Hong Kong Society of Theoretical and Applied Mechanics

上海市力学学会

Shanghai Society of Theoretical and Applied Mechanics

Proceedings of

The 22nd Annual Conference of HKSTAM 2018

The 14th Shanghai - Hong Kong Forum on Mechanics and Its Application

April 14, 2018 (Saturday)

The Hong Kong Polytechnic University, Hong Kong SAR

Editors

Zhongqing SU and Li CHENG

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The Hong Kong Polytechnic University
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PREFACE

The 22nd Annual Conference of HKSTAM (2018) in conjunction with the 14th Shanghai – Hong Kong Forum on Mechanics and Its Application is held on April 14, 2018 at the Hong Kong Polytechnic University. This conference is co-organized by the Hong Kong Society of Theoretical and Applied Mechanics (HKSTAM), the Shanghai Society of Theoretical and Applied Mechanics (SSTAM), and The Hong Kong Polytechnic University (PolyU). The conference topics cover mechanics and its applications in all science and engineering disciplines.

This conference aims to provide a platform for all scientists, engineers, and mathematicians working on mechanics and related areas to share, communicate and exchange ideas, and to enhance co-operations within relevant parties. This proceeding consists of 43 abstracts including 5 Distinguished Lectures by Prof. Wei-Hsin LIAO from The Chinese University of Hong Kong, Prof. Jianbing CHEN from Tongji University, Prof. Qingping SUN from Hong Kong University of Science and Technology, Prof. Yinfeng LI from Shanghai Jiao Tong University, and Prof. Heung-Fai LAM from City University of Hong Kong. The conference is structured into 8 parallel sessions with 38 presentations.

The Society appreciates all the speakers and contributors for their efforts to make this event a successful one. Special thanks go to Mr. Yehai Li (PolyU), Mr. Wuxiaong CAO (PolyU) and Mr. Xiongbin YANG (PolyU) for their great help in making connections with various parties and conference preparation. The Society also wishes to thank the generous support from Institution Members of HKSTAM.

On behalf of and for the Executive Committee.

Prof. Zhongqing SU
Secretary of HKSTAM
Professor
Department of Mechanical Engineering
The Hong Kong Polytechnic University

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The 22nd HKSTAM Annual Conference in conjunction with The 14th Shanghai-HK Forum on Mechanics and Its Application

Conference Program (14 April 2018)

Conference Venue: Lee Shau Kee Building (李兆基樓) at The Hong Kong Polytechnic University (PolyU)

April 14, 2018, Saturday Morning (Y304, Lee Shau Kee Building, PolyU)

08:30 – 12:00	**Registration and Reception [3/F Lobby, Lee Shau Kee Building, PolyU]**
09:00 – 09:10 **[10 mins]**	Opening addresses (MC: Professor Zhongqing SU (蘇衆慶), PolyU, Secretary of HKSTAM) **Professor Li CHENG (成利)** **President of HKSTAM** **Professor Jian XU (徐鑒)** **President of SSTAM**
09:10 – 09:50 **[40 mins]**	**Chair**: Professor Li CHENG (成利), The Hong Kong Polytechnic University, President of HKSTAM **Distinguished Lecture I** **Professor Wei-Hsin LIAO (廖維新)** Associate Dean and Professor, Department of Mechanical and Automation Engineering The Chinese University of Hong Kong **“Smart Materials, Adaptive Structures and Intelligent Systems”**

09:50 – 10:30 **[40 mins]**	**Chair**: Professor Paul H.F. LAM (林向暉), City University of Hong Kong, Vice President of HKSTAM **Distinguished Lecture II** **Professor Jianbing CHEN （陳建兵）** Professor, Department of Civil Engineering Tongji University **"Probability Density Evolution Analysis of Dynamic Response and Reliability of Complex Civil Engineering Structures under Disastrous Actions"**
10:30 – 11:00 **[30 mins]**	Photo Taking Coffee Break (**3/F Lobby, Lee Shau Kee Building, PolyU**)
11:00 – 11:40 **[40 mins]**	**Chair**: Professor Zhongqing SU (蘇衆慶), The Hong Kong Polytechnic University, Secretary of HKSTAM **Distinguished Lecture III** **Professor Qingping SUN（孫慶平）** Associate Department Head and Professor, Department of Mechanical and Aerospace Engineering Hong Kong University of Science and Technology **"Novel Property of Materials through Nanoscale Phase Transition ----- Microstructure Design and Processing"**
11:40 – 12:20 **[40 mins]**	**Chair**:Prof. Jian XU (徐鑒), Tongji University, President of SSTAM **Distinguished Lecture IV** **Professor Yinfeng LI (李寅峰)** Associate Professor, Department of Engineering Mechanics Shanghai Jiao Tong University **"Mechanical Properties and Biomechanical Behaviors of Low Dimensional Materials"**
12:20 – 14:00 **[1 hour 40 mins]**	**Buffet Lunch** at 4/F of the Communal Building, PolyU （香港理工大學南北小廚） Speakers of the following sessions please load their presentation files onto the computers in this break.

April 14, 2018, Saturday Afternoon (Lee Shau Kee Building, PolyU)

14:00 – 14:40 **[40 mins]**	**Chair**: Professor Zhongqing SU (蘇衆慶), The Hong Kong Polytechnic University, Secretary of HKSTAM **Distinguished Lecture V** **Professor Paul Heung-Fai LAM（林向暉）** Associate Professor, Department of Architecture and Civil Engineering City University of Hong Kong **"Bayesian Model Updating and Structural Health Monitoring Utilizing Ambient Vibration Data"**			
14:50 – 15:50 **[60 mins]**	**Session A1** **[Seminar Room Y304]** **Chair: Prof. YAO Haimin**	**Session B1** **[Seminar Room Y305]** **Chair: Prof. NIU Xinrui**	**Session C1** **[Seminar Room Y306]** **Chair: Prof. LU Yang**	**Session D1** **[Seminar Room Y602]** **Chair: Prof. HUANG Duruo**
14:50 – 15:05 [15 mins]	**ZHANG Hongti** (CityU) Deep Ultra-Strength of Silicon Nanowires and Their Fracture Behaviour	**GAO Rundong** (SRIBS) 裝配整體式混凝土結構檢測技術研究與標準編制	**REN Xiaodan** (TongJi U) 基於 SPH 的松質骨力學行為類比與骨植入性能研究	**PENG Yongbo** (TongJi U) 基於正交展開的非線性振子系統多項式隨機最優控制
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15:50 – 16:05 **[15 mins]**	Coffee Break (**3/F Lobby, Lee Shau Kee Building, PolyU**) Speakers of the following sessions please load their presentation files onto the computers in this break.			

16:05 – 17:35 [1 hour 30 mins]	**Session A2 [Seminar Room Y304] Chair: Prof. YE Wenjing**	**Session B2 [Seminar Room Y305] Chair: Prof. TANG Hui**	**Session C2 [Seminar Room Y306] Chair: Prof. LIN Yuan**	**Session D2 [Seminar Room Y602] Chair: Prof. LEE Yi-Kuen**
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17:35– 17:50 [15 mins]	**Closing Ceremony and Award Presentation [Y304, Lee Shau Kee Building, PolyU]** Attendees: All conference participants			
17:50 – 18:50 [60 mins]	**HKSTAM Annual General Meeting [Y304, Lee Shau Kee Building, PolyU]** Attendees: Representatives of all Institution Members and all Full HKSTAM Members			
18:50 – 20:05	**Conference Banquet** at Lunch at 4/F of the Communal Building, PolyU （香港理工大學南北小廚）			

Distinguished Lecture I

Speaker of Distinguished Lecture

Professor Wei-Hsin LIAO

The Chinese University of Hong Kong

Wei-Hsin Liao received his Ph.D. in Mechanical Engineering from The Pennsylvania State University, University Park, USA. Since August 1997, Dr. Liao has been with The Chinese University of Hong Kong, where he is now Professor and Associate Dean (Student Affairs), Faculty of Engineering. His research interests include smart structures, vibration control, energy harvesting, mechatronics, and medical devices. His research has led to publications of over 200 technical papers in international journals and conference proceedings, 16 patents in US, China, Hong Kong, Taiwan, Japan, and Korea. He was the Conference Chair for the 20th International Conference on Adaptive Structures and Technologies in 2009; the Active and Passive Smart Structures and Integrated Systems, SPIE Smart Structures/NDE in 2014 and 2015. He is a recipient of the *T A Stewart-Dyer/F H Trevithick Prize* 2005, the ASME 2008 *Best Paper Award in Structures*, the ASME 2017 *Best Paper Award in Mechanics and Material Systems*, and three Best Paper Awards in the IEEE conferences. At CUHK, he received the *Research Excellence Award* (2011), and was awarded *Outstanding Fellow of the Faculty of Engineering* (2014). He recently received the SPIE 2018 *SSM Lifetime Achievement Award*. Dr. Liao currently serves as an Associate Editor for *Mechatronics*, *Journal of Intelligent Material Systems and Structures*, as well as *Smart Materials and Structures*. He is a Fellow of the American Society of Mechanical Engineers, Institute of Physics, and The Hong Kong Institution of Engineers.

Smart Materials, Adaptive Structures and Intelligent Systems

Wei-Hsin Liao, Ph.D.

