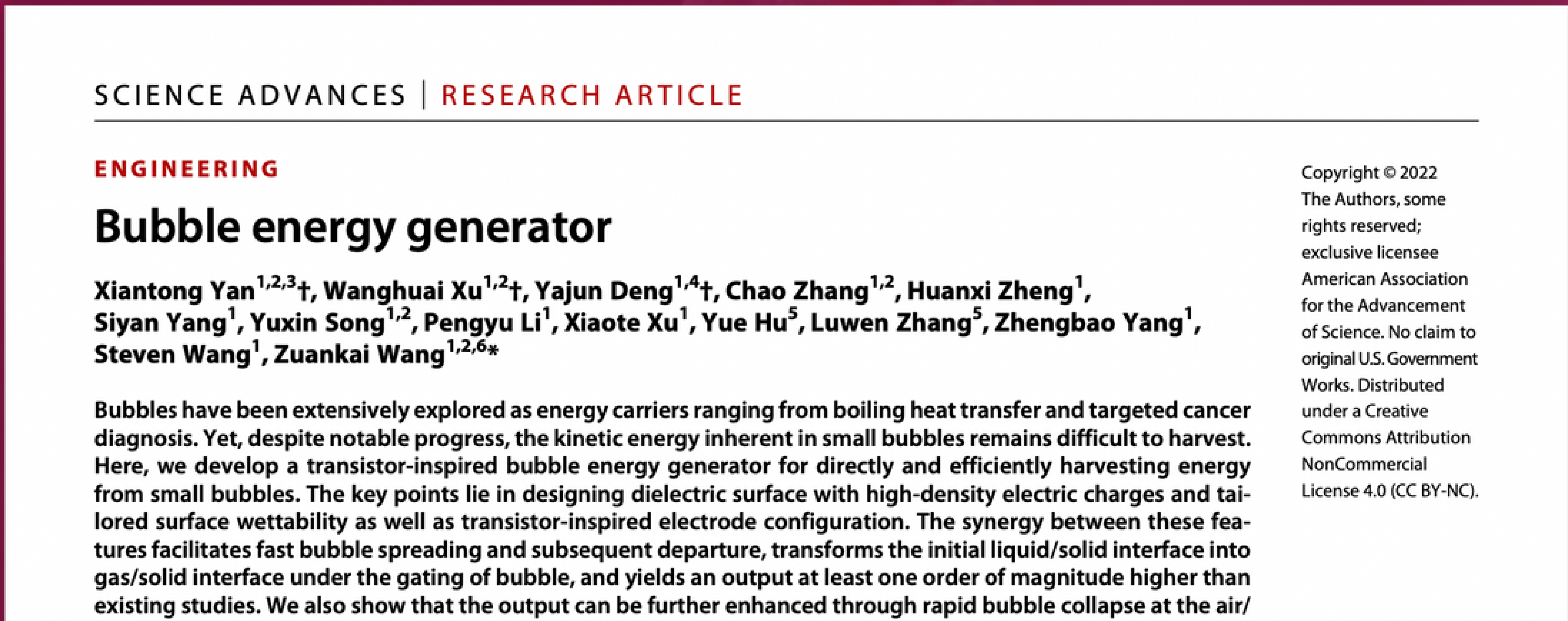
The research team has clearly shown that the TBENG (Bubble energy generator) able to continuously generate electricity. The paper concluded with two demonstrations - 1. powering a multifunctional sensor to monitor temperature, humidity and time. And 2. powering a wireless temperature monitoring system.

Moving forward

Despite the rapid development of battery technology such as lithium-metal and lithium-ion batteries, due to the enormous use of batteries and their limited lifespan, great efforts are still required to develop clean and efficient energy - to improve energy utilization. Collecting and using energy lost by friction is an environmentally friendly and effective way to improve energy efficiency.



