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

MNE Newsletter

In this issue, we introduce two of our colleagues and highlight our recent significant research achievements, which were published in Nature Materials and Nature Communications. We are also proud to introduce our wide variety of alumni and students from around the world.

Department of Mechanical Engineering
香港城市大學
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Prof. DAOUD Walid

Research Interest

- Approaches for harvesting light and kinetic energies
- Hybrid nanogenerators for self-powered wearable electronics
- Flexible organic-based photovoltaics
- Compatible energy-storage batteries
- Solar wearable self-cleaning nanotechnology

Prof. Daoud graduated from the University of Technology Graz, Austria, with a Dipl-Ing degree (BS and MS) in Chemical Engineering and received his PhD in flexible bilayer photovoltaic cells from the University of Sheffield, UK. In 2002, he joined the Hong Kong Polytechnic University, where he played a substantial role in the establishment of the Nanotechnology Center in 2003 and took up a lectureship in 2005. In 2007, he moved to Monash University, Australia, as a lecturer and was promoted to senior lecturer in 2010. He joined City University of Hong Kong in 2012 and served in various administrative roles, including Programme and Stream Leader and Associate Dean for Research and Postgraduate Studies.

Prof. Daoud's current research is focused on energy harvesting and smart wearable technologies. His group is developing approaches for harvesting free or waste energy, such as light and kinetic energies. It is equally important to find storage solutions for this form of energy, as it is intermittent in nature. Therefore, his group is interested in the modelling and design of compatible energy-storage batteries. Prof. Daoud has received international renown and several awards for his pioneering work on wearable solar and kinetic energy harvesting technologies. His research has been featured in Nature (2004) and Science (2008) and the international media, such as Reuters (2014), the BBC (2015), the SCMP (2017), Physics World (2021), and PV Magazine (2022). He has been invited to give plenary and keynote lectures at international conferences, and is currently serving as Chief Editor of Wearable Electronics, Frontiers in Electronics, and is an Advisory/Editorial Board member of the Journal of Power Sources, Advances and Industrial Chemistry & Materials.

Prof. ZHU Pingan

Research Interest

- Microfluidics
- Fluid dynamics
- Wettability
- Micro/Nanofabrication
- Micro/Nanoscale motors/ actuators

Prof. Zhu Pingan received his Bachelor's degree from the University of Science and Technology of China in 2013 and a PhD in Mechanical Engineering from the University of Hong Kong (HKU) in 2017. He is currently an Assistant Professor in the Department of Mechanical Engineering at the City University of Hong Kong (CityU). Before joining CityU, he worked as a postdoctoral fellow in Prof. Liqiu Wang's group at HKU and in Prof. Joanna Aizenberg's group at Harvard University from 2017 to 2020. His research focuses on microscale fluid flows, including microfluidics, fluid dynamics, surface wettability, micro/nanorobots, and biomimetics, and is aimed at addressing key issues in multidisciplinary fields such as energy, environment, engineering, and biomedicine by combining fundamental and applied studies.

Prof. Zhu has developed a versatile platform, referred to as microfluidics-enabled soft manufacture (MESM), for fabricating materials with tailorable properties and functionalities by using microfluidics-produced fluid systems as soft templates. MESM holds great promise for overcoming the long-standing challenge of simultaneously achieving high-precision and mass production of micro-/nano-mechanical systems, which would trigger a paradigm shift in advanced manufacturing around the globe. Compared with existing micro/nanofabrication technologies, MESM has three advantages: (1) MESM is compatible with diverse fluidisable materials, such as polymers, hydrogels, particulates, and stimuli-sensitive materials; (2) due to the deformable nature of soft fluid templates, materials fabricated using by MESM can have rich and diverse structures, including particles/capsules, fibers, and porous membranes; (3) MESM combines the virtues of bottom-up and top-down fabrication approaches, allowing both precise control and scalable fabrication of functional materials, and bridging the long-standing gap in advanced manufacturing with vastly-varied length scales. Prof. Zhu has demonstrated the promising potential of MESM for applications in diverse fields including micromotors, microactuators, drug delivery, wound dressing, water treatment, water harvesting, liquid transport/manipulation and heat transfer.