Professor, Department of Mechanical and Automation Engineering
The Chinese University of Hong Kong

Smart materials are those that alter their shape, stiffness or other properties when they are subjected to changes in temperature, electrical or magnetic field. By utilizing these adaptive features, smart materials can be built as sensors and actuators. Integrating with controllers, such systems perform work like nerves, muscles, and brains in our human bodies. Piezoelectric material and magneto-rheological (MR) fluid have been used for controlling vibration. They have been applied to hard disk drives and vehicle suspension. Energy can also be harvested from vibration and human motion. Piezoelectric and electromagnetic power generators were used to transform the mechanical energy from vibration and human motion into electrical energy. The self-powered systems will be more environmentally friendly since they are using otherwise wasted mechanical energy from the vibration and human motion. On the other hand, exoskeletons that can assist people with impaired mobility have been developed. With the developed device, paralyzed individual can regain the ability to stand up and walk. Smart ankle-foot prosthesis with compact cam-spring mechanism have also been implemented to help amputees walk with less effort while having more symmetrical gait. Utilizing additive manufacturing into smart materials has led to 4D printing technology for creating devices that can change their shape and/or function on-demand and over time. Adaptive structures capable of self-expanding and self-shrinking were created by 4D printing. Actuator units were designed and fabricated directly by printing fibers of shape memory polymers in flexible beams with different arrangements. They can serve as tubular stents and grippers for biomedical or piping applications. In this talk, related research projects and key results will be presented.

Distinguished Lecture II

Speaker of Distinguished Lecture

Professor Jianbing CHEN

Tongji University

Jianbing Chen is now professor of Civil Engineering at Tongji University. He received his Ph.D. in 2002 from Tongji University, and has been a visiting scholar/professor in the University of Southern California and Technical University of Vienna, etc.

His major research interests include stochastic dynamics of structures, reliability of structures and systems, and earthquake engineering. Specifically, he is working on the development of a family of probability density evolution method (PDEM) for performance evaluation and reliability assessment of structures/engineering systems involving randomness both in the system parameters and excitations. He published 4 books, over 100 peer-reviewed journal papers and over 80 papers in international conferences, and was invited to give 16 keynote/invited lectures in national/international conferences. He is/was the PI of 6 NSFC (National Natural Science Foundation of China) granted projects, including the Outstanding Young Scientist Fund Project of NSFC in 2017.

Dr. Chen is a member of the international Joint Committee on Structural Safety (JCSS), a fellow of Chinese Society on Vibration Engineering (CSVE), and serves as the vice chairman of the Random Vibration Committee of CSVE, and in the editorial board of international/Chinese journals including Structure and Infrastructure Engineering and Journal of Vibration Engineering.

He received various awards, including the National Natural Science Award (2nd class, 2nd achiever) in 2016 and the International Association for Structural Safety and Reliability (IASSAR) Early Achievement Award in 2017, and was selected among the National Outstanding Scientific and Technological Workers in 2014.

复杂土木工程结构的灾害动力响应概率密度演化与可靠性

Probability Density Evolution Analysis of Dynamic Response and Reliability of Complex Civil Engineering Structures under Disastrous Actions

陈建兵　李杰

（1．同济大学土木工程学院 土木工程防灾国家重点实验室　上海　200092）

灾害性工程动力作用下复杂土木工程结构将进入强非线性、甚至可能倒塌。因此，复杂土木工程结构的灾害动力非线性响应分析需要同时考虑动力作用和系统本身参数（如混凝土强度等）的随机性，其力学分析问题具有如下特点：（1）土木工程结构本质上是连续系统，经过离散的数值模型也往往具有极大的自由度数；（2）土木工程结构在灾害性动力作用下往往表现出强非线性行为，例如强滞回耗能、刚度退化、强度退化等特性；（3）灾害性动力作用如地震、强风等往往是强非平稳过程。上述特点导致复杂土木工程结构的灾害非线性随机响应与可靠性分析具有高度挑战性。在过去半个多世纪中，人们为此付出了艰苦的努力，取得了重要的研究进展，相继发展了虚拟激励法、等价线性化方法、FPK 方程降维方法、耗散的拟 Hamilton 系统方法等，并在工程实际中发挥了重要作用。本世纪初以来，提出了非线性系统随机响应与可靠性分析的概率密度演化理论。基于概率守恒原理，结合系统物理方程，导出了状态变量解耦的广义概率密度演化方程，较为系统地研究和发展了求解的数值方法。本文将简要介绍在此方面的最新进展及其工程应用，并讨论需要进一步研究的问题。

关键词：概率密度演化，灾害动力作用，结构，非线性，可靠性

Distinguished Lecture III

Speaker of Distinguished Lecture

Professor Qingping SUN
Hong Kong University of Science and Technology

Dr. Qingping SUN is the Professor of the Department of Mechanical and Aerospace Engineering and the Director of the Institute of Integrated Microsystems at the Hong Kong University of Science and Technology (HKUST). Prof. SUN received his PhD in solid mechanics from Tsinghua University in 1989 and joined the faculty of HKUST in 1995. Prof. Sun's primary research area is the mechanics of phase transitions in materials, with special interests in phase transition process in shape memory alloys, ceramics and nano- and biological materials/systems. His research work covers problems in the inter-disciplinary area between mechanics, solid state physics, biology and materials science. He is an internationally renowned expert in mechanics of shape memory materials and is distinguished for his contributions in the areas of nanoscale phase transition and mechanics of multi-scaled processes with multi-field coupling. He has published over 140 research papers in prestigious journals in the fields of mechanics, solid state physics and material science. He has received national and international recognition for his research and teaching, including the "State Natural Science Award of China" (1996); the "Best Engineering Teaching Excellence Award" (2002) of HKUST; the "Citation Classic Award" from ISI (2001). He gave over 40 invited Keynote Lectures and 14 Plenary Lectures in international conferences. He was the visiting professor in several universities/national labs in France (Ecole Polytechnique, Ecole Normal Superieur, etc.) and served as the editorial boards for 6 international journals and as the Chairman and members of Scientific Committees for many international conferences.

Novel property of materials through nanoscale phase transition ----- microstructure design and processing

Qingping SUN

Department of Mechanical and Aerospace Engineering
Hong Kong University of Science and Technology

Mechanics, as an old and traditional discipline, is nowadays expanding its territory rapidly and becomes much more interdisciplinary with other field like materials, physics and biology and medicine. In this talk, I briefly report recent advances in developing nano-structured NiTi shape memory alloys with improved novel properties by manipulating its microstructure using advanced fabrication, modelling and characterization techniques. The topics include the effects of material internal length scales in property control, developing negative and zero thermal expansion NiTi SMAs (thermal metamaterial), high fatigue resistance SMA, Elastic modulus control (Elinvar), grain refinement via microscale severe plastic deformation (SPD), etc.

Acknowledgement: The work presented are supported by the following GRF projects of the Hong Kong Research Grant Council (No. 619113, **PI** (2014-2016); No. 16209414, **PI** (2015-2017); No. 16214215, **PI** (2016-2018); No. 16239316, **PI** (2017-2019); No. 16209817, **PI** (2018-2020)).

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Distinguished Lecture IV

Speaker of Distinguished Lecture

Professor Yinfeng LI

Shanghai Jiao Tong University

Dr. Yinfeng Li received the Ph.D. degree from the department of engineering mechanics at Shanghai Jiao Tong University in 2014, and now serves as an associate professor there. He has focused on the understanding of basic principles that control mechanical properties and behaviors of materials in both micro- and nano-scale. In particular, the mechanical and biological behaviors of low dimensional materials that mainly involve 0- and 2-Dimensions (ranging from nanoparticles to graphene, boron nitride and CBN planar and epitaxial heterostructure). Based on the nature of the studied subjects, the continuum theory, molecule dynamics method and density functional theory calculations are employed, and a series of new models, solutions and observations is drawn. Even in his early academic career, Dr. Li has published 30 SCI indexed papers in high impact journals with more than 550 citations, including PNAS, JMPS, Carbon, Nanoscale, Acta Mater, Compos Sci Technol, etc. He has been selected in Shanghai Chenguang talent project and awarded the prestigious 'IAAM Scientist Medal' by International Association of Advanced Materials for notable and outstanding research in his field.

Mechanical properties and biomechanical behaviors of low dimensional materials

Yinfeng Li[a,b,*]

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With the rise of nanotechnology and the advances in interdisciplinary research, low dimensional materials (LDM) such as graphene have received intense global interest due to their unique physical and chemical properties over traditional materials. This talk is aimed to summarize some of our recent studies on the mechanical properties and biomechanical behavior of LDM, including nanoparticles, graphene allotropies and two dimensional heterostructures, characterized using molecular dynamic simulations combining first principle calculation as well as theoretical analysis. Atomistic models of monolayer and multilayer graphene structures are constructed for the effect of surface functionalization (hydrogenation) as well as hybridization (with Boron Nitride) on the in-plane tensile strength, torsion capacity as well as thermal conductivity. Theoretical models are applied to the hybrid grain boundary in a planar heterostructure of graphene and hexagonal boron nitride for the key parameters affecting the mechanical properties. Graphene multilayers with ordered interlayer characteristics are further constructed and analyzed. The coarse-grained MD simulations are performed to analyze the dynamic penetration process of LDM across a cell membrane. The evolutions of free energy as LDM piercing through the cell membrane are calculated by the innovative application of thermodynamic integration in nano-biological systems. The physical mechanisms of surface functionalization, stiffness and topological shapes on the penetrability of LDM are revealed by analyzing the change of penetration barrier and mode, and bioimaging experiments are carried out for verifications. Investigations about the principles and mechanisms of the mechanical properties and behavior of LDM are critical to its functional design and biological control, which is the cutting-edge project in the current research of nanomechanics.