Read the full paper



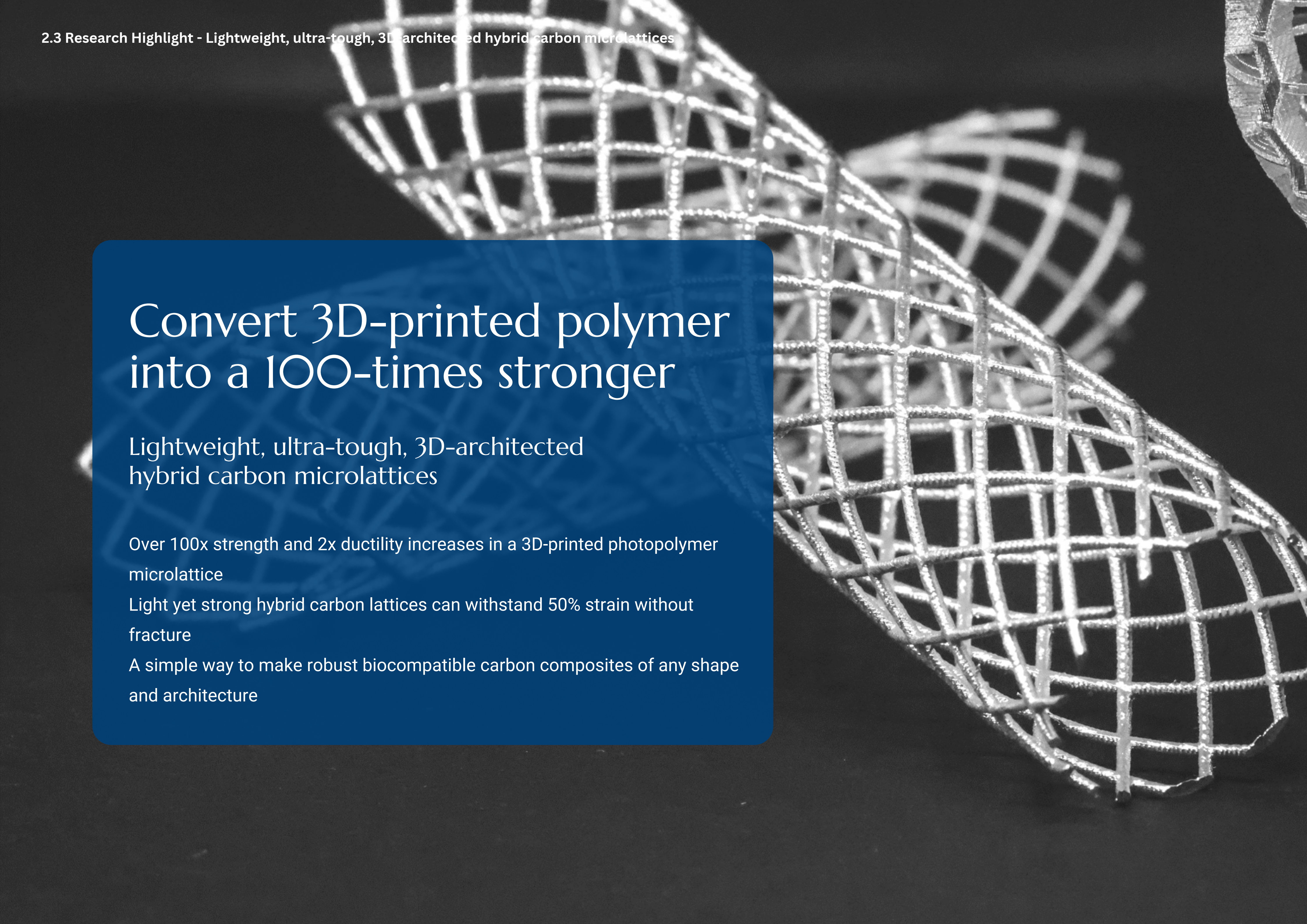
SCIENCE ADVANCES | RESEARCH ARTICLE

ENGINEERING

Bubble energy generator

Xiantong Yan[1,2,3]†, Wanghuai Xu[1,2]†, Yajun Deng[1,4]†, Chao Zhang[1,2], Huanxi Zheng[1], Siyan Yang[1], Yuxin Song[1,2], Pengyu Li[1], Xiaote Xu[1], Yue Hu[5], Luwen Zhang[5], Zhengbao Yang[1], Steven Wang[1], Zuankai Wang[1,2,6]*

Bubbles have been extensively explored as energy carriers ranging from boiling heat transfer and targeted cancer diagnosis. Yet, despite notable progress, the kinetic energy inherent in small bubbles remains difficult to harvest. Here, we develop a transistor-inspired bubble energy generator for directly and efficiently harvesting energy from small bubbles. The key points lie in designing dielectric surface with high-density electric charges and tailored surface wettability as well as transistor-inspired electrode configuration. The synergy between these features facilitates fast bubble spreading and subsequent departure, transforms the initial liquid/solid interface into gas/solid interface under the gating of bubble, and yields an output at least one order of magnitude higher than existing studies. We also show that the output can be further enhanced through rapid bubble collapse at the air/



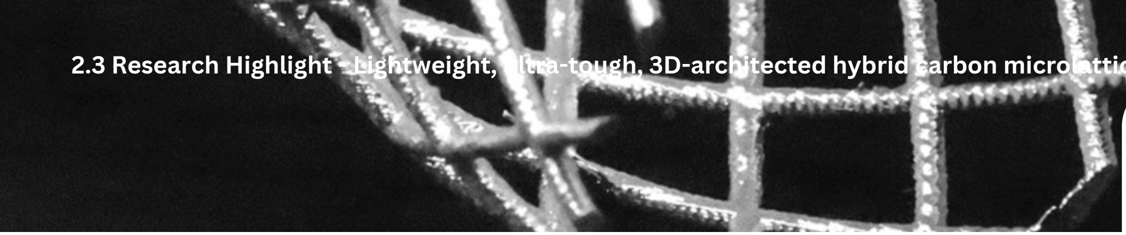
Convert 3D-printed polymer into a 100-times stronger