Morphing of inorganic perovskites without damaging their functional properties

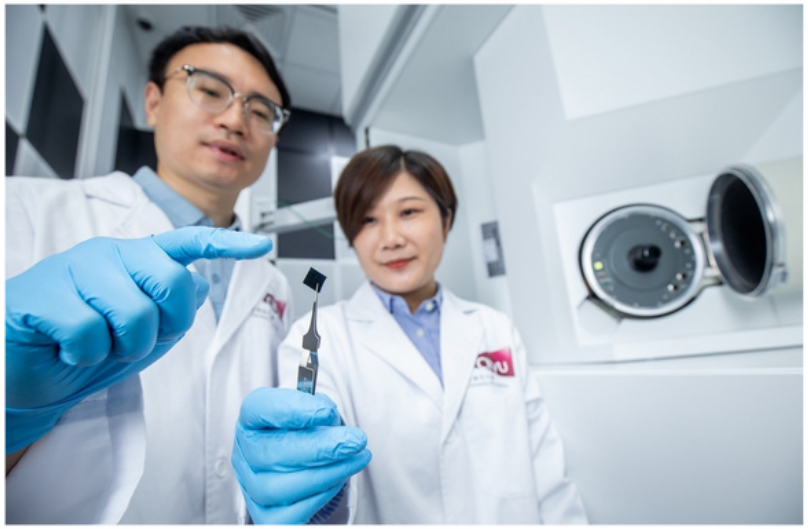
A research team co-led by scholars from City University of Hong Kong (CityU) has **morphed all-inorganic perovskites at room temperature without compromising their functional properties**. Findings demonstrates the potential of this class of semiconductors for use in the manufacturing of next-generation deformable electronics and energy systems.

Front row, from left: **Professor ZHAO Shijun**, and **Adjunct Professor LU Yang** of the MNE department (CityU), Professor **Johnny HO Chung-yin**, Associate Head and Professor of the Department of Materials Science and Engineering. Back row, from left: **Dr MENG You** and **Dr LI Xiaocui**, postdocs of the Department of Materials Science and Engineering.

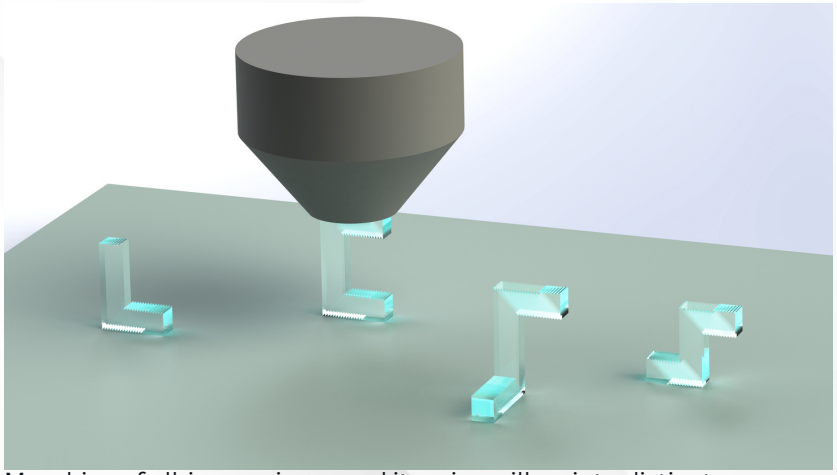
2 Research Highlight - 2.1 Multislip-Enabled Morphing of All-Inorganic Perovskites

“All-inorganic lead halide perovskites are becoming increasingly important semiconducting materials in energy conversion and optoelectronics because of their outstanding performance and enhanced environmental stability. However, unlike metal materials or polymers, inorganic semiconductors are often brittle and hard to process. This greatly restricts their applications in optoelectronic products that must withstand mechanical stress and strain without losing their functionality,” said **Professor CHEN Fu-Rong**, Associate Vice-President (Mainland Collaboration) and Chair Professor of Materials Science at CityU, who co-led the study.

To overcome this limitation, a research team led by Professor CHEN, along with Professor Johnny HO Chung-yin, Professor ZHAO Shijun, and Professor LU Yang, explored the deformability of all-inorganic perovskites ($CsPb_3$ where X can be a Cl, Br, or I ions). They found that perovskites can be substantially morphed into distinct geometries at room temperature while preserving their functional properties, which is an unprecedented achievement in the field of conventional inorganic semiconductors.



