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

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May 2023

MNE Newsletter

Introducing our exciting new programme:
Aerospace Engineering

It is delightful to see all the smiling faces back on campus after the challenging 3 years.

In this issue, we introduce one of our young faculty members who is an expert in aerospace engineering. We are proud to highlight three innovative researches of our faculty members: metallic glass-based triboelectric nanogenerator, two-phase flow simulation, and turning Hong Kong traffic into electricity. We also profile one of our alumni and his start-up story of Super Bamboo.

IN THIS ISSUE

People Stories

Dr. ZHANG Peng

Associate Professor

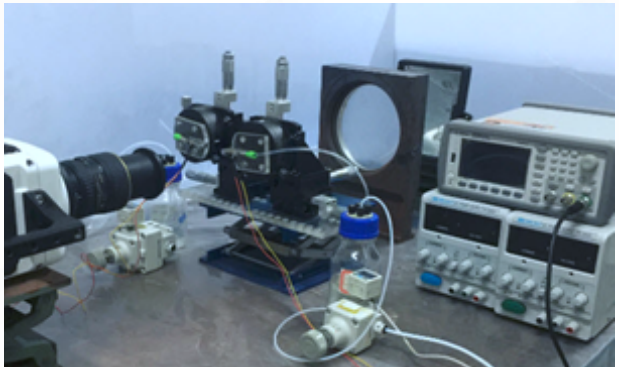
Research Interests:

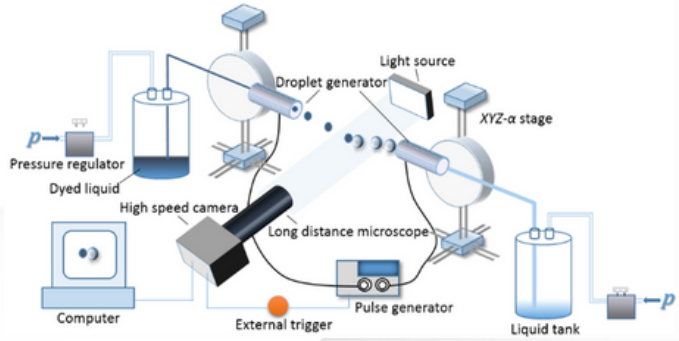
- Droplet and spray dynamics
- Theoretical and computational combustion
- Theoretical chemical kinetics

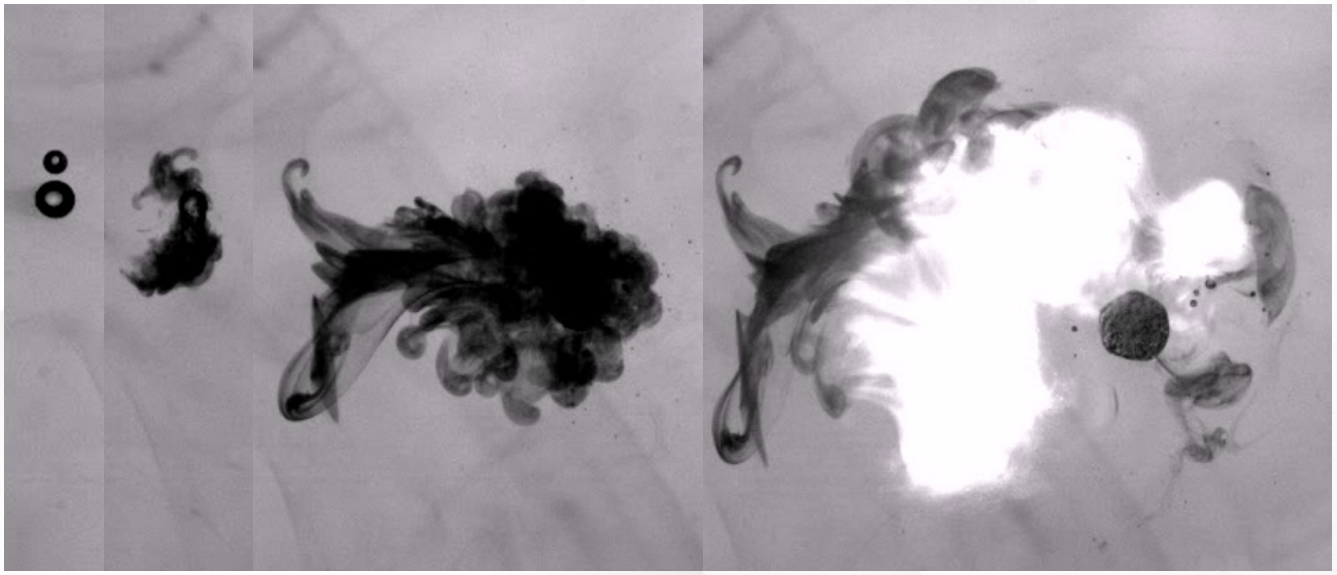
Dr. ZHANG Peng obtained a Bachelor in Mechanical Engineering in the Department of Mordern Mechanics at the University of Science and Technology of China, a Master of Aerospace Engineering at the Institute of Mechanics at the Chinese Academy of Sciences and a Ph.D. in Mechanical and Aerospace Engineering in the Department of Mechanical and Aerospace Engineering at Princeton University.