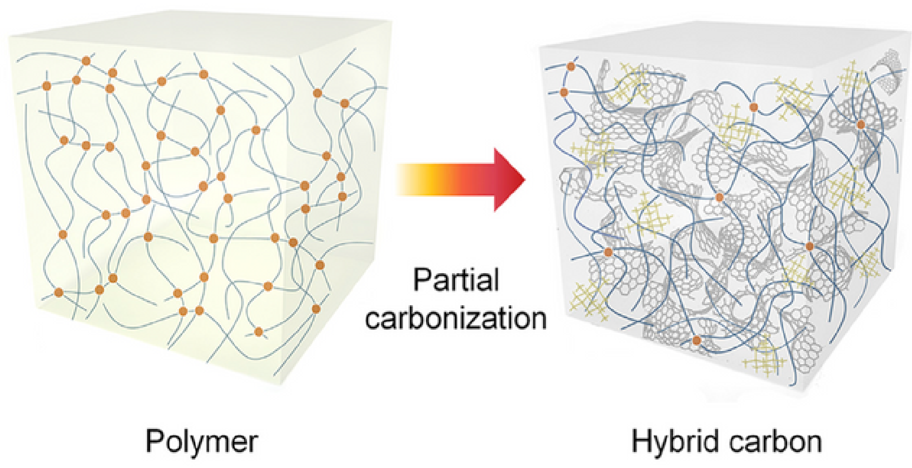
Lightweight, ultra-tough, 3D-architected hybrid carbon microlattices

Over 100x strength and 2x ductility increases in a 3D-printed photopolymer microlattice

Light yet strong hybrid carbon lattices can withstand 50% strain without fracture

A simple way to make robust biocompatible carbon composites of any shape and architecture





Meet the team

Department of Mechanical Engineering, CityU:
James Utama Surjadi, Yongsen ZHOU, Liqiang WANG, Maoyuan LI, Sufeng FAN, Xiaocui LI, Jingzhuo ZHOU, Prof. Zuankai WANG (MNE Chair Professor), Prof. Yang LU (MNE Professor)

Department of Biomedical Engineering, CityU:
Siping HUANG
Dr. Raymond H.W. LAM (BME Associate Head and Associate Professor)

Overview

Fighting the dilemma

The trick to further advancing many of our current technologies has always been engineering a better material. Materials that are lightweight, high strength and ductile are very desirable for certain domains such as Aerospace and Medical implant systems. However, these properties are mutually exclusive. High-strength materials tend to have a high density (weight) and low ductility. Leaving engineers with the critical task of finding the best trade-off for optimal performance. But what if it doesn’t have to be this way?

The Problem

Microlattices | post-processing

Micro/nanolattices have recently emerged as a lightweighting strategy because they benefit from precisely designed geometries. A lattice is a porous network of structs connected in a way that is less brittle, has higher strength and is lower in density than a solid - as struts can support loads in various directions. Bone is a classic example of such structure.

Manufacturing of these complex structures requires additive manufacturing - 3D printing. And 3D printed carbon polymer remains the material of choice compared to 3D printed metal due to cost and stability of print quality.

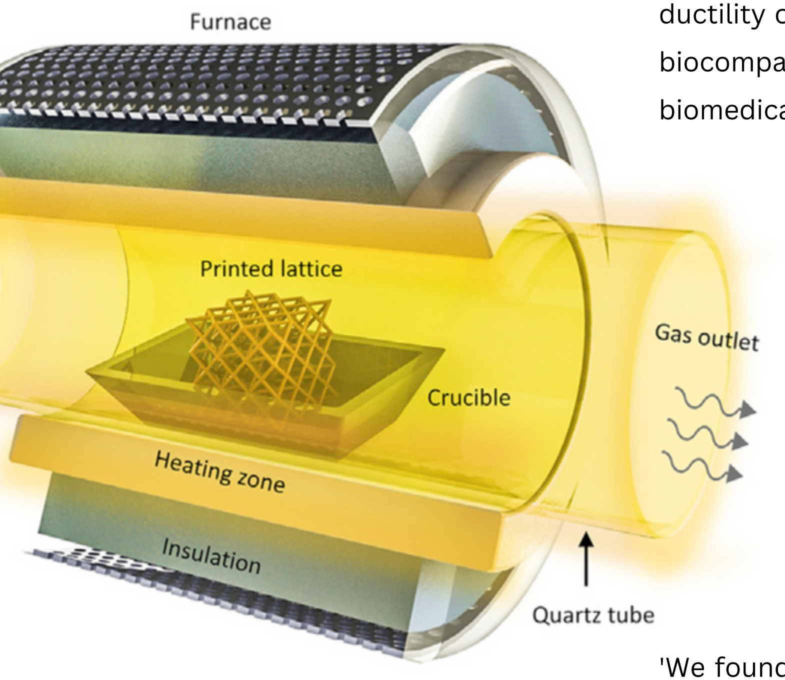
But further strength enhancements are still needed to use 3D printed polymer as functional structural parts. Up to now, pyrolysis has been the most effective post-processing treatment for increasing the strength of these 3D printed structures - that is, by heating the polymer in optimal conditions.