Distinguished Lecture V

Speaker of Distinguished Lecture

Professor Paul Heung-Fai LAM

City University of Hong Kong

Dr. Lam is a faculty member in the Department of Architecture and Civil Engineering at the City University of Hong Kong. Dr. Lam has published over 70 referred journal papers and delivered over 5 keynotes and 30 invited lectures worldwide. He has received over HK$39,000,000 research grants.

Dr. Lam is the Guest Editor of Special Issue on Structural Assessment and Health Monitoring in International Journal of Structural Stability and Dynamics (IJSSD), an editorial board member for International Journal of Lifecycle Performance Engineering, and the review editor for Structural Sensing of Frontiers in Built Environment.

Dr. Lam is currently the Vice-president of the Hong Kong Society of Theoretical and Applied Mechanics (HKSTAM). He was elected as the General Secretary of the International Steering Committee of the East Asia-Pacific Conference on Structural Engineering and Construction (EASEC). Dr. Lam is a committee member of the IASC-ASCE Task Group on Structural Health Monitoring, and the System Identification and Structural Control of the International Association of Structural Safety and Reliability.

In engineering education, Dr. Lam has received over HK$1,000,000 teaching grants. He is current Chairman (Education and Training) of the Hong Kong Construction Metal Structures Association (HKCMSA) and received the Teaching Excellence Award (TEA) in 2008.

Bayesian Model Updating and Structural Health Monitoring Utilizing Ambient Vibration Data

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This presentation reports the development of a theoretically rigorous and practical method for model updating of civil engineering structures, such as buildings and bridges, based on a set of measured ambient vibration data following the Bayesian statistical system identification framework (Hu et al. 2017; Lam et al. 2017). Structural model updating is a hot topic in the areas of mechanical, structural and civil engineering with a wide spectrum of applications including structural damage detection (Lam et al. 2017a), optimal structural design and structural vibration control. It is a main area of research under the topic of structural health monitoring (Yang et al. 2015). Several well-known difficulties for structural model updating will be discussed in the presentation. They are: (1) the quality and quantity of measured data are usually not high enough to accurately identify a single model in the parameter space of interest; (2) it is difficult to select a class of models with "appropriate" complexity. If the model class is too complex, the model updating results conditional on a given set of measured data will be highly uncertain as the number of unknowns is too large when compared to the amount of information that can be extracted from the set of measured data. If the model class is too simple, the match between the measured and model-predicted responses will be very bad resulting in a poor likelihood function; (3) under the effects of model error and measurement noise, the results of model updating are highly uncertain in practice. As a result, the calculation of the posterior (updated) probability density function (PDF) of the model parameters is a challenging task.

In this presentation, a recently developed Bayesian model updating method, which approximates the posterior PDF using a set of samples generated by the Markov chain Monet Carlo (MCMC) simulation, will be presented. Particular concern will be given to the development of the novel stopping criteria in the MCMC simulation. The application of the MCMC samples for Bayesian model updating selection will also be covered (Lam et al. 2017). To verify the proposed Bayesian model updating method, a series of ambient vibration tests were carried out on existing buildings in Hong Kong. The vibration measurement and the corresponding modal identification (Lam et al. 2017b; Ni et al. 2015; Zhang et al. 2017) will also be covered in the presentation. The case study results are very encouraging showing that the extension of the MCMC-based Bayesian model updating method in SHM is possible. At the end of the presentation, the limitation of the proposed method will be discussed, and possible solution will be given as the future development of the proposed method.

Acknowledgements

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Deep Ultra-Strength of Silicon Nanowires and Their Fracture Behaviour

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Achieving large elastic deformation in silicon (Si) nanowires, one of the most important and versatile building blocks in nanoelectronics, would enable many novel applications in flexible electronics and bio-nano interfaces. Here we show that VLS–grown single-crystalline Si nanowires with diameters of ~100 nm can be repeatedly stretched above 10% elastic strain at room temperature, approaching the theoretical elastic limit of silicon (17 to 20%). A few samples even reached ~16% tensile strain, with estimated fracture stress up to ~20 GPa. The deformations were fully reversible and hysteresis-free under loading-unloading tests with varied strain rates, and the failures still occurred in brittle fracture, with no visible sign of plasticity. The ability to achieve this "deep ultra-strength" for Si nanowires can be attributed mainly to their pristine, defect-scarce, nanosized single-crystalline structure and atomically smooth surfaces. Our results indicate that semiconductor nanowires could have ultra-large elasticity with tunable band structures for promising "elastic strain engineering" applications. The insights obtained in the fracture study will be of help on the development of robust silicon nanowire-based mechatronic devices.

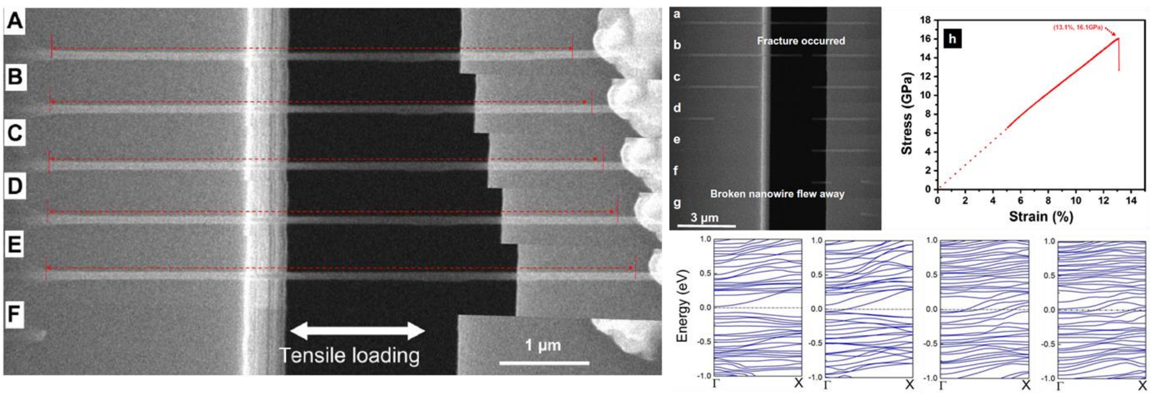

Figure 1. Pristine single crystalline silicon nanowires were uniaxially stretched to ~13% elastic strain as well as their corresponding fracture behaviour and band structure evolution process.

Acknowledgements

The authors wish to thank Research Grants Council of the Hong Kong Special Administrative Region, China

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Size-dependent fracture behavior of silver nanowires

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Silver (Ag) nanowires have great potential to be used in the flexible electronics industry for their applications in flexible, transparent conductors due to high conductivity and light reflectivity. Those applications always involve mechanical loading and deformations, which requires an in-depth understanding of their mechanical behavior and performance under loadings. However, current understanding on the mechanical properties of Ag nanowires is limited, especially on their size-dependent fracture behavior. In this work, mechanical properties of Ag nanowires with diameters ranged from 50 to 300 nm were systematically studied by in situ TEM tensile testing for the first time. The size effect was clearly found, with the increasing of the diameter of Ag nanowires the ultimate tensile stress decreased. More importantly, the fracture behavior of Ag nanowire was studied and a brittle-to-ductile transition in fracture behavior was observed at the diameters around 100 nm which could be attributed to the dislocation activities within the geometry confinement. This work could give insights for understanding nanosized Ag wires and the design of Ag nanowire-based flexible devices and touchable panels.

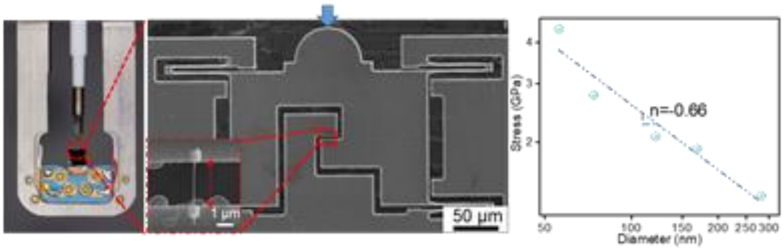

Figure 1. in situ TEM experiment setup and the size-dependent of the ultimate strength of Ag nanowire.

Acknowledgements

The authors wish to thank the National Natural Science Foundation of China (Grant # 51301147), the Research Grants Council of the Hong Kong Special Administrative Region of China (GRF # CityU 11209914) and City University of Hong Kong (Grant # 9680108). The work was also supported by the Innovation and Technology Commission via the Hong Kong Branch of National Precious Metals Material Engineering Research Center.

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Oxidative Removal and Strength Properties of Bisphenol-A Contaminated Soil by Activated Persulfate

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Activated persulfate oxidation process identified as an efficient degradation of recalcitrant contaminations (Sharma et al. 2015). In this study, sodium persulfate (SPS), sodium percarbonate (SPC) and clay soil were used in this experiment to evaluate the variation of geotechnical properties and removal capability of BPA in consolidated soil. The SPC is not only an extremely strong oxidant but is an important reactant in the formation of $CaCO_3$. As the author's knowledge, there was no study on investigating the engineering properties and removal effect of BPA in the consolidated soil by SPC-SPS. A series of laboratory tests were conducted to estimate the shear strength and the removal percentage of clay matrix. The undrained shear strength of soil with the BPA is lower than that of natural soil as shown in Figure 1. The undrained shear strength of soil with BPA+1% SPS+0.5% SPC shows a significant increase than that with BPA+1% SPS, which exhibits a good performance of 1% SPS+0.5% SPC on BPA removal.