Research Interest

As a contemporary combustion researcher, Dr. ZHANG is conversant in both fluid mechanics and chemical kinetics. His current research interests are focused on the theoretical aspects of combustion-related fluid mechanics and chemical kinetics. His choices of research topics are largely motivated by his curiosity and aesthetic in science while paying attention to the latest technological development trends. He loves developing concise and beautiful mathematical theories to interpret new physical phenomena observed in well-designed model experiments or sufficiently validated computer simulations. His ongoing research includes but is not limited to, studying the **dynamics of droplet collision**, **the vortex dynamics of flames and fire whirls**, **theoretical chemical kinetics of rocket propellants and ammonia**, **and flow-chemistry-coupled problems of orbit-maneuvering rocket engines used in spaceships and satellites**.







The collision of two liquid droplets is a classical problem and of great significance to many natural and industrial processes such as raindrop formation, atmospheric aerosol circulation, spray combustion, and painting technology. Due to its multi-scale and multi-physics nature, droplet collision is not completely understood. Dr. Peng Zhang and his collaborators carried out, for the first time, the collision experiment of hypergolic propellant droplets, and obtained much new physical understanding of hypergolic ignition in rocket engines for orbit manoeuvre satellites.

2

Research Highlights

2.1 Metallic glass-based triboelectric nanogenerators

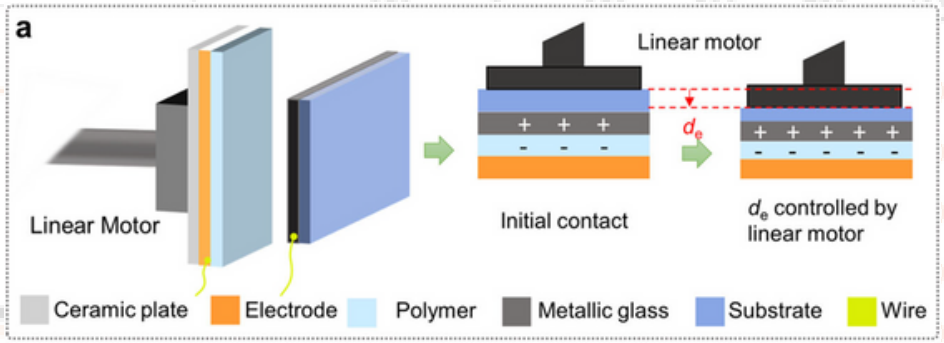
2.2 Development of three-dimensional simulation method for two-phase flow in square-pitch tube bundle in secondary side of steam generators based on porous drift-flux model

2.3 Turning Hong Kong Traffic into Electricity

2.1 Metallic glass-based triboelectric nanogenerators

Prof. YANG Yong, together with his team and collaborators, successfully employed metallic glass (MG) as the triboelectric interface for the design of triboelectric nanogenerator (TENG). Compared with traditional solid/solid-interface TENGs, the MG-based TENG exhibits higher triboelectrification efficiency with excellent humidity- and wear-resistance. Under different gas pressures, the MG-based TENG approached the theoretical limit of charge generation, exceeding that of a Cu-based TENG by 35.2%. Additionally, the MG-based TENG achieved a peak power-density of 15 MW·m-2.

Prof. YANG Yong

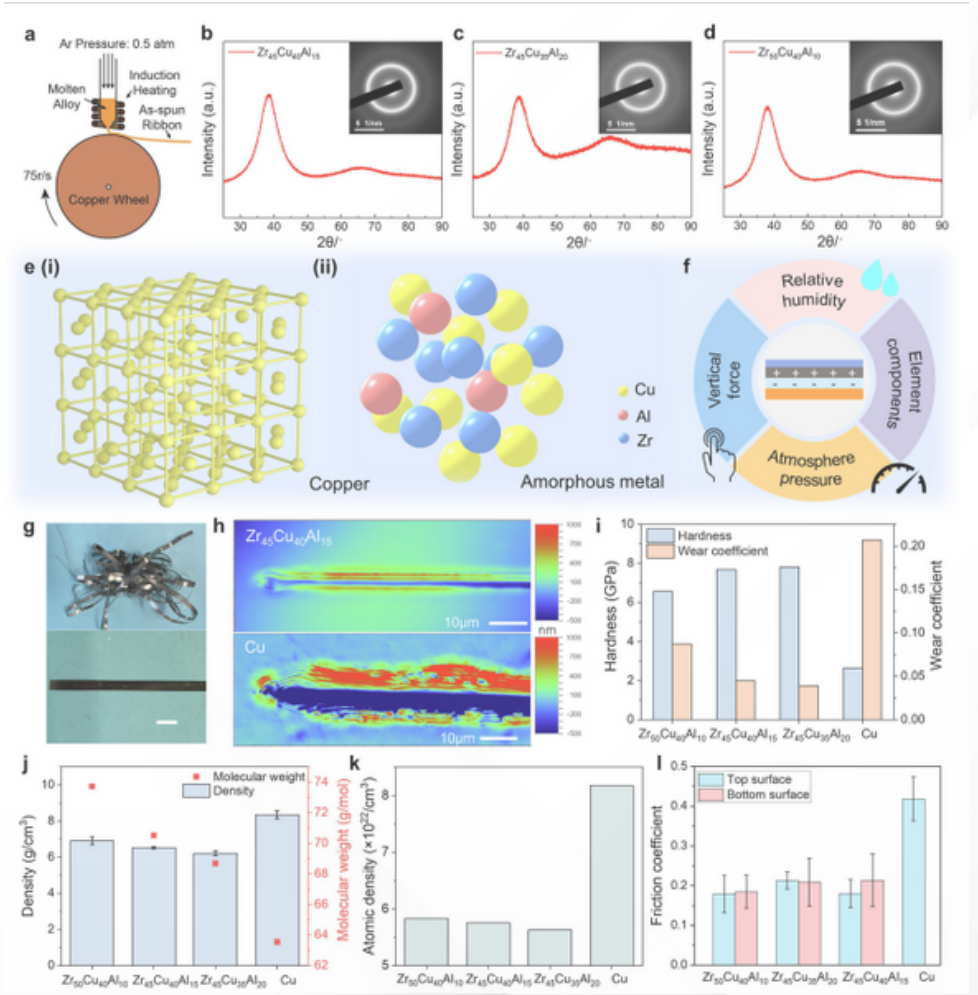


The problem:

TENGs are an increasingly popular type of energy harvester. However, the surface wear is a major hindrance in the solid/solid interface of TENG, severely affecting their output performance, stability and working life, thereby limiting their productization and industrial development. Moreover, the output performance of TENGs based on solid/solid interfaces is easily affected by environmental factors, preventing their application in extreme conditions.

The solution:

To solve these problems, we applied metallic glass (MG) as triboelectric interface of TENG. Compared with other interfaces such as copper, MGs were found to have a lower wear and friction coefficient. Due to the low atomic density and disorders atomic structure, metallic glass interface can improve the surface charge density, thus enhance the triboelectric efficiency of the TENG.

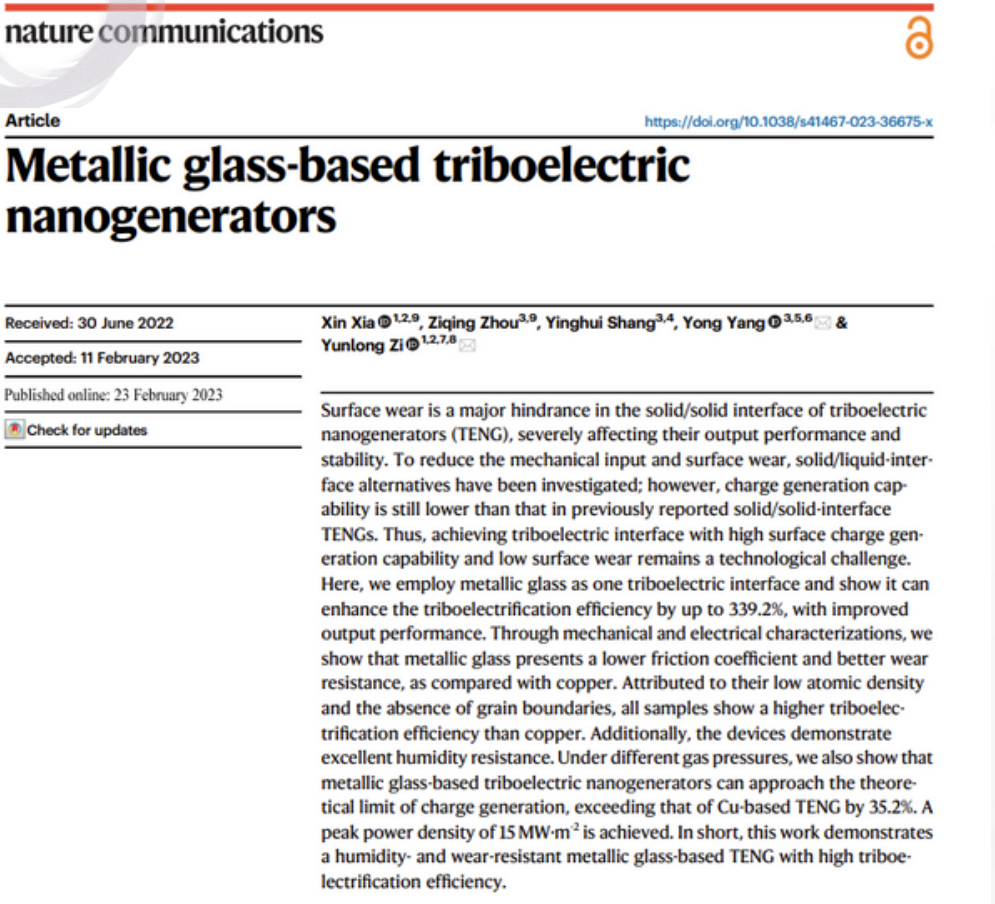


Where did the idea come from?

Prof. Yang and his group mainly focus on the research of metallic glass. Metallic glasses have attracted extensive research attention because of their excellent properties, which include excellent hardness, good hydrogen absorption capacity, and so on. These properties can be fully utilized to improve TENG performance. Through melting spinning, the metallic glass can be made as ribbons with proper thickness, which will be convenient for the multiple structural design for TENG devices.

This work firstly introduced the metallic glass to the field of energy harvest as the triboelectric interface for TENG. The application of the MG greatly improved the performance of the TENG, which include the high triboelectric efficiency, excellent wear and humidity resistance. The TENG based on MG interface can realize the peak power density to 15 MW·m-2 and successfully lighten the 9W LED using a small vertical load.