> 'However, pyrolytic carbon lattices exhibit brittle fracture behaviour at low strains (typically around 20% or less), resulting in low toughness that restricts their structural applications.
>
> It also exhibits prominent size effect, where increasing its feature size results in reduced strength and deformability.'
>
> **Utama Surjadi, et al, Lightweight, ultra-tough, 3D-architected hybrid carbon microlattices**
>
> *Cell Press, Matter*, 2022

The innovation

Less is more | Partial Carbonization

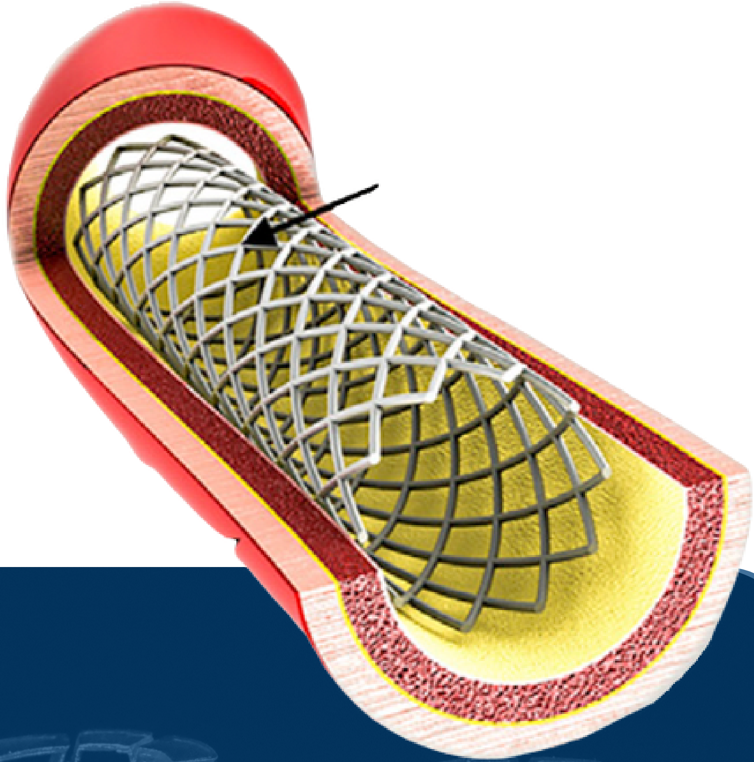
The team discovered a facile method to carbonise pyrolyzed materials partially. That involved heating the printed polymer in optimal conditions, thus increasing the material's strength without compromising ductility or making the treated material brittle. Furthermore, the partially carbonized material has better biocompatibility than its pure polymer counterpart, opening up various new applications such as biomedical use.



Details of the method:

Polymer lattices were heat treated at 200 C for 4 h. This removes moisture and allows a homogenous mixture of polymer and carbon to be formed. And partially carbonized at 350 C in N2 environment at a rate of 3 C min.

'We found that our partial carbonization method could produce a carbon composite microlattice that is both stronger (over 100 times) and more ductile (over two times increase) compared with the pristine polymer microlattice. The lightweight, partially carbonized microlattice exhibits ultra-high specific energy absorption without fracture up to its densification strain, surpassing all other microlattices fabricated created to date.' said the research team



The Impact

The Novel method forms a hybrid carbon/polymer composite only from one starting material, reducing processing time, cost, and defects for the final printed parts. The technology is well suited for biomedical implants with enhanced biocompatibility compared to pure polymer; or even allergic if certain metals were used.

Their findings have successfully demonstrated low-cost, simple, and scalable methods for manufacturing lightweight, strong, and ductile metamaterials with virtually any geometry - for applications across multiple domains.