The sample in the photo is a photodetector constructed from morphed perovskites



Morphing of all-inorganic perovskite micropillars into distinct geometries through multislip

The impact

“This achievement represents a significant step towards designing and manufacturing innovative energy devices and deformable electronics. The underlying mechanism, uncovered by TEM at the atomic level has important implications for the search for other intrinsic ductile semiconductors,” **Professor CHEN** added.

Read the full paper on


nature materials

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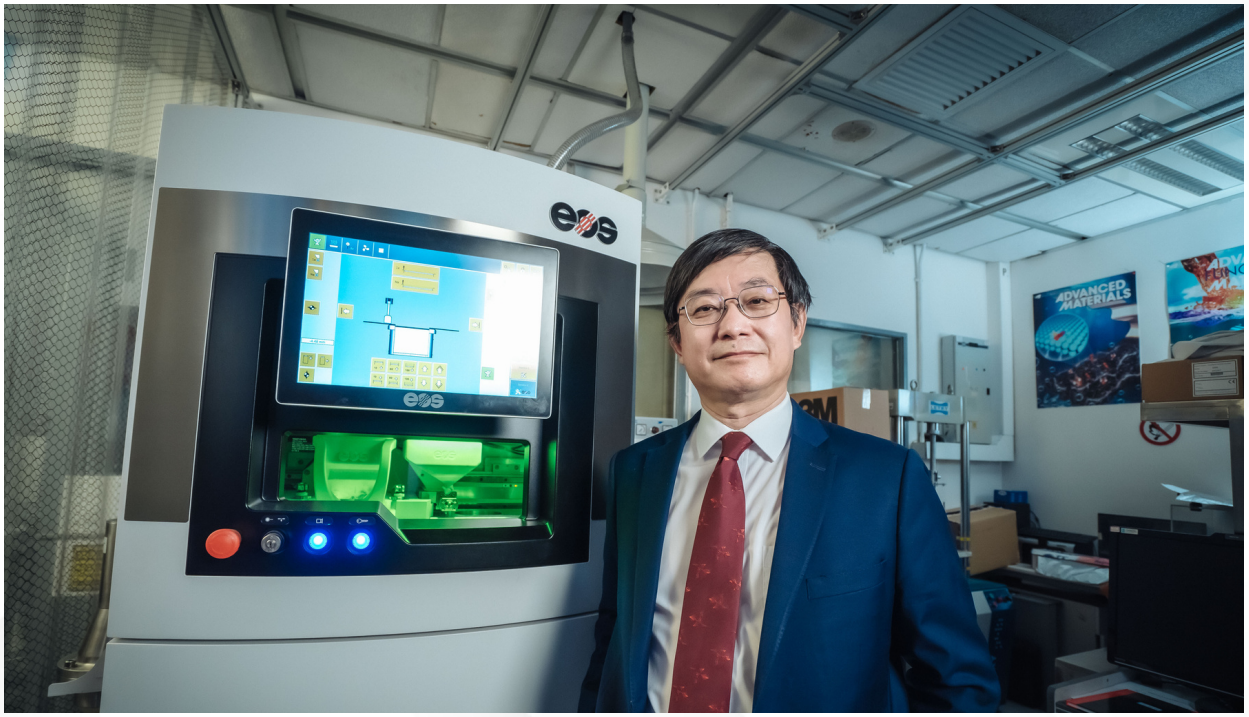
Article | Published: 14 August 2023

Multislip-enabled morphing of all-inorganic perovskites

Xiaocui Li, You Meng, Wanpeng Li, Jun Zhang, Chaoqun Dang, Heyi Wang, Shih-Wei Hung, Rong Fan, Fu-Rong Chen ✉, Shijun Zhao ✉, Johnny C. Ho ✉ & Yang Lu ✉