Read the full paper



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Article

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Metallic glass-based triboelectric nanogenerators

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Check for updates

Xin Xia[1,2,9], Ziqing Zhou[3,9], Yinghui Shang[3,4], Yong Yang[3,5,6] & Yunlong Zi[1,2,7,8]

Surface wear is a major hindrance in the solid/solid interface of triboelectric nanogenerators (TENG), severely affecting their output performance and stability. To reduce the mechanical input and surface wear, solid/liquid-interface alternatives have been investigated; however, charge generation capability is still lower than that in previously reported solid/solid-interface TENGs. Thus, achieving triboelectric interface with high surface charge generation capability and low surface wear remains a technological challenge. Here, we employ metallic glass as one triboelectric interface and show it can enhance the triboelectrification efficiency by up to 339.2%, with improved output performance. Through mechanical and electrical characterizations, we show that metallic glass presents a lower friction coefficient and better wear resistance, as compared with copper. Attributed to their low atomic density and the absence of grain boundaries, all samples show a higher triboelectrification efficiency than copper. Additionally, the devices demonstrate excellent humidity resistance. Under different gas pressures, we also show that metallic glass-based triboelectric nanogenerators can approach the theoretical limit of charge generation, exceeding that of Cu-based TENG by 35.2%. A peak power density of 15 $MW \cdot m^{-2}$ is achieved. In short, this work demonstrates a humidity- and wear-resistant metallic glass-based TENG with high triboelectrification efficiency.

Prof. Takashi HIBIKI

2.2 Development of three-dimensional simulation method for two-phase flow in square-pitch tube bundle in secondary side of steam generators based on porous drift-flux model

Solving the green premium problem

A steam generator in a nuclear power plant is a vertical U-shaped heat exchanger that generates steam using thermal energy from the pressurized water. The heat of the primary fluid passing through the reactor core is transferred through the heat transfer tube walls to the secondary fluid in the steam generator. The primary fluid flows inside heat transfer tubes in a steam generator, and the secondary fluid flows outside tubes. The secondary fluid is single-phase sub-cooled water at the inlet of the steam generator. The flow is converted into a steam-water boiling two-phase mixture by receiving the heat from the primary fluid. The secondary fluid becomes almost single-phase steam at the outlet of the steam generator, and the steam rotates the turbine for power generation.

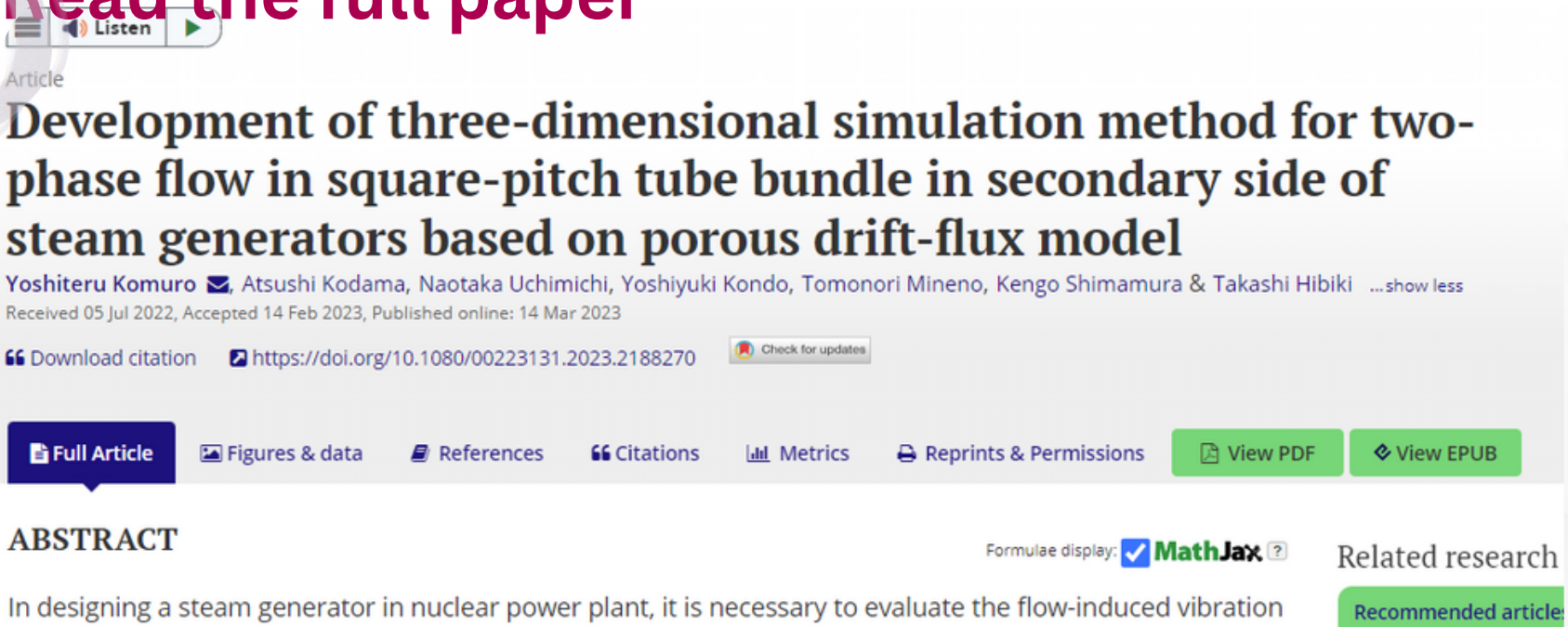
The Problem:

In steam generators, an integral component of pressurized water reactors, one of the key design issues is to prevent damage to the heat transfer tubes caused by corrosion and flow-induced vibration. When designing U-tube bundles for steam generators, thermal-hydraulic simulation codes are used to calculate velocity and density distributions along the tubes, etc. In many cases, calculation codes that model the steam generator tube bundle by the porous media approach are used for computational cost and simulation accuracy reasons. In such codes, the average velocity of the control volume is calculated and converted to an area-averaged mixture volumetric flux at the minimum gap between the two tubes by the mass conservation equation. The resulting area-averaged mixture volumetric is converted to a local interfacial velocity at the subchannel center by using the interfacial velocity correlation, and this value can be compared with the measured interfacial velocity value to validate the calculation code. In other words, an appropriate interfacial velocity correlation is essential for the validation of the calculation code.