Read the full paper


Matter

CellPress

Article

Lightweight, ultra-tough, 3D-architected hybrid carbon microlattices

James Utama Surjadi,[1,2] Yongsen Zhou,[1] Siping Huang,[3] Liqiang Wang,[1] Maoyuan Li,[1,4] Sufeng Fan,[1] Xiaocui Li,[1] Jingzhuo Zhou,[1] Raymond H.W. Lam,[3] Zuankai Wang,[1] and Yang Lu[1,2,5,6,*]

SUMMARY

A lightweight material with simultaneous high strength and ductility can be dubbed the "Holy Grail" of structural materials, but these properties are generally mutually exclusive. Thus far, pyrolytic carbon micro/nanolattices are a premium solution for ultra-high strength at low densities, but intrinsic brittleness and low toughness limits their structural applications. Here, we break the perception of pyrolyzed materials by demonstrating a low-cost, facile pyrolysis process, i.e., partial carbonization, to drastically enhance both the

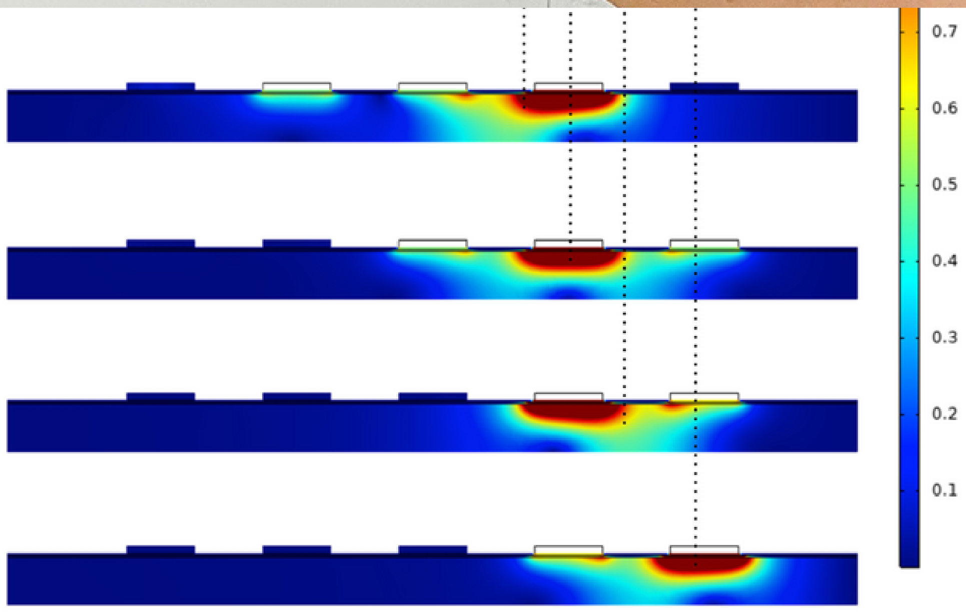
PROGRESS AND POTENTIAL

A lightweight material that is both strong and ductile is ideal for structural applications but challenging to get as they are often mutually exclusive. Pyrolysis of polymer architectures has been shown to yield light and strong, yet extremely brittle, carbon

This technology could let you cuddle your cat in virtual reality

Super-resolution wearable electrotactile rendering system

The sense of touch and haptic feedback is considered to be the missing puzzle for enabling many activities in the virtual world. Researchers at MNE, together with Tencent, have developed a novel wearable electro-tactile rendering system that mimics tactile stimuli.



Meet the team

Department of Mechanical Engineering, CityU:
Weikang LIN, Dongsheng ZHANG, Wang Wei LEE, Xuelong LI, Ying HONG, Qiqi PAN, Ruirui ZHANG, Guoxiang PENG, Hong Z. TAN, Zhengyou ZHANG, Lei WEI, Dr. Zhengbao YANG (MNE Associate Professor)

Overview

The missing puzzle | Touch

Touch is one of five essential human senses.

With displays and cameras, we're able to capture and reproduce sound and sight. Virtual Reality(VR) takes our experience of interacting with the digital world to the next level - with advanced optics enabling depth and perception for better immersion. However, to further improve a better sense of presents, we need a way to reproduce the sense of touch.
From a warm handshake or sympathetic hug to a congratulatory pat on the back. Humans have developed complex body language to aid communication, cultures, and emotional expressions through physical contact. This paper presents a breakthrough tactile rendering technology which fills the gap in advancing the sense of touch in the digital world.

The Problem

Current solutions | limitations

Existing techniques to reproduce tactile stimuli can be classified into two categories - mechanical and electrical stimulation. By applying localized mechanical force or vibration on the skin, mechanical actuators can provide stable and continuous tactile sensations. However, mechanical actuators are bulky. And the spatial resolution of mechanical actuators is limited when integrated into a portable or wearable device.

While the second category of tactile stimuli technique; electrotactile stimulators, can be light and flexible while offering higher resolution and faster responses. They require high voltage to penetrate the outer layer of our skins to activate the nerves. This led to safety concerns, together with the problem of tingling sensations.