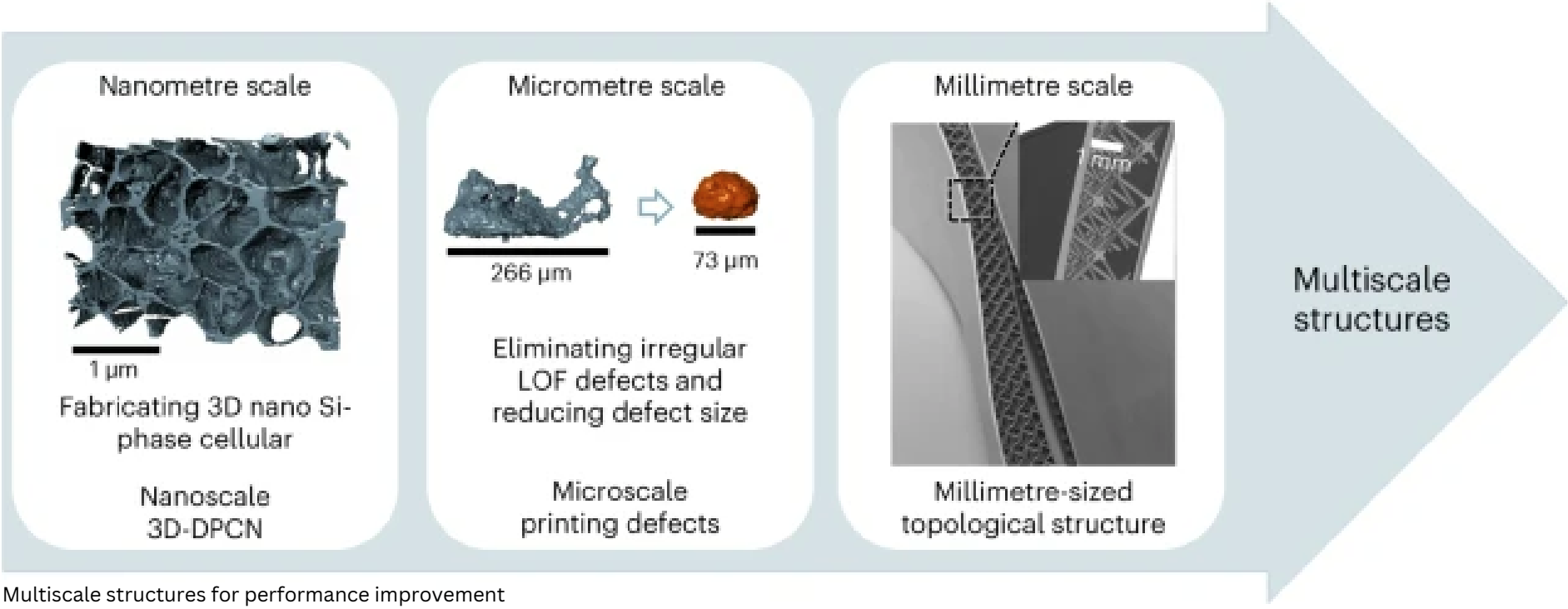
Achieving ultrahigh fatigue resistance in AlSi10Mg alloy by additive manufacturing

It is estimated that over 80% of engineering failures are due to material fatigue, and so the fight against metal fatigue failure continues, as it is a key parameter of lightweight structures in all mechanical systems, such as aircraft, automobile, and energy-production systems. Recently, joint research by City University of Hong Kong (CityU) and Shanghai Jiao Tong University achieved a breakthrough by creating an aluminum alloy with unprecedented fatigue resistance using advanced 3D printing techniques. The new fatigue-resistance strategy can also be applied in other 3D-printed alloys to help develop lightweight components with increased load efficiency for various industries.



Prof. LU, Jian, Dean of College of Engineering, Chair Professor of MNE

“The fatigue phenomenon in metals was discovered about two centuries ago. Since then, fatigue failure has become one of the most important factors affecting the lifespan and reliability of all dynamic mechanical systems, such as those in aircraft, automobiles and nuclear power plants,” said **Professor Lu Jian**, Dean of College of Engineering, and Director of the Hong Kong Branch of the National Precious Metals Material Engineering Research Center (NPMM) in CityU, who co-led the research.



Multiscale structures for performance improvement

Conventional metals typically exhibit fatigue strengths that are less than half of their tensile strengths. “Low fatigue strength is caused mainly by multi-scale defects in materials, that continue to grow and evolve with cyclic loading, forming macroscopic cracks and eventually expanding into larger cracks that destroy the entire structure of materials,” Prof. LU explained. “This challenging phenomenon also occurs in alloys produced by additive manufacturing (also known as 3D-printing) limiting further applications of 3D-printed materials.”