The Solution:

In this paper, a new interfacial velocity correlation applicable to two-phase flow in a square array of tube bundles is proposed to benchmark a three-dimensional code that approximates a square array of steam generator tubes as a porous medium. HCFC-123 and SF6-ethanol are used as the simulated fluids, and tests are conducted with pressure and gas and liquid phase flow rates as parameters. Local void fraction and gas-liquid interfacial velocity are measured using an optical two-needle probe sensor, and the interfacial velocity correlation is derived using a drift-flux model. The uncertainty of the prediction by the obtained correlation is evaluated to be +6.7% (bias) ±24.2% (random error), which is smaller than the existing correlation. The range of flow and geometrical parameters for which the interfacial velocity correlation was validated were: the density ratio from 25 to 55, the superficial gas velocity at the gap 0.92 to 16 m/s, apparent liquid phase velocity at the gap 0.003 to 2.9 m/s, tube O.D. 9.53 to 22.23 mm. The developed interfacial velocity correlation is derived semi-theoretically using the drift-flux model, and thus is expected to be applicable beyond the validated parameter range.

Read the full paper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Article

Development of three-dimensional simulation method for two-phase flow in square-pitch tube bundle in secondary side of steam generators based on porous drift-flux model

Yoshiteru Komuro, Atsushi Kodama, Naotaka Uchimichi, Yoshiyuki Kondo, Tomonori Mineno, Kengo Shimamura & Takashi Hibiki ...show less

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ABSTRACT

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In designing a steam generator in nuclear power plant, it is necessary to evaluate the flow-induced vibration