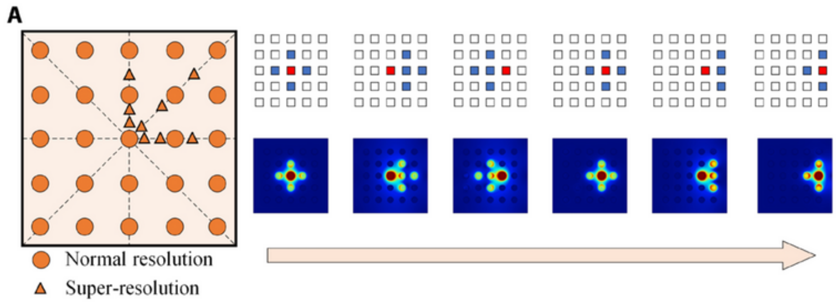
> "When an external force deforms the skin, mechanosensitive ion channels are opened, depolarising the soma of mechanoreceptors and thus triggering action potentials propagated to the somatosensory cortex through peripheral nerve bundles. That's why we can feel a tactile perception. There is no doubt that we cannot use electrical stimulation to mimic the human natural tactile perception, but we need to reduce the high operating voltage and further improve the tactile rendering resolution simultaneously." (From the SCMP interview)

Dr YANG Zhengbao
Associate Professor, MNE

The innovation

Novel super-resolution | Feeling the smallest detail

The newly developed electro-tactile actuator is very thin and flexible, Thinner to a point where it can be integrated into a finger cot easily. This fingertip wearable enables tactile sensations, such as pressure, vibration, and even texture roughness - in high fidelity.



The problem of unsafely high voltage required for penetrating stratum corneum layers (outer layer of the skin) has also been solved. Unlike most electro-tactile stimulators that rely on high voltage direct current pulses to penetrate our skin, The team invented a high-frequency alternating stimulation strategy. They succeeded in lowering the operating voltage under 30 V and ensuring the tactile rendering was safe and comfortable.

Further, the key breakthrough of this research - Ultrahigh tactile resolution, enables a more realistic tactile perception. In previous studies, the number of tactile rendering points depends on the number of electrodes. However, the research team propose a novel super-resolution strategy in which they can render tactile sensation at locations in-between physical electrodes. The team's current steering super-resolution strategy thus increases the spatial resolution four times (from 25 to 105 points) without extra hardware.

The results

Use cases | Making Reality, Virtual

The team have created a wearable electro-tactile rendering system that provides tactile stimuli both with high spatial resolution and rapid refresh rates. The novel current-steering super-resolution stimulation technique reduced the operating voltage below 36 V for user safety. This opened up applications across domains which were previously not possible.

VR/AR are the obvious use cases for this technology. For instance, the high spatiotemporal control of haptic stimulation is well suited for rendering the texture of clothes in a virtual shopping scenario. **Even interacting with pets in the virtual would become possible. The feedback resolution is high enough to provide the feeling of roughness variances when petting a cat's fur.** The sense of touch and haptic feedback is considered to be the missing puzzle for enabling sports in the virtual world - which is one of the most promising markets within the world of VR.

Source: unsplash.com

Another exciting application of this technology is frontier explorations - for astronauts and deep-sea divers. The protective suits of these personnel have a thick insulation layer, and often time it is also pressurized. This prevents intricate motoring tasks from being performed by hand because of the lack of senses.

The technology can restore high-fidelity tactile perception that is currently unavailable. By integrating the newly developed electrotactile rendering system into the protective glove, sensors capture pressure distributions on the glove's surface and relay the information to the user in real time through tactile stimulation. For example, this allows the user to quickly and accurately locate a tiny steel washer using only tactile feedback from the sensorized glove.

The Impact

The idea for all of these is that one day we could truly have a sense of presents in the virtual world. And when that happens, much more good use of the technology will be developed - not only for entertainment but also for professional use cases like virtual training or even 5G remote surgery.

Read the full paper

SCIENCE ADVANCES | RESEARCH ARTICLE

ENGINEERING

Super-resolution wearable electrotactile rendering system

Weikang Lin[1,2]†, Dongsheng Zhang[1]†, Wang Wei Lee[1]†, Xuelong Li[1], Ying Hong[2], Qiqi Pan[2], Ruirui Zhang[1], Guoxiang Peng[1], Hong Z. Tan[1]‡, Zhengyou Zhang[1], Lei Wei[1]*, Zhengbao Yang[2]*

The human somatosensory system is capable of extracting features with millimeter-scale spatial resolution and submillisecond temporal precision. Current technologies that can render tactile stimuli with such high definition are neither portable nor easily accessible. Here, we present a wearable electrotactile rendering system that elicits tactile stimuli with both high spatial resolution (76 dots/cm^2) and rapid refresh rates (4 kHz), because of a previously unexplored current-steering super-resolution stimulation technique. For user safety, we present a high-frequency modulation method to reduce the stimulation voltage to as low as 13 V. The utility of our high spatiotemporal tactile rendering system is highlighted in applications such as braille display, virtual reality shopping, and digital

Alumni Stories

Q & A

Mr. LAM Wah Shing, Henry
(Alumni of MNE, formerly MBE)

By

MNE General Office

Mr LAM Wah Shing

BEng (Hons) Mechatronic Engineering (MNE, formerly MBE)

PhD Candidate, Biomedical Engineering (BME)
Co-founder and Chief Executive Officer

> Be thoughtful in how you can be most beneficial to the world by utilizing your current skills

The day we spoke to Henry was a tough day: Hong Kong has been fighting its waves of COVID just like every other country. Society restrictions and perpetual covid testing have slowed down too much of our life. But for Henry, there is no time to be slowed.