The Impact

The team's NTD-AI alloy has already been used to fabricate prototypes of large thin-walled structures, including the fan blades of aircraft engines which require high fatigue strength, and has successfully passed the qualifying fatigue test.

"These findings indicates the potential applicability of our alloy for the lightweight structures necessary in industries where fatigue properties are the key design criterion. Our alloy can help reduce weight by increasing the load efficiency of moving components".

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Article | Published: 17 August 2023

Achieving ultrahigh fatigue resistance in AlSi10Mg alloy by additive manufacturing

Chengyi Dan, Yuchi Cui, Yi Wu, Zhe Chen ✉, Hui Liu, Gang Ji, Yakai Xiao, Han Chen, Mingliang Wang, Jun Liu, Lei Wang, Yang Li, Ahmed Addad, Ying Zhou, Siming Ma, Qiwei Shi, Haowei Wang & Jian Lu ✉

Nature Materials **22**, 1182–1188 (2023) | Cite this article

6062 Accesses | **1** Citations | **56** Altmetric | Metrics

The Problem

Vanadium redox flow batteries (VRFBs) promise a route to low-cost and grid-scale electricity storage based on using renewable energy resources. However, the interplay of mass transport and activation processes in high-loading catalysts makes it challenging to access high-performance density VRFB.

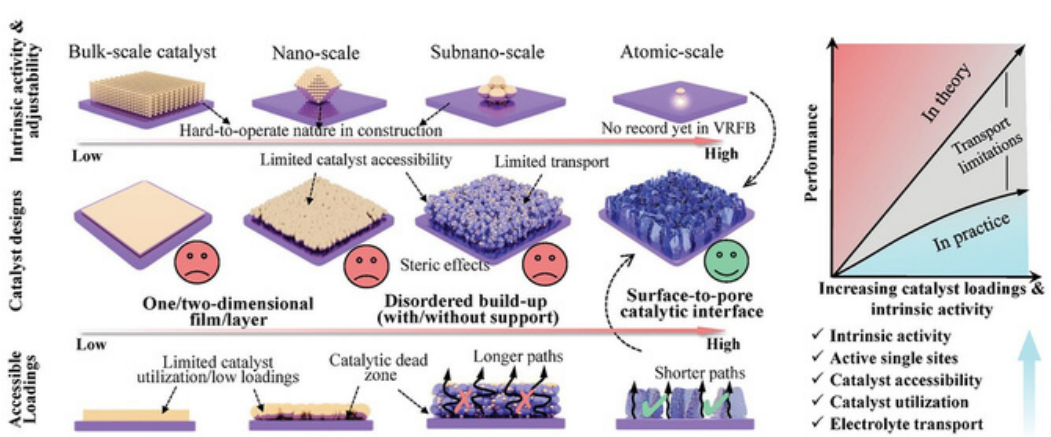
The Innovation

We have developed a surface-to-pore interface design that unlocks the potential of atomic-Bi-exposed catalytic surfaces by decoupling activation and transport. The functional interface accommodates an electron-regulated atomic-Bi catalyst in an asymmetric Bi-O-Mn structure that expedites the V^{3+}/V^{2+} conversion, and a mesoporous M_3O_4 sub-scaffold for rapid shuttling of redox-active species, whereby the site accessibility is maximised, contrary to conventional transport-limited catalysts. By in-situ grafting this interface onto micron-porous carbon felt (Bi1-sM_3O_4-CF), a high-performance flow battery was achieved, yielding a record high energy efficiency of 76.72%, even at a high current density of 400 mA cm^{-2} and a peak power density of 1.503 W cm^{-2}, outdoing a battery with sM_3O_4-CF (62.60%, 0.978 W cm^{-2}) without a Bi catalyst. Moreover, this VRFB had an extraordinary durability of over 1500 cycles, representing a crucial advance towards sustainable RFBs.

The impact

This study addressed critical challenges in conventional catalyst designs, aiming to substantially upgrade VRFB performance while sustaining remarkable durability to encourage widespread adoption of VRFBs.

Prof. DAOUD Walid and his team



Problems with current catalysts used in VRFB, design criteria for an ideal catalytic interface, and activation and transport aspects of proposed solution.