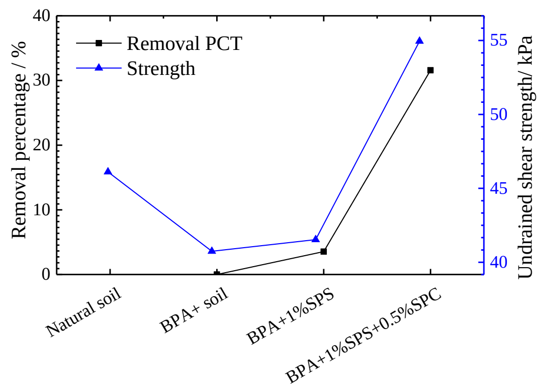

Figure 1. Relationship of removal percentage and undrained shear strength with different additives.

Acknowledgements

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Mechanically stable ternary heterogeneous electrodes for energy storage and conversion

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Recently solid asymmetric supercapacitor (ASC) has been deemed as an emerging portable power storage or backup device for harvesting natural resources.[1–3] Here we rationally engineered a hierarchical, mechanically stable heterostructured FeCo@NiCo layered double hydroxide (LDH) with superior capacitive performance by a simple two-step electrodeposition route for energy storage and conversion. *In situ* scanning electron microscope (SEM) nanoindentation and electrochemical tests demonstrated the mechanical robustness and good conductivity of the FeCo-LDH. This serves as a reliable backbone for supporting the NiCo-LDH nanosheets. When employed as the positive electrode in the solid ASC, the assembly presents high energy density of 36.6 Wh kg^{-1} at a corresponding power density of 783 W kg^{-1} and durable cycling stability (87.3% after 5000 cycles) as well as a robust mechanical stability without obvious capacitance fading when subjected to bending deformation. To demonstrate its promising capability for practical energy storage applications, the ASC has been employed as a portable energy source to power a commercially available digital watch, mini motor car, or household lamp bulb; and as an energy storage reservoir, coupled with a wind energy harvester, to power patterned light-emitting diodes (LEDs).

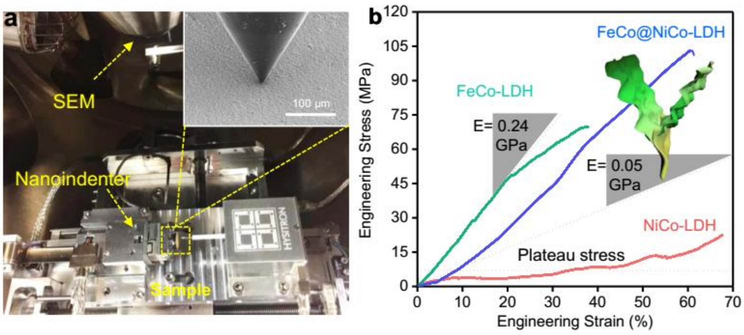

Figure 1. *in situ* nanoindentation mechanical test of LDH film inside SEM.

Acknowledgements

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Balance Between Water Nucleation and Transport: Effect of Nanoscale Bumpy Topography with Wetting Contrast

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Water scarcity has become a global issue of severe concern. Great efforts have been undertaken to develop low-cost and highly efficient condensing surfaces for harvesting water from air. However, balancing the trade-off between moisture capture and water transport poses a great challenge for water collection due to the conflicting requirements of surface wettability. To reconcile the trade-off, in this work, a scalable surface processing technique is introduced to architect a biphilic topography consisting of hydrophilic nanoscale bumps on top of a superhydrophobic substrate.[1] This biphilic topography combines the merits of biological surfaces with distinct wetting features (e.g., fog-basking beetles and water-repellent lotus) to enhance water nucleation and transport simultaneously.[2] Particularly in a moisture-lacking atmosphere, the biphilic surface demonstrates a twofold higher water collection rate as compared to the state-of-the-art superhydrophobic surface. Moreover, the condensation dynamics (i.e., water nucleation and departure efficiency) on this novel surface topography can be readily tuned by controlling the density of hydrophilic nano-bumps, promising a wide range of applications in water harvesting, dehumidification, and desalination.

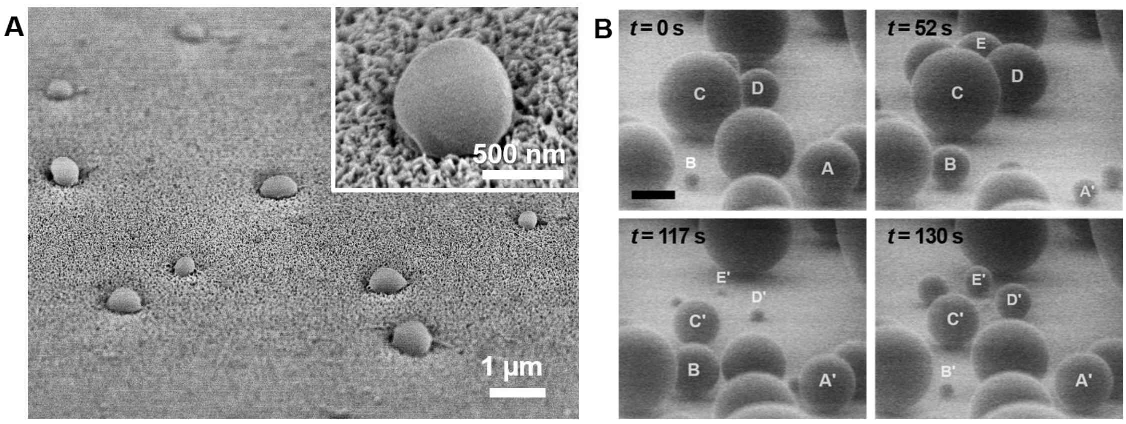

Figure 1. (A) SEM image showing the biomimetic biphilic surface consisting of superhydrophobic background nanostructures and hydrophilic nanoscale bumps. Inset shows the magnified view of the nano-bumps, scale bar is 500 nm. (B) ESEM snapshots showing cyclical spatial-control of droplet growth on the biphilic surface. The letters A to E represent the droplets prior to departure, and A' to E' denote the regeneration of droplets at the identical positions. Scale bar is 10 μm.

Acknowledgements

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From brittle to ductile fracture in Au-Al intermetallic compounds with atom ratio controlling

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Wire bonding is the technique of connecting the Al pads (attaching to the Si chips) and the Au wires, which is known as one of the most efficient and commonly used techniques in the electronic packaging industry. Au-Al intermetallic compounds (IMCs) always form within the bonding interface, and cause damage through the bonding layer. In the present we introduce micro-scale three-point bending and single-edge cantilever tests to reveal the fracture behaviours of $AuAl_2$ (Al-rich) and Au_2Al (Au-rich) IMCs. The result shows that the Au-rich IMC exhibits brittle fracture behaviour with high bending strength. However, the Al-rich IMC exerts ductile fracture with low bending strength. The intergranular fracture both appears in two types IMCs, but the slip bands contribute the plastic deformation capability in Au-rich IMC grains. This is the first report of the mechanical properties of Au_2Al and $AuAl_2$ IMCs, and the results could provide instructive suggestion for Au-Al bonding technique.

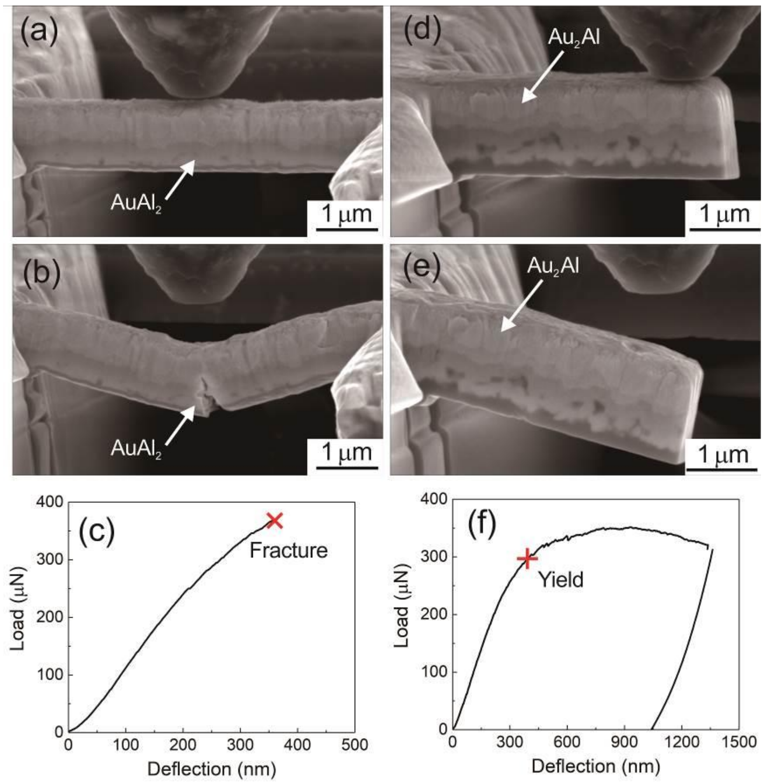

Figure 1. The (a, b, c) three-point bending test of $AuAl_2$ IMC, and (d, e, f) single-edge cantilever test of Au_2Al IMC.