Related research

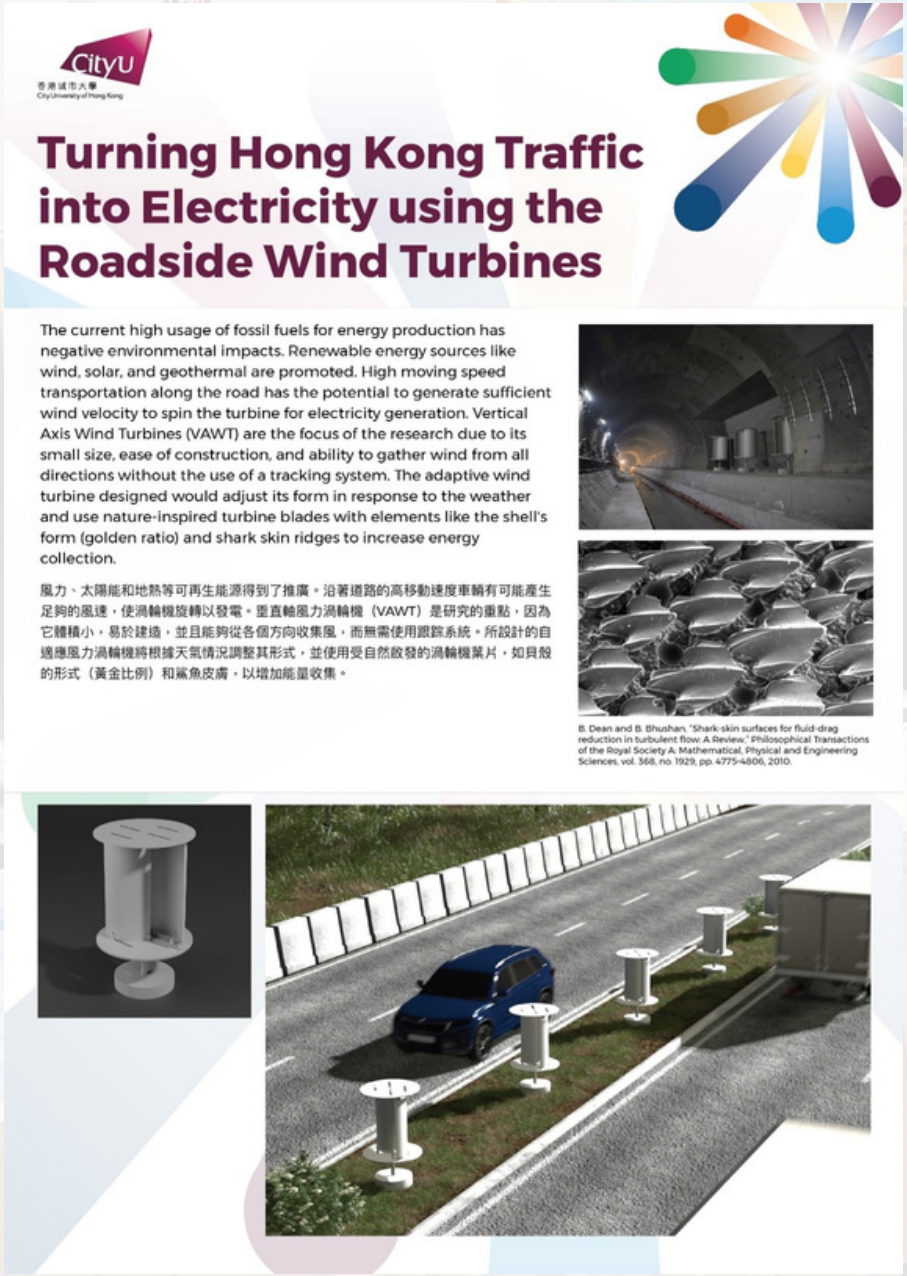
Recommended article

2.3 Turning Hong Kong Traffic into Electricity

On 27 March, CityU held the **Employers' Luncheon 2023** at the Hong Kong Convention and Exhibition Centre. This marks the return of the highly acclaimed event after a short hiatus since 2019. First launched in 2015, the Luncheon is an important platform for networking and interaction between CityU and industry, with the aim of strengthening connections and collaboration between CityU academics, students and enterprises.

One of our faculty members, **Dr. Steven WANG** participated in this event, showcasing one of his latest projects - **Turning Hong Kong Traffic into Electricity using the Roadside Wind Turbine.** This received substantial attention and interests for developing new projects based on his research. The event aimed to connect our faculties and students with the enterprises as potential collaborators.

The Acting Dean, College of Engineering of CityU, Prof. C.H. Shek (on the left) visited Dr. Steven WANG's booth



The Problem:

The current high usage of fossil fuels for energy production has negative environmental impacts. Thus, renewable energy sources such as wind, the sun, and geothermal are being explored and promoted. High-moving-speed transportation on roads also has the potential to generate sufficient wind velocity to spin turbines for electricity generation.

The solution:

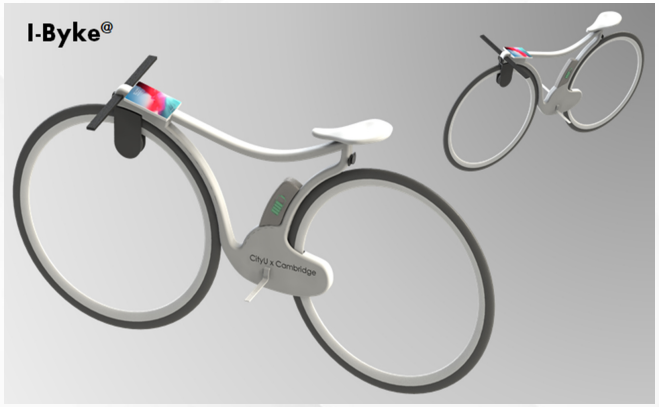
Vertical Axis Wind Turbines (VAWT) are the focus of this research, due to their small size, ease of construction, and ability to gather wind from all directions without the use of a tracking system. The adaptive VAWT designed in this project will adjust its form in response to the weather , and will be used multi-speed VAWT to optimise energy capture.

About the Principal Investigator

Dr. Steven WANG

Assistant Professor

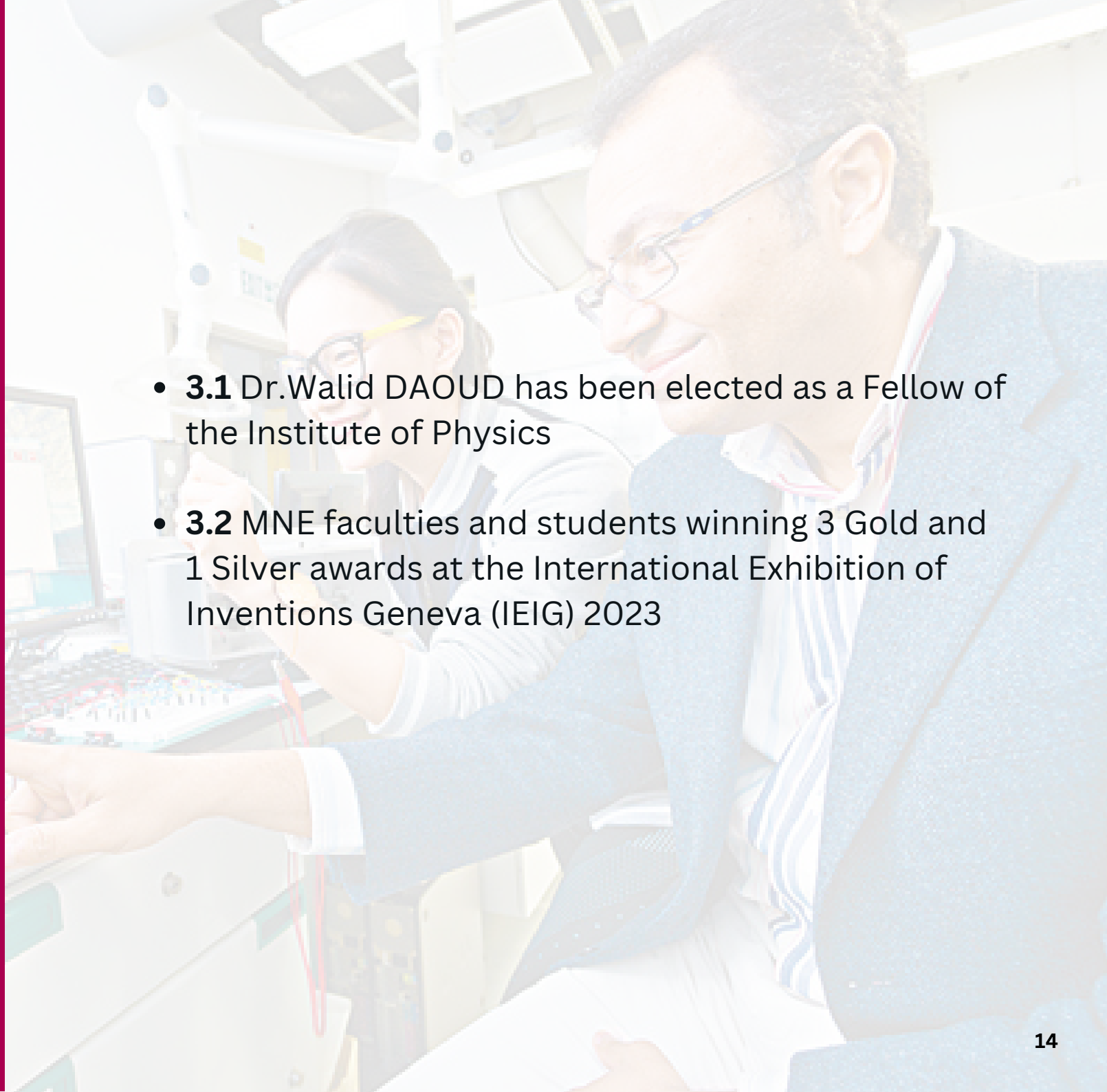
With his mechanical engineering background, **Dr. Steven WANG** has a great interest in new inventions. Recently, he was awarded a HKD3,070,000 grant from the Innovation and Technology Commission (ITC) and an industry partner for his latest project: **"Development of an aero e-bike integrated with a high-performance, highly-stable and long-life battery pack"**. In addition, via the ITF Research Talent Hub, an additional HKD3,070,000 will be provided to enable the engagement of up to four talented researchers at bachelor/master/doctoral level to conduct R&D work for a maximum period of 36 months on this project. The total funding amount will be HKD6,140,000. We congratulate on Dr. WANG on his success!