Read the full paper

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Decoupling Activation and Transport by Electron-Regulated Atomic-Bi Harnessed Surface-to-Pore Interface for Vanadium Redox Flow Battery

Xiangyang Zhang, Agnes Valencia, Weilu Li, Kelong Ao, Jihong Shi, Xian Yue, Ruiqin Zhang, Walid A. Daoud

First published: 22 August 2023 | https://doi.org/10.1002/adma.202305415 | Citations: 1

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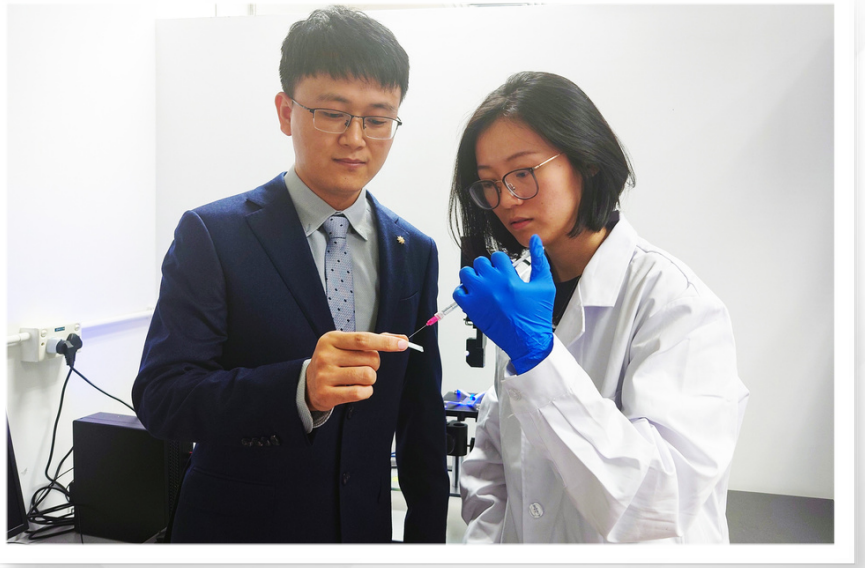
Suppression of Hollow Droplet Rebound on Super-Repellent Surfaces

The Problem

Droplet rebound is an ubiquitous phenomenon on super-repellent surfaces and the interaction between kinetic and surface energies suggests that rebound suppression is unachievable due to negligible energy dissipation during the conversion.

The Innovation

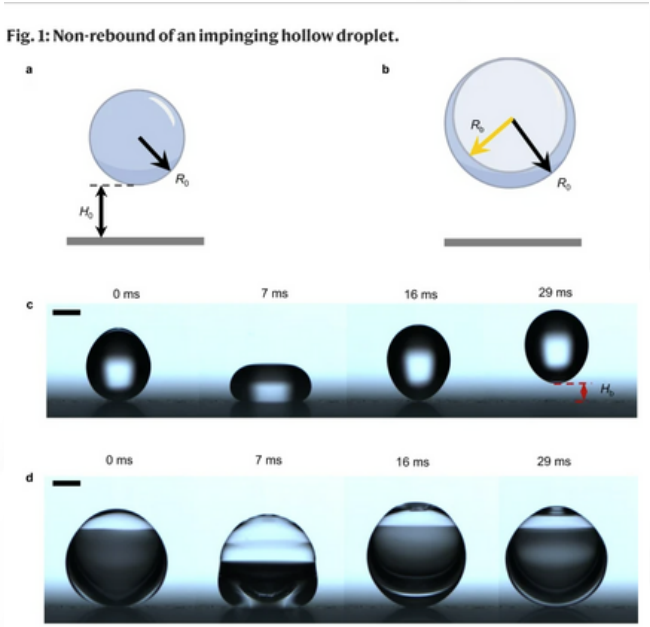
We devised an effective approach to suppressing rebounds even in super-repellent states by incorporating bubbles into droplets. This suppression arises from the counteractive capillary effects within bubble-encapsulated hollow droplets. The capillary flows induced by a deformed inner-bubble surface counterbalance those driven by the outer-droplet surface, resulting in a reduction of the effective take-off momentum. We propose a double-spring model with reduced effective elasticity to accent for the behaviour of the hollow droplets, wherein the competing springs offer distinct behavior from the classic single-spring model employed for single-phase droplets. Through experimental, analytical, and numerical validations, we established a comprehensive and unified understanding of droplet rebound, revealing that the behavior of single-phase droplets represents the exceptional case of zero bubble volume and can be encompassed within our overarching framework.