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Tribological study of sand-grain contacts

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In the study, micromechanical experiments are conducted on a variety of geological and manufactured sand-sized grains to obtain insights into the important factors that influence the inter-particle coefficient of friction (μ). Chrome steel balls (CSB), glass beads (GB), Leighton Buzzard quartz sand (LBS), limestone grains (LS) and completely decomposed granite (CDG) of size between 1.18 and 3.00 mm are studied. The experiments are conducted using a custom-built micromechanical loading apparatus at the City University of Hong Kong (Senetakis and Coop, 2014). The normal load contact tests are performed to obtain the apparent Young's modulus based on Hertzian fitting. The tangential load contact tests are conducted to measure the inter-particle coefficient of friction. The results show that the coupled increase of roughness and decrease in Young's modulus increase μ (Sandeep and Senetakis, 2018). Greater scatter of the data is acknowledged for rougher grains or grains subjected to weathering in comparison to un-weathered and smoother geological materials as well as manufactured grains.

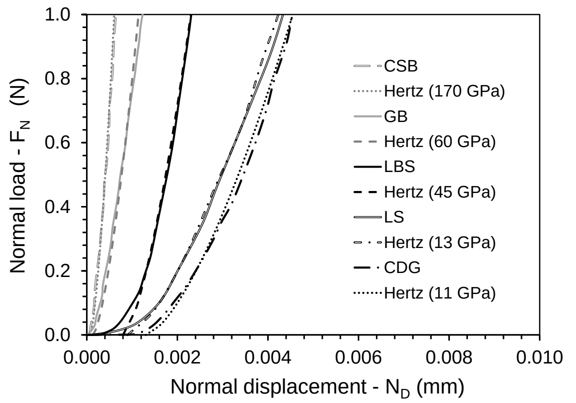

Figure 1. Normal load - deflection behavior of variable types of grains

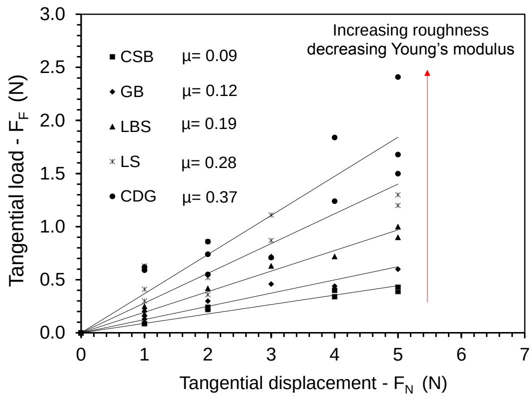

Figure 2. Tangential load – normal load relationship of variable types of grains

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Modelling and Design for Surface Diffusion

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Surface diffusion induced silicon migration has been demonstrated as a promising microfabrication technique for achieving large released structures without traditional sacrificial etch or backside etch methods. This new technique, however, has not been widely used partially due to the inavailability of a modelling and design tool. In this talk, we will present an efficient modelling and design tool developed for surface diffusion induced silicon migration technology.

For the modelling part, an improved phase-field method was developed and used to predict the structure evolved from surface diffusion for a given initial configuration. The improved phase-field method eliminates or reduces some adverse artificial effects such as shrinkages, coarsening and false merging existing in the previous phase-field methods. Satisfactory experimental validation has been achieved and will be demonstrated in the talk.

For the design part, that is, finding the corresponding initial configuration for a given final structure, the challenge lies at the difficulty of finding the corresponding initial structure that satisfies certain constraints imposed by microfabrication techniques such as minimum feature size and shapes. In the traditional approaches, for example, the topology optimization, these constraints should be expressed analytically in the form of optimization variables, which is very hard or impossible to formulate for this design problem. We have developed an artificial neural network, which can learn these constraints automatically instead of formulating them explicitly. This neural network can also link the initial configuration with the corresponding final structure and hence automatically produces the initial configuration, which satisfies all the constraints, for a given final structure.

Mechanical Enhancement of Core-Shell Microlattices through High-Entropy Alloy Coating

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Mechanical metamaterials such as microlattices are an emerging kind of new materials that utilize the combination of structural enhancement effect by geometrical modification and the intrinsic properties of its material constituents. Prior studies have reported the mechanical properties of ceramic or metal-coated composite lattices. However, the scalable synthesis and characterization of high entropy alloy (HEA) as thin film coating for such cellular materials have not been studied previously. In this work, stereolithography (3D-printing) was combined with Radio Frequency (RF) magnetron sputtering to conformally deposit a thin layer (~ 800 nm) of CrMnFeCoNi HEA film onto a polymer template to produce HEA-coated three-dimensional (3D) core-shell microlattices for the first time. The presented polymer/HEA hybrid microlattice exhibits high specific compressive strength (~ 0.018 MPa kg^{-1} m^3) at a density well below 1000 kg m^{-3}, significantly enhanced stiffness (>5 times), and superior elastic recoverability compared to its polymer counterpart due to its composite nature. The findings imply that this highly scalable and effective route to synthesizing HEA-coated microlattices have the potential to produce novel metamaterials with desirable properties to cater specialized engineering applications.

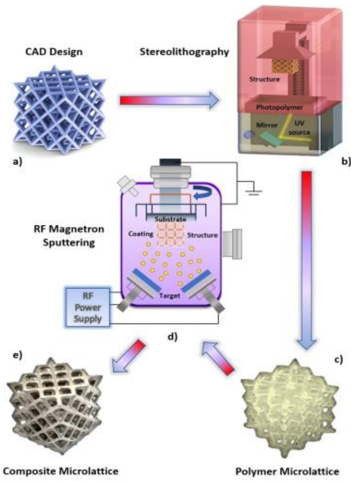

Figure 1. Schematic illustration of the synthesis of HEA-coated microlattices.

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装配整体式混凝土结构检测技术研究与标准编制

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针对装配整体式混凝土结构关键连接部位，研发了基于 X 射线工业 CT 法的套筒灌浆缺陷检测技术，可用于平行试件灌浆质量检测；研发了基于预埋传感器法的套筒灌浆饱满度检测技术，可对套筒灌浆饱满程度进行实时监测；研发了基于预埋钢丝拉拔法的套筒灌浆饱满度检测技术，钢丝拉拔后可用内窥镜校核灌浆饱满程度；研发了基于便携式 X 射线法的套筒灌浆缺陷检测技术，可对灌浆施工后或装配整体式混凝土建筑使用过程中对灌浆质量有怀疑的部位进行检测；研发了基于小直径、高频率换能器的改进超声法检测技术，可用于预制剪力墙底部接缝灌浆质量检测；研发了基于超声成像法的后浇混凝土叠合面质量检测技术，可用于后浇混凝土叠合面孔洞、脱空及浮土杂质的检测；研发了基于淋水法的各类密封胶密封性检测技术，可用于装配整体式混凝土建筑嵌缝质量检测。

编制了上海市工程建设规范《装配整体式混凝土建筑检测技术标准》（DG/TJ08-2252-2018），该标准涵盖了材料、构件、连接、结构、外围护、设备与管线、内装等各个层面。该标准的制定有利于促进上海市建筑工业化的健康发展，加快建筑业转型，具有重要的经济、社会和生态效益。

图 1 超声成像法

图 2 预埋传感器法

图 3 预埋钢丝拉拔法

图 4 X 射线工业 CT 法

图 5 X 射线胶片成像法

图 6 改进超声法

Bayesian model updating in ballasted tracks with the consideration of non-linear ballast stiffness

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The nonlinear behaviour of granular engineering materials is widely known; and railway ballast has no exception. Under large amplitude vibrations, the behaviour of ballast becomes non-linear. Therefore, to reduce modelling errors in the detection of ballast damage, most importantly, under the sleeper; the nonlinear elastic behaviour of the ballast must be considered. Non-linear modelling is usually synonymous with discrete element modelling (DEM), in which the time constraint and the computational cost hinder applicability in large scale analysis. This paper reports the development of a methodology for model updating of the rail-ballast-sleeper system based on the Bayesian stsatistical framework, by incorporating non-linear ballast stiffness into finite element models. Instead of calculating the ballast stiffness, the proposed methodology estimate the marginal posterior (updated) probability density function (PDF) of various nonlinear ballast stiffness parameters utilizing a set of measured vibration data. To avoid the limitations identified with modal parameters, time-domain vibration data were utilized in the methodology. The applicability and effectiveness of the proposed model updating methodology were verified using simulated impact hammer vibration data. Different case studies with different simulated noise levels and different amount of measured data were also considered to investigate the robustness of the methodology. The analysis results are very encouraging showing possible extension of the proposed methodology in ballast damage identification.

Acknowledgements

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Prediction of Field-Monitored Soil Suction using Genetic Programming

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In the shallow soil layers of geotechnical infrastructure, soil suction is greatly affected by vegetation and atmosphere. Genetic programming (GP) can be used to develop a model for describing complex relationship of multiple variables (Zhou et al., 2016; Zhou et al., 2017). In this study, a field monitoring of approximate two months (1st Nov. 2016 to 30th Dec. 2016) was carried out for monitoring variations of soil suction, soil temperature, air relative humidity and air temperature at different distances (0.5m, 1.5m and 3.0m) from the tree and at a constant depth of 20cm under natural environmental conditions. MPS sensors and the VP-4 sensor were employed for measuring the soil suction/temperature and air relative humidity/temperature, respectively. Based on collected data, a computational model was built using genetic programming for describing the functional relationship between soil suction and the other seven variables that include initial suction (x1/kPa), air relative humidity (x2/%), air temperature (x3/°C), soil temperature (x4/°C), distance from the tree (x5/m), drying time (x6/hour) and canopy (x7). Based on the comparison of actual and predicted values of soil suction (Figure 1), the efficiency of developing computational model using GP method for predicting field-monitored soil suction was validated.