Dr.WANG's Design on the Aero-E bike

3

Faculty Achievements



- **3.1** Dr.Walid DAOUD has been elected as a Fellow of the Institute of Physics
- **3.2** MNE faculties and students winning 3 Gold and 1 Silver awards at the International Exhibition of Inventions Geneva (IEIG) 2023

Dr. Walid DAOUD has been elected a Fellow of the Institute of Physics (IOP) for his outstanding contributions to energy harvesting and smart wearable technologies. He has received international renown and several awards for his pioneering work on wearable solar and kinetic energy harvesting technologies using the concepts of nanoscience and nanotechnology. His research has contributed to the advancement of knowledge, which has provided demonstrable benefits and positive impacts to industry, society, and the environment.

Fellow is the highest level of membership attainable within the institute of Physics (IOP) and is a recognition of accomplishment for making a significant impact on their sector. IOP Fellowship means being part of a community of like-minded scholars who commit to promote science at the highest standard and to act as a role model for the next generation in their respective field.

Dr.DAOUD is also an elected Fellow of the Institute of Materials, Minerals and Mining (IOM3), which promotes the science, design, engineering and technology of materials, minerals and mining and their practical applications.

Dr. Walid DAOUD

IOP
Institute of Physics

3.2 MNE faculty and students winning 3 Gold and 1 Silver awards at the International Exhibition of Inventions Geneva (IEIG) 2023

Dr. Walid Daoud and his PhD student **Almardi Jasim Mohamed Jasim Mohamed** won the Gold Award for their invention“Omni-direction Omni-frequency Wave Energy Converter.”This wave energy converter is designed to harvest ocean waves’ kinetic energy from all directions using an oscillating weight inspired by the way an automatic watch harvests the kinetic energy of arm movements.

Prof. LU Jian and **Dr LI Yangyang**, MSE and MNE; **Dr ZHOU Binbin**, and **SHEN Junda**, PhD student, MSE, received the Gold award for their invention “Multifunctional Detection System Based on Nano-engraved Sensor.” This portable Raman spectrometer system for rapid on-site contaminant detection, based on a 10× reusable Nano-engraved silver-needle sensor that is up to 6× faster and 100× more sensitive than commercially available sensors.

Prof. LU Jian and **Dr MAO Zhengyi**, Postdoc, MNE; **Dr CAO Zhaowebo**; **CHEN Yingxian**, PhD student, MSE, won the Gold award for their invention “EcoSponge–Utilising Solar Energy for Sustainable Freshwater Production”. This eco-friendly, low-cost solar-powered device that produces enough water to meet an individual’s daily intake needs. Scalable and can be rapidly deployed in developing regions lacking clean potable water.

Dr ZHAO Shijun and **ZHANG Jun**, PhD student, received the Silver award for their "Superior AI Modeling of Large Atomic Systems." This project developed a deep-learning scheme based on atomic graph attention networks for fast, highly accurate modeling of long-term molecular dynamics in large multi-atomic systems, to aid in drug, material and battery design.