Prof. ZHU Pingan (left) with his Research Assistant Miss ZHOU Ying

The impact

The ability to suppress droplet rebound presents exciting prospects for the advancement of droplet-based shock absorbers. These can facilitate non-sticking liquid deposition, which has practical applications in various fields, such as spray cooling, self-cleaning, inkjet printing, agricultural spraying, liquid transport, and fire extinguishing.



Non-rebound of an impinging hollow droplet

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Article | Open access | Published: 04 September 2023

Suppression of hollow droplet rebound on super-repellent surfaces

Ying Zhou, Chenguang Zhang, Wenchang Zhao, Shiyu Wang & Pingan Zhu

Nature Communications **14**, Article number: 5386 (2023) | Cite this article

First NRE Graduate Achieved His Professor Dream

Prof. PAN Chin, Head of MNE, visited Dr. WANG Longcong at the Nuclear Power Simulation Research Center of Harbin Engineering University

Dr. WANG Longcong was a graduate of the second cohort of NRE (Nuclear and Risk Engineering) Programme and he is now teaching at the College of Nuclear Science and Technology of Harbin Engineering University, a top tier university in Mainland China. We are delighted to interview Dr. WANG in this issue.

1: What made you decide to take NRE at CityU back when you were choosing your major?

When I was at the crossroads of selecting my major, I realised it would be a critical decision for me as I would dedicate the rest of my career to that field. Additionally, it was a tough and challenging decision. I reviewed the curriculums of the majors in the Bachelor of Engineering programme and was finally drawn to NRE. Honestly, I was not perfectly sure what nuclear engineering and risk engineering were at that time, but this ambiguity ignited my curiosity. This eagerness to figure out these questions was definitely a major reason I took the path of NRE.

2: How would you describe your days at CityU?

Overall, my days at CityU left me with tons of valuable memories. I can still vividly recall the times with my friends, the supportive department staff, and the inspiring faculty members in my programme. Those days were a mixture of joy and dedication. I took time to act as a tourist and enjoy the wonderful cityscape of Hong Kong, while I also dedicated myself to preparing for final exams and course projects.

The days at CityU prepare me for my future career and motivated me to pursue an academic career. Those days were foundational, definitely contributing to my success and help to shaping the person I am today.

3 Outstanding alumnus - First NRE Graduate Achieved His Academic Dream

3: Please tell us a bit about your background and current career?

I started my studies at CityU in 2013 and obtained a degree of Bachelor of Engineering in NRE. After completing my undergraduate study at CityU, I pursued studies in nuclear engineering at the University of Illinois at Urbana-Champaign where I obtained a master's degree. Then, I finished my doctorate at North Carolina State University. During my PhD studies, I focused on exploring the trustworthiness of an AI/ML-supported nearly autonomous control system for nuclear reactors.

In 2023, I joined the College of Nuclear Science and Technology at Harbin Engineering University and started my academic career here. I currently hold a tenure-track faculty position at the Nuclear Power Simulation Research Center. I am continuing my research at the trustworthiness of AI/ML applications in nuclear engineering. Additionally, I am engaged in pioneering new paradigms in nuclear reactor safety analysis.

4: What is your vision and an ultimate goal of your career?

I have two academic goals and visions.

As a teacher or educator, I am obliged to deliver high-quality courses to both undergraduate and graduate students, so my first goal is to help students grasp the core of nuclear engineering and realise their responsibilities. By sharing my knowledge and experience with them, I aim to prepare them for their future careers. In addition, I am looking forward to witnessing the growth and future success of students under my supervision.

Second, from the perspective of research, my goal is to contribute to and shape the field. Given the growth in AI technologies and their potential, I have dedicated my research to assessing and improving the trustworthiness of AI in nuclear applications. I hope that my research will make the nuclear engineering communities, especially regulatory bodies, ready to implement cutting-edge AI technologies. Finally, safety and economy are critical to nuclear engineering. Pioneering new safety analysis approaches, I hope that my research will contribute to safer nuclear reactors and better understandings of nuclear reactor safety.