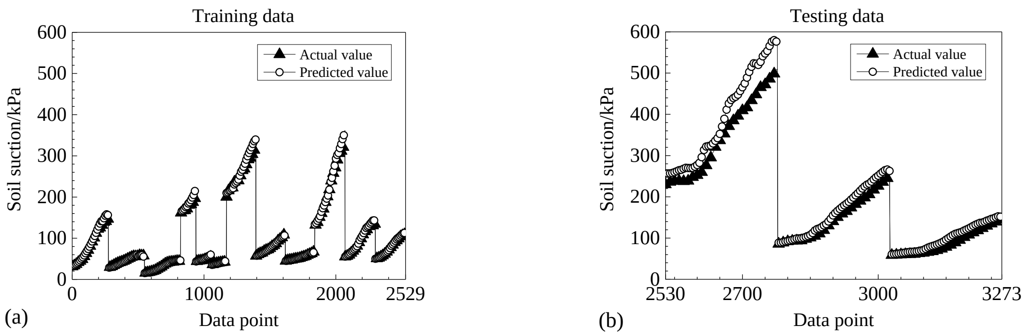

Figure 1. Comparisons of actual and predicted variation curves of soil suction: (a) training data; (b) testing data.

Acknowledgements

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Fully integrated 3D ground motion simulation on Site-City Interaction in an urban transport hub

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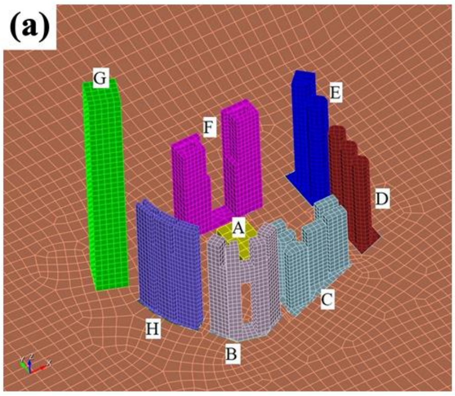
Site-City interaction (SCI) is important for sustainable seismic design in densely populated cities, however, due to its complexity the phenomenon is not yet fully understood. In this study, a fully integrated 3D model was developed to simulate SCI effects in an urban transportation hub. The testbed, Kowloon Station in Hong Kong, assumes a typical downtown layout with a centre plaza and an underground metro station surrounded by 16 high-rise buildings with deep foundations, shown in Figure 1(a). This study aims to examine SCI emphasizing on Soil-Underground Structure-Soil interaction (SUSSI) and contamination of ground motions caused by the closely-spaced high-rise buildings. To simulate visco-elastic wave propagation at the site, a discontinuous Galerkin spectral element code (SPEED) is employed. Results highlight entrapment and reflections of waves between underground structures (SUSSI), which lead to significant amplifications of the wave energy and perturbation of the wave field as shown in Figure 1(b, c). Distinctive patterns in energy ratios in the outskirts of the hub follow the shape of the building layout with an increase from 25-50% up to 500 meters. Peak displacement perturbation of 1.4cm occurs in the centre plaza on both sides of the metro station. The SCI phenomena are governed by the layout of buildings and subsurface structures, which highlights the importance of a realistic fully integrated model for sustainable urban design.



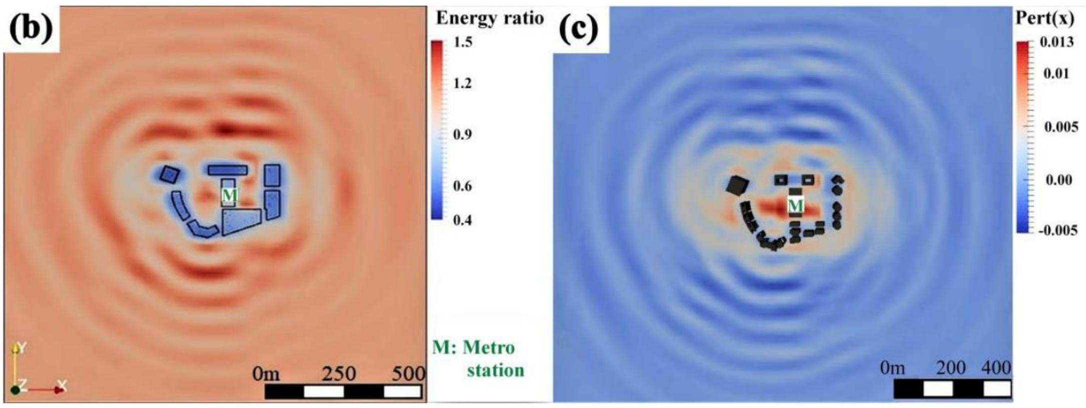


Figure 1. (a) Layout of building cluster in the transportation hub; (b) Ratio of SCI and free field velocity signal energies; (c) Perturbed wavefield (displacement) in meters at peak occurrence.

Acknowledgements

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Numerical simulation of debris flow using Material Point Method

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Rainfall induced landslides are commonly observed in mountainous areas such as Hong Kong, which caused a significant threat to human properties and natural environment. In this study, we developed a novel computational framework to capture the fully coupled hydro-mechanical behaviour of partially and fully saturated soils based on Material Point Method (Sulsky *et al.* 1995). The governing equations are established based on Biot theory (e.g., Xie and Wang 2014) and its extended version, considering that partially saturated soil is composed of solid skeleton, fluid phase and air. Two sets of material points are adopted to represent solid skeleton and fluid phase separately, so that the interaction between two phases is considered. The implementation of the proposed formulation is first validated against the drainage of a vertical sand column experiment. It will further simulate the landslide triggering during heavy rainfall, where the coupling mechanism between hydraulics and mechanical response of the soil will be investigated, in particular, the pore water pressure change due to rainfall infiltration and consequent large deformation and flow.

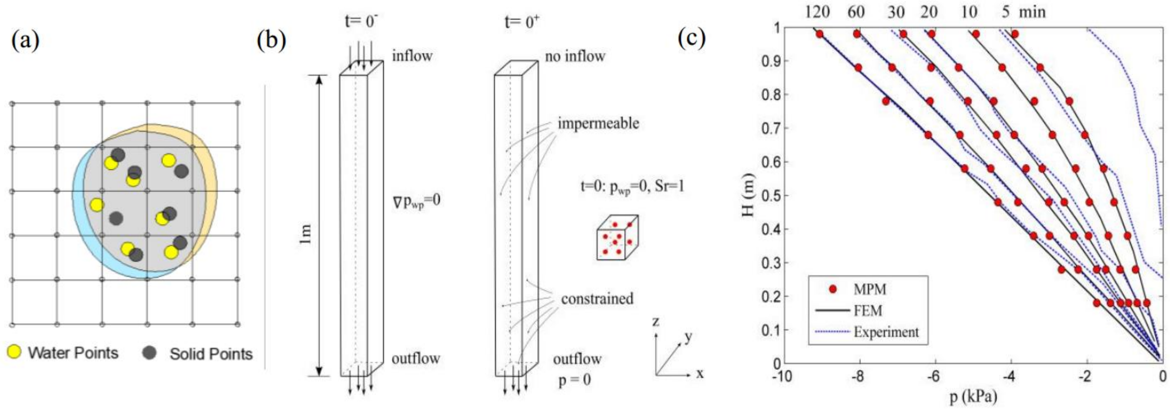

Figure 1. (a) MPM coupling scheme; (b) Configuration of test; (b) The pore water pressure distribution

Acknowledgements

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Analysing the Effect of Tensile Stiffness on Geogrid Pullout Behavior using Discrete Element Method

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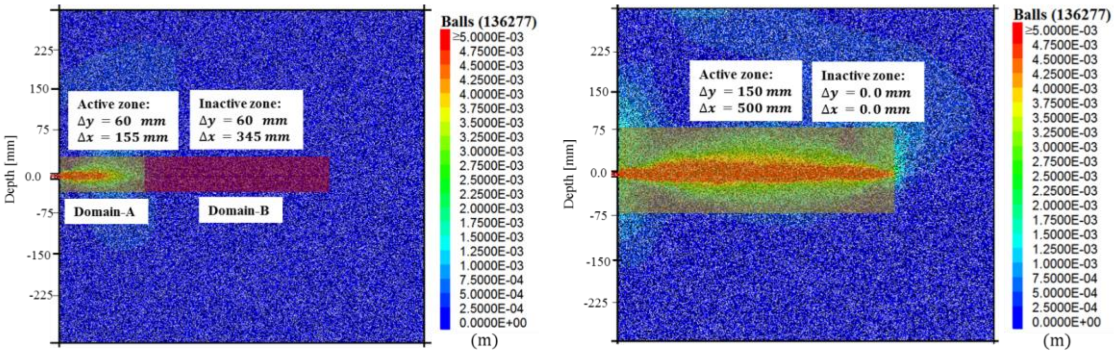
The geogrid-soil interaction mechanism is highly complex, depending mainly on the properties of both elements. To adequately understand the geogrid-soil interaction mechanism, many studies on the interface behavior have been carried out by researchers (Sieira et al., 2009; Chen et al., 2014). However, limited work has been conducted on the comparison of pullout behaviors between stiff and extensible geogrids from the microscopic perspective. Accordingly, a series of numerical pullout tests was performed using the Discrete Element Method (DEM) to investigate the effect of geogrid tensile stiffness on geogrid pullout behavior. The active and inactive zones were defined based on the displacement fields, as shown in Figure 1. The results showed that the higher the geogrid stiffness, the larger the thickness and length of the active zone that was mobilized in the soil under the same pullout displacements d_s, as shown in Figure 1. Contact force chain was presented to reflect contact force distributions within the soil sample. Moreover, the stiffer geogrid could activate the affected length into the full range more rapidly than the less stiff one prior to failure. The tensile forces at the load ends of stiff geogrids were larger than those for extensible geogrids at all d_s.