These significant awards inherit the brilliant tradition of MNE faculty, staff and students in winning Geneva Invention awards. Last year, MNE received 3 awards at Inventions Geneva Evaluation Days (IGED) 2022 including one Gold Medal with Congratulations of the Jury (**Prof. WANG Zuankai** and **Dr. Steven WANG**), 1 Gold Medal (**Prof. WANG Zuankai**) and 1 Silver Medal (**Dr. Steven WANG**). In particular, the invention "Fog-to-Electricity Generator with Ultra-High Power Density" by the team led by **Prof. WANG Zuankai** and **Dr. Steven WANG** and three PhD students **LING Chen**, **YAO Xiaoxue** and **WANG Hongbo** received one Gold Medal with Congratulations of the Jury. 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.

5

Alumni Stories

- **5.1** The Start-Up Story of Super Bamboo
- **5.2** MNE Homecoming Day 2023

From left to right: Prof. LU Yang (Adjunct Professor), Mr. Andy ONG (Founder of Super Bamboo), Dr. FAN Rong (Visiting Assistant Professor) and Dr. James Utama SURIADI (Co-Founder of Super Bamboo)

The start-up story of Super Bamboo

Q & A

Mr. Andy ONG
(Founder of Super Bamboo and MNE Outstanding Alumni)

By

MNE Department

Mr. Andy ONG

BEng (Hons) Mechanical Engineering Alumni

Founder of SUPER BAMBOO

Reaching carbon neutrality is an important goal for human kind – for both ourselves and next generations. In the past decade, countries, scientists and engineers world-wide have been striving to develop technologies and products, such as electronic vehicles and new materials, in efforts to reach carbon neutrality.

Mr. Andy ONG, who is a new graduate in our department, also wants to contribute to these efforts. He came up with the idea of using bamboo to replace wood and some metal components in furniture; construction; and interior components of automobiles, trains, and even satellites, in the future. He developed a specially made bamboo that is over three times stronger than natural bamboo, and is also stronger than steel and titanium alloy. Most importantly, there are no toxic chemicals added to form the bamboo. Therefore, aside from aiding efforts to reach carbon neutrality, this bamboo will enable sustainable development in a massive scale. Andy has started his own company - Super Bamboo, with the help of his teachers in MNE, this green material start-up has received a $HK 1 million Angel Fund grant from the CityU TECH300 programme.

We are glad to have Andy with us, and look forward to watching the progress of this young entrepreneur and his company.

Mr. Andy ONG

SUPER BAMBOO

1. Did you always want to start your own business?

Starting my own business has always been a dream since I was in high school; it has always inspired me. Growing up, I really liked technology, designing and hardware... at some point I couldn't stop thinking of creating my own products. But I didn't really think of it when I started college, because I only arrived in Hong Kong 5 years ago, to go to university. The whole place was completely new for me. I couldn't have imagined I would have my own start-up now; it gives me huge satisfaction.

2. How would you describe your days at CityU?

It was tough but fun for me. As engineering majors, we had to take more credits than students in other subjects, so we had to sacrifice some of our leisure and rest time. But thinking back on it now, all the time spent working was worth it, given what we learned. I still remember the days I stayed the whole day in library and the lab; it was painful but I learnt a lot, and it gave me a strong grounding in the skills of to found a start-up. All these experiences have moulded me into a more resilient person.

Mr. Andy ONG as speaker of the Entrepreneur Day 2021

3. How would you describe yourself?

I would say I am a gentle person and care a lot about people's feelings. Therefore, it is not naturally easy for me to be assertive and disagree when necessary. However, during my start-up journey, I realized that it is my responsibility to lead and make the right decisions to enable success, even when it is incredibly difficult to do so. Therefore, although there is a lot of pressure, I believe that as long as I maintain my integrity and professionalism, I will be able to learn to achieve the right balance in my decisions. I also consider myself a strict person when it comes to professionalism and integrity; I think these are very important attributes, especially when you have a team to cooperate with. But I am learning to address these issues in a factful way so I don't hurt anyone's feeling and maintain team spirit.

4. How did our teachers encourage you on your studies/ help with your start up?

All of the teachers in MNE were very supportive and encouraging; they trusted me enough to let me do everything I wanted and be creative. I remember one time I sent an email to a teacher at 2 in the morning and he replied to me in 5 minutes! I was shocked and really appreciated his help. I wouldn't have been successful without the help of my teachers at MNE.

From left to right: Dr.FAN Rong (Visiting Assistant Professor), Mr.Stephen AU (Business Advisor), Mr.Andy ONG (Founder of Super Bamboo) and Dr.James Utama SURIADI (Co-founder of Super Bamboo)

5. What are some of the challenges you have in terms of being a CEO of a start-up company?

One of the biggest challenges for knowledge transfer-based start-ups is the mismatch of understanding and communication between the different stakeholders. This mismatch, whether between start-ups and a university, industry, or market, makes it tough for new technologies to be developed and applied. Therefore, one big part of my job is to link everything up to enable a smooth collaboration between science and business. The second challenge is to scale up our materials from a lab-scale prototype to mass-production scale to be consumed in the market.

5.2 MNE Homecoming Day 2023

Memorable Moments

The MNE Thanksgiving Luncheon was successfully held on 12 March 2023 (Sunday). We are especially grateful for the support of **Prof. Lawrence LI** (Associate Head), **Dr. Patrick WONG** (Associate Professor, Departmental Alumni Coordinator), and **Dr. Weiyin MA** (Associate Professor) in making the lunch a memorable gathering for our alumni. At the luncheon, we presented thank you card to the alumni who had contributed to or helped the Department last year. It was a great opportunity to strengthen the connection between the Department and alumni, and share with them the latest updates on the Department!

Department of
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