5: What have you learnt throughout the years that you would like to share with our students?

Although it has been some time since I graduated from CityU, I would still consider myself in the early stages of my career and life journey. Thus, I am still continually learning, and may not be able to share many deep insights. Until now, the most critical lesson I learned in my academic study is to be active. This means actively engaging in learning, actively asking questions, actively trying, and even actively embracing opportunities to learn from mistakes.

Go beyond what you have been taught and beyond the textbook. Every single piece of knowledge is connected to many others, so actively learning new knowledge can help you articulate your own answers to questions. Do not hesitate to ask. Learning from others and communicating with others by asking questions are effective and efficient learning strategies. Additionally, nothing can be done without trying. Trying new paradigms and approaches can be essential, as it can correct your path and correct the mistakes you made along your old path. Do not be afraid to make mistakes when you are trying new things, and do not become frustrated when you make mistakes. No one is free of mistakes, and the only difference is that some people learn from them.

10 Students were Admitted to TIGER Programme

We were proud to admit ten TIGER students from seven different countries to our department in the 2023 cohort. They came from China; Indonesia; Kazakhstan; Kyrgyzstan; Nigeria; Pakistan; and Thailand;. The TIGER Programme targets newly admitted undergraduate students with outstanding academic performance and high-achieving first-year students. We were delighted to welcome these elite students to MNE.

The programme aims to benefit society by nurturing the talent of tomorrow and transforming students into future global leaders. With constant guidance and support from our world-class faculty members, these talented students enrich their knowledge, cultivate their expertise in their respective fields of study, and prepare themselves for a promising future. Overall, the programme brings together high-flying students to pursue intellectual excellence and develop their potential through inspirational, interactive, and innovative learning.

5.1 CityU Undergraduate Information Day 2023

The Information Day was held on 7 October 2023, and was a great success for the MNE Department. We were very excited to host the event in full-scale physical mode for the first time since 2019, as we could interact and communicate with the visitors at our exhibition booth. This year, we had our first ever robot demonstration by Prof. YIN Peng and his team in the morning session. The University received approximately 20,000 visitors (including prospective students and parents) during the day.

We provided two Admission Consultation Sessions, Alumni Sharing Sessions, and programme talks in our three major subject areas: Aerospace Engineering, Mechanical Engineering, and Nuclear and Risk Engineering. We also provided guided tours of our laboratories and the CLP Power Low Carbon Energy Education Centre, respectively. The talks and tours attracted over 250 people. Moreover, as we did last year, we invited one of our current PhD students (who is also an M.E. graduate of the department) to share some admission and career tips and experiences with our visitors.

5.2 Closing Ceremony of the HKIE Mentorship Programme 2023

Group photo of mentors
From left to right: Miss Kathy YEUNG; Ir. Annie KOU; Ir. Oliver CHAN; Dr. Francis LEE; Prof. Ir Prof Ken CHEUNG; Prof. PAN Chin; Ir Prof Ken CHEUNG ; Dr. BL LUK; Prof. Alice HU; Mr. Henry KWOK; Mr. Stan MOU, and Mr. John CHING

The Nuclear Division of HKIE has organised the Mentorship Programme for undergraduates studying Nuclear and Risk Engineering Programme at City University of Hong Kong (CityU) since 2021. The objective of the Mentorship Scheme is to foster connections between practising engineers and engineering students while providing valuable professional advice regarding career paths in the nuclear industry. The programme commenced on 18 March 2023 and included formal sharing sessions on the nuclear industry, as well as informal peer mentoring between industry professionals and students.

To conclude the successful programme, the Nuclear Division, with the support of MNE, hosted a closing ceremony on **15 November 2023** at the CityU Faculty Lounge. All mentors and mentees, as well as distinguished guests such as **Dr Francis LEE**, President of Hong Kong Association of Medical Physics (HKAMP), were invited to attend this event.

5 Student Activities - 5.2 Closing Ceremony of the HKIE Mentorship Programme 2023

Prof PAN (centre left) and Ir Prof Ken CHEUNG (centre right) with mentors and mentees

Mentor and mentees celebrating the successful conclusion of the mentorship programme

Mentors sharing their career experiences

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mech.eng@cityu.edu.hk

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