(a) (b)

Figure 1. Displacement fileds on soil specimens with geogrids: (a) Geogrid-1 and (b) Geogrid-4 at d_s= 25 mm

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Deployments of Tensegrity Towers Driving by Length Changes of Structural Components

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Tensegrities are a class of pre-stressed truss-like structures consisting of a set of axial loaded components (i.e. bars under compression and strings under tension). These structures have unique mechanical properties, and hold promises for a wide variety of technologically important applications, ranging from civil, mechanical, and aerospace engineering. In this paper, we investigate the active deployments of tensegrity towers assembled by a series of planar and prismatic elementary cells, respectively. The structural deformations are actuated by the length changes of the components and simulated by using a stiffness matrix-based nonlinear numerical method. We consider two kinds of connecting relations of the strings: all of them are connected by pin-joints to assemble pinned towers; or several of them run through loops at the ends of the bars to form clustered towers. The actuation efficiency based on the length changes of the strings and bars are also compared. This work could be used in the path design for adjusting the tower shape to satisfy the functional demand.

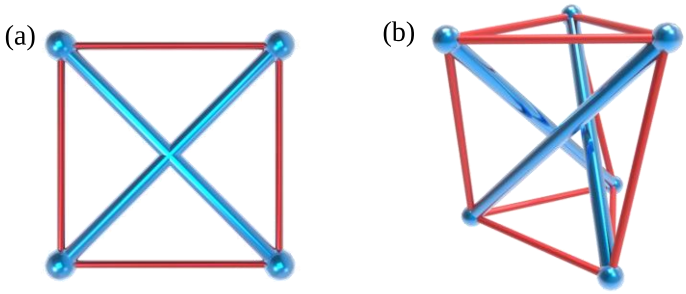

Figure 1. Elementary cells of towers: (a) planar X-shaped tensegrity and (b) triangular prismatic tensegrity.

Acknowledgements

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A Data-driven Method for DEM-based Multiscale Modelling

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Discrete element method (DEM) has been widely used in geotechnical engineering to simulate the behaviour of granular materials. One major challenge to DEM modellers is its expensive computational cost, especially when it is used in a hierarchical multiscale coupling scheme, such as the FEM-DEM coupling scheme (Guo and Zhao 2014, 2016). In FEM-DEM coupling, each Gauss integration point of FE mesh is assigned with a representative volume element (RVE) for DEM to solve for solution in each time step. The nonlinear nature of granular materials frequently demands use of small time step, leading to excessive computing resources spent by the DEM computational alone and greatly impeding practical application of this method for large scale problems. In this study, we develop a data-driven method (Bessa et al. 2017) to predict the behaviours of RVEs along different loading paths. Unlike the previous model where only one-step prediction is needed, to predict the behaviour of a RVE along a specific path requires multi-step predictions. The machine-learning model needs thus to learn sequential information while maintaining its accuracy to an acceptable level, so that the accumulative error will not blow up. A simple shear test is used as a demonstrative example for this method. A dataset containing the stress-strain behaviour of the same RVE under different loading paths is first generated with DEM simulation. A recurrent neural network model is then built and trained on this dataset to capture the connection of different load steps. The trained model is then used to predict the stress behaviour of the same RVE with a new testing strain path with the initial steps and given strain (not included in the training dataset). The model provides fairly acceptable predictions, indicating the power of machine learning for computational geo-mechanics. With an appropriate large dataset and fine-tuning of the parameters, this recurrent neural model may provide a possibility that for a specific RVE, its behaviour under different loading paths can be given directly by a trained model rather than having to resort to expensive DEM simulations, which may greatly save the computational cost for multiscale modelling and make it feasible for modelling large-scale practical problems.

Keywords: Multiscale modelling, DEM simulation, recurrent neural network, simple shear

Acknowledgements

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The Tip speed ratio effect on the near wake structure of a five-straight-bladed Vertical Axis Wind turbine Measured by Particle Image Velocimetry

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Wind energy has attracted wide attentions among scientists around the world. Compared to HAWTs, VAWTs have shown outstanding characteristics such as their low noise, no yaw equipment, etc[1]. Particle Image Velocimetry (PIV) can be used to visualize the wake structure behind the VAWT in wind tunnels. Many valuable literatures related to PIV applications can be found. In this paper, the studied VAWTs were installed at the mid-width of an tunnel's cross-section, and the schematic of the whole PIV system and wind turbines are shown in 0a. To investigate the solidity ratio effect on the wake structures, the time-average velocity and phase-average velocity fields behind 2-bladed, 3-bladed, and 5-bladed VAWT samples will be measured in x-y planes, x-z planes, and y-z planes respectively, and the diameter (D = 0.52 m), the chord length (c = 78 mm) and blade shape of the three turbine samples are kept constant. In an recent experiment, a 5-bladed VAWT was tested in y = 0 plane with the rotating speed equal to 380 rpm as the upstream wind velocity is 11 m/s (as shown in 0b). The measured area is 0.8D × 0.5H (H = 0.35 m). It is clear to find that the maximum velocity already recovers to 19.8% upstream wind velocity.

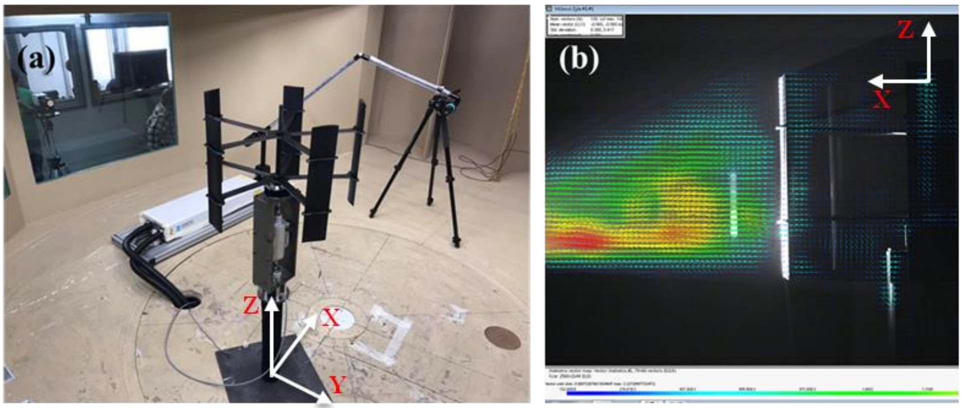

Figure 1. (a)Schematic of the whole PIV system and wind turbines; (b) time-averaged velocity field of the 5-bladed turbine in y = 0 plane as the rotating speed is 380 rpm with 11 m/s streamwise wind speed.

Acknowledgements

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Simulation of a flexible beam in uniform flows

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Phenomena involving fluid-structure interactions (FSI) are everywhere in our daily life, such as fish swimming, bird flying, and flags flapping [1]. Addressing these problems typically requires coupling fluid dynamics and structural mechanics by solving these two parts simultaneously [2]. In the work, we study the dynamics of a clamped-free flexible beam in a uniform flow using a newly developed FSI simulation framework, as sketched in Fig. 1. The lattice Boltzmann method (LBM) is used for modelling the flow field. The beam structure with large deformation is solved by using a finite element method (FEM) based on the co-rotational formulation method, so that geometrical nonlinearity can be handled. The immersed boundary (IB) method is used to deal with the fluid-structure interface. Mechanisms underlying the dynamics of the fluid-beam system are analysed systematically. Different states of the beam deformation and kinematics are identified. In addition, the effects of the beam mass ration and bending stiffness on these states are studied. The conversion between the flow energy and the beam elastic energy is also analysed. The simulation results provide more physical insights into the dynamics of this fluid-structure system.

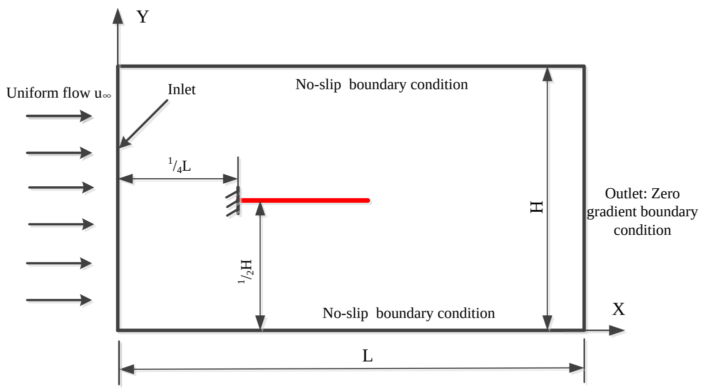

Fig.1. Schematic of a flexible beam in a uniform flow.