Henry is our graduate from the class of 2018 in BEng Mechatronic Engineering. During his undergraduate study, he created a robotic transfer wheelchair which helps the disabled to live their lives more convenient and independent when their caregiver is not around. The project later became Henry's first company and was funded by the HKTECH 300 start-up fund. After graduating, he continues his innovation journey by pursuing a PhD in Biomedical Engineering and, at the same time, continuing to grow his company.

Henry is a driven person with the thirst for helping people. Read on to know him better in his own words.

Tell us a bit about the work you're doing now?
I am currently a PhD candidate in biomedical engineering at City University of Hong Kong. Working on knee joint regeneration therapy with microrobots and stem cells. Besides the scientific research, I found Asa Robotics Limited, a robotic start-up working on a universal robot analytic and management platform (RAMP). RAMP can make robot deployment and service more intelligent and efficient.

Can you tell us more about the company and its mission?
ASA Robotics Limited is a robotic startup that provides vendor-independent robotic management platforms and AI-based data analysis services for enterprises, property management agencies and the government. ASA spun off from City University of Hong Kong (CityU) in 2021. It is funded by HKTech300 Angel Fund, CityU TSSSU, SEED and HKSTP incubation program concurrently. All ASA founders have engineering backgrounds and technical advisors are prestigious professors from CityU and Centre for Artificial Intelligence and Robotics, Hong Kong Institute of Science & Innovation, Chinese Academy of Sciences. Our vision is to connect and maximise robotic applications, and provide more intelligent robotic solutions.

What do Science and Entrepreneurship mean to you?
Science is about discovering, and understanding the fundamental principle of how our world works. Entrepreneurship is about creating something that has value to others and can make some changes and impact to society.

Can you tell us about your journey from ME student to starting your company? (from family story, having the idea, making a prototype (horizon) and seeing a more significant need (RAMP)
When I was a year two student, I remember a case in that I saw a wheelchair user who couldn't get into a taxi himself, and that scenario inspired me to think about what I could do as an engineering student to solve the problem. Can I build something to help those who are in need of help? After some brainstorming I would like to invent a patient transfer wheelchair at that time. Still, as a junior student, I didn't have much professional knowledge and resources. **Hence, I emailed my department head (Mechanical and Biomedical Engineering) to request some resources to work on the project. The department heads arranged a lab resource and technician to guide me in building the wheelchair.** During the creation process, I learnt a lot about the science and engineering principle of wheelchairs and product engineering. Eventually, that transformable wheelchair was successfully built and got many awards and recognition. CityU emphasises and spends resources to encourage students to have hands-on experience and start their own innovation journey. After graduation, I decided to study PhD in CityU to continue my innovation and technology journey. My PhD advisor is professor SUN Dong and his motto is that:

> **'Every engineering research and innovation needs its application. As researchers, we must transfer our knowledge into tangible value to society.'**

The motto encourages me to put my invention which is the patient transfer robot into a business and hope to help as many people as possible...

...Besides the patient transfer robot hardware, we also worked on robotic software which is RAMP, a centralise robot management platform that simplifies the robot deployment process and make robot smarter with software packages.

> **RAMP is the only centralized management platform and standard for robot-robot and robot-building communication in the future.**

Tell us a bit more about HK Tech 300?
(Journey to winning the seed and angel fund)
HKTech300 is a flagship entrepreneur program aiming to encourage and facilitate the Hong Kong entrepreneurship ecosystem. The program offers seed fund and angel funds. The seed fund that has 100K HKD requires the team to have a clear picture of the business model and technology roadmap. Once the team finishes the minimum viable product/prototype, the team can graduate from the seed program and apply for an Angel fund with 1 million HKD support. The Angel fund is more demanding because it requires us to really built the product with core technology and also needs to close a business deal or pilot projects with clients.

What is the highlight, lowlight and challenge when working toward a PhD and starting your company?
As a PhD candidate, we always have lots of lowlights and challenges as you can see from PhD wording (Permanent head Damage). We conduct a research project for four years and many experiment results don't meet the expectations so we need to pivot the original approach and start again. The uncertainty and competition from other researchers who might also have similar ideas did create lots of pressure on me. But with the guidance from supervisors and lab mates, I was able to deliver the expected results and outcomes. The highlight parts always come from the recognition of works done by other people like supervisors, peer researchers and public like getting awards, compliments for my research and startup product.

What are your future plans?
Complete my PhD study and expand ASA Robotics business to make ASA a unicorn startup in the coming seven years.

Any suggestions for future students?
Be thoughtful in how you can be most beneficial to the world by utilizing your current skills.

'Opportunities are out there; grab them proactively.'

4

News & Notable

Pursue your dream in one of Asia's best city

Research Grants Council (RGC) of Hong Kong - Hong Kong PhD Fellowship Scheme (HKPFS)

'Established by the Research Grants Council (RGC) of Hong Kong in 2009, the Hong Kong PhD Fellowship Scheme (HKPFS) aims at attracting the best and brightest students in the world to pursue their PhD studies in Hong Kong' - Read more on HKRGC website.

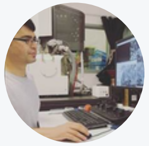
The Fellowship provides the following for each awardee for three years:

- **a yearly stipend of USD41,692 (~ HK$325,200)**
- **conference and research related travel allowance of USD1,744 (~HK$13,600) per year**
- **In addition, CityU will award each successful Fellowship recipient a Scholarship, which covers students' tuition and on-campus hostel accommodation fees in their first year of research studies and provide a full stipend to support the fourth year of PhD study.**

My main research is focused on novel electrode materials for energy storage systems, particularly super-capacitors. In general, fossil fuel is continuously depleted, and adverse effects have been noted in our surroundings, like the emission of greenhouse gases, climate change, and harmful effects on human health. Thus, there is strong support amongst government and even researchers like me to provide clean, green, and renewable energy sources and their storage that can replace nonrenewable energy.

With the Hong Kong Ph.D. Fellowship Scheme (HKPFS) granted to me in my Ph.D. studies, I was fortunate to study and develop new and novel materials that can be used as batteries and super-capacitors.

The scheme also helped me to collaborate and be in an exchange program under the supervision of Professor Yury GOGOTSI in the United States. There, I enjoyed international conferences, cultural exchange programs, talked to leading scientists and engineers, and made numerous collaborations that I look forward to working with them in the future. Because of the support of the HKPFS, I was fortunate to publish dozens of scientific papers together with collaborative works in Australia, South Korea, the United States of America, the United Arab Emirates, Turkey, etc., and win awards. All these achievements were not possible without the support of HKPFS, City University of Hong Kong, and my supervisor, Professor ZHANG Kaili.



Mr HUSSAIN Iftikhar
HKPFS Awardee, MNE PhD Student

Application Procedures and Deadlines

CityU Hong Kong PhD Fellowship Scheme Website

Hong Kong PhD Fellowship Scheme

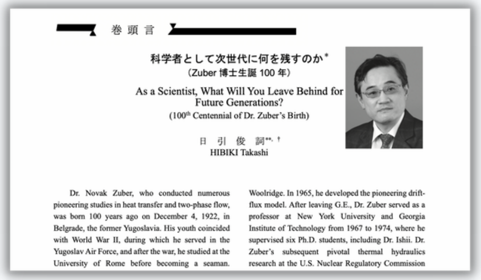
RGC HKPFS Website

Making nuclear power safer

Improvement of constitutive equations for best estimate accident analysis of light water reactor

We are honoured to announce Prof. HIBIKI has been granted the project 'Improvement of constitutive equations for best estimate accident analysis of light water reactor' from the Secretariat of Nuclear Regulation Authority, Japan.
The project will further enhance the safety of light-water nuclear reactors, making it one step closer toward a carbon-neutral future.

> **The S-NRA considers that Prof. HIBIKI is the only scientist to perform this project in the world**
>
> Secretariat of Nuclear Regulation Authority (S-NRA)
>
> Japan



巻頭言

科学者として次世代に何を残すのか*

（Zuber 博士生誕 100 年）

As a Scientist, What Will You Leave Behind for Future Generations?

(100th Centennial of Dr. Zuber's Birth)

日 引 俊 詞**, †

HIBIKI Takashi

Dr. Novak Zuber, who conducted numerous pioneering studies in heat transfer and two-phase flow, was born 100 years ago on December 4, 1922, in Belgrade, the former Yugoslavia. His youth coincided with World War II, during which he served in the Yugoslav Air Force, and after the war, he studied at the University of Rome before becoming a seaman. Woolridge. In 1965, he developed the pioneering drift-flux model. After leaving G.E., Dr. Zuber served as a professor at New York University and Georgia Institute of Technology from 1967 to 1974, where he supervised six Ph.D. students, including Dr. Ishii. Dr. Zuber's subsequent pivotal thermal hydraulics research at the U.S. Nuclear Regulatory Commission

'As a scientist, what will you leave behind for future generations?'

Prof. HIBIKI Takashi

Chair Professor of Thermal-Fluid Engineering

Department of
Mechanical Engineering

香港城市大學
City University of Hong Kong

THANK YOU

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