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基于 SPH 的松质骨力学行为模拟与骨植入性能研究 1)

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松质骨是骨的重要组成部分，正常工作状态下，松质骨承担部分荷载并保证骨的整体和局部稳定性。当骨折发生时，往往需要借助骨植入改善骨折部位的受力性能。骨植入与松质骨的相互作用包含两个方面：其一，骨植入需要比较容易地穿过松质骨植入到预定部位；其二，到达预定部位之后，骨植入需要与松质骨可靠连接，保证有效的应力传递，不发生因局部应力过大而导致的破坏。上述两点相互联系，需要合理的分析和设计。本研究开发了基于松质骨 Micro-CT 图像建立无网格分析模型的方法，基于 SPH 方法对松质骨的力学行为进行了详细地数值模拟分析和研究，并讨论了骨植入的几何形状对松质骨破坏过程的影响。本研究可为骨植入的设计提供基础和依据。

Microscopic ridge-like surface morphology: An antifouling strategy learn from nature

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In nature, organisms through millions of years of evolution have developed a variety of apparatuses to enhance their survival chance in the severe biological competitions. For example, the adhesive of biofouling organisms (e.g., barnacles, mussels, and tubeworms) provide adequate stickiness to their attachment and accumulation on the solid surfaces immerged in ocean, while the leaves of *Sonneratia apetala*, one kind of mangrove tree living in intertidal zones prevent the fouling organisms attaching. In this study, settlement tests with tubeworm larvae on polymeric replicas of *S. apetala* leaves confirm that the microscopic ridge-like surface morphology of the leaves plays a key role in preventing biofouling. A contact mechanics-based model indicates that the tubeworm settlement depends on the structural features of the microscopic ridge-like morphology. Under the direction of the guidelines obtained from the theoretical modelling, a synthetic surface with microscopic ridge-like morphology is developed, exhibiting antifouling performance comparable to that of the *S. apetala* replica. These findings not only uncover the underlying mechanism accounting for the superior antifouling property of the *S. apetala* leaves, but also provide applicable guidance for the development of synthetic antifouling surfaces.

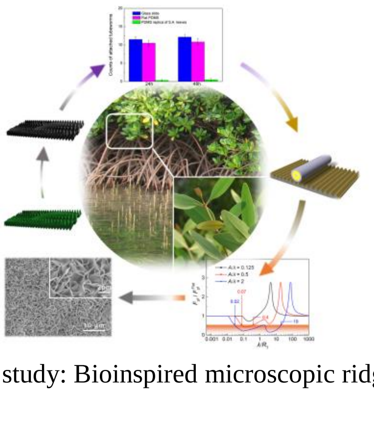

Figure 1. Flow diagram of the study: Bioinspired microscopic ridge-like surface morphology:

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Traumatic retraction of neurons regulated by cell adhesion

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Damage to neural cells and retraction of axons during traumatic brain injury (TBI) are believed to trigger disintegration of the neural network and eventually lead to severe symptoms such as permanent memory loss and emotional disturbances. Unfortunately, a method allowing us to quantitatively characterize the traumatic retraction of neural cells as well identify key players involved is still lacking. In this study, we used a sharp atomic force microscope (AFM) probe to transect axons and trigger their retraction. It was found that a well-developed axon may not fully shrink back to the main cell body after the first axotomy. Instead, the retracting motion can be arrested/stopped presumably by strong cell-substrate adhesion. Interestingly, axon retraction will be re-triggered if a second transection is conducted. A simple model was also developed to describe the observed injury-induced retraction of axons, which suggested that the retraction process is tightly regulated by the level of pre-stretch in the axon, the apparent elastic modulus and viscosity of neural cells, and the strength of cell-substrate adhesion. By choosing reasonable parameter values, predictions from this model agree very well with the large set of data obtained from our experiment.

Direct quantification of mechanical responses of TiSiN/Ag multilayer coatings through uniaxial compression of micropillars

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The TiSiN/Ag multilayer coatings with fixed TiSiN layer thickness and different individual Ag layer thicknesses were prepared by arc ion plating. Quantification of mechanical response of TiSiN/Ag multilayer coatings through uniaxial micropillar compression tests was carried out to identify the elastic modulus, fracture strength, deformation and failure mechanism. The deformation and failure behavior of the micropillars assessed by direct SEM observation after the uniaxial compression tests revealed a linear increase of stress with strain up to a fracture point for all 1-μm micropillars, indicating an elastic response with brittle failure. In addition, in-situ micro-compression was carried out mainly on the micropillars with diameters of 600 nm and 300 nm; the stress-strain curves show an initial linear elastic response until the yield point was reached, followed by plastic deformation with a total strain of 27.99 % and 42.7 %, respectively. Moreover, size defect was also found in the micropillar compressions in which, the 300-nm micropillar showed the highest fracture strength of 16.71 ± 0.63 GPa.

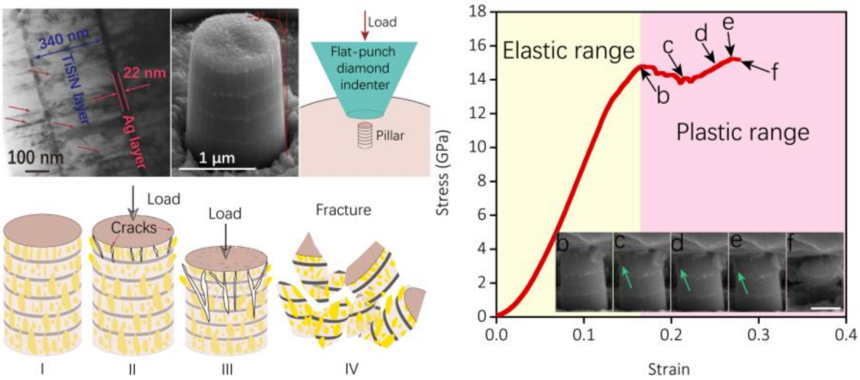

Figure 1. Typical TEM and SEM micrographs of TiSiN/Ag multilayer coating, micropillars, Compressive stress-strain curve and schematic illustration of damage mechanism under uniaxial compression tests.

Acknowledgements

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The Surface Hydrophobicity Effect on the Capture Efficiency of Cancer Cells in Microfluidic-Elasto-Filtration Chips

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The capture efficiency (η_c) is the most critical performance to achieve an excellent isolation result of circulating tumor cells (CTCs) from blood. Previously, we have proposed a Microfluidic-Elasto-Filtration (MEF) method using the optimized Elasto-Capillary number (Ca_e^*) to isolate CTCs with high η_c, however, without considering the impacts from the different hydrophobicity of filter surfaces. Here, we study the hydrophobicity effect on the η_c in MEF using filters made from Silicon on Insulator (SOI) wafers. The surface was originally hydrophobic, which can be adjusted to hydrophilic by O_2 plasma treating as shown in Figure 1 (a) and (b). The η_c was determined as the ratio between the number of captured cancer cells (Figure 1 (c)) and that of the injected cells. With a series of MEF experiments under Ca_e^*, the η_c showed no difference on the filters with different hydrophobicity when the normalized cell diameter (d^*) with respect to the filter pore diameter (d_p) was 2.2. The η_c of the hydrophilic filter surfaces became 4% and 20% higher than that of the hydrophobic surfaces when d^* was 2.07 and 1.57, respectively, due to the higher cell adhesion forces on the hydrophilic surfaces. Thus, a critical value of d^* (~2.07) was identified to determine whether the surface hydrophobicity induced cell adhesion forces can enhance the cancer cell capturing in MEF under Ca_e^*, which was also verified by our nonlinear mass-damper-spring model of MEF.

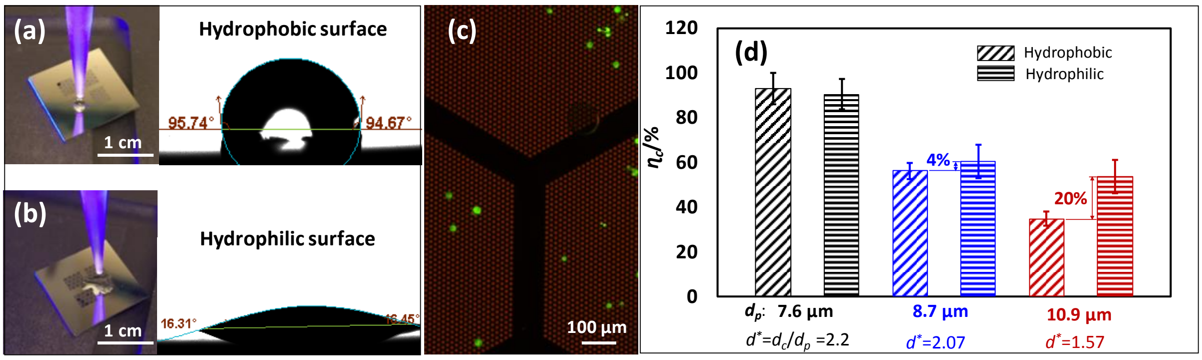

Figure 1. (a) and (b) The measurement of contact angles (water droplet, air and filter surface) of the SOI-wafer filters with different hydrophobicity; (b) MCF-7 cells captured in filer pores; (c) The capture efficiency of MCF-7 cells became higher on the hydrophilic filter surfaces only when the normalized cell diameter(d^*)> 2.07.

A platform for rapid drug-resistance identification of non-small cell lung cancer (NSCLC) cells

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A major challenge in today's cancer treatment is that patients undergoing therapy can develop resistance to previously effective drugs. As such, finding new and faster ways to achieve drug resistance identification of cancer cells has always been an area of great interest. Interestingly, our recent study showed that the drug-resistance of tumor cells can be evaluated by the electroporation efficiency, i.e. the percentage of cells with membrane pores created, based on a electroporation platform which was designed and fabricated that allows us to achieve rapid test on different cells. It was found that the efficiency will decrease significantly as the resistivity of the cells against Erlotinib increases. And the validity of this platform was assessed on six non-small cell lung cancer (NSCLC) cell lines using different fluorescent dyes. Furthermore, we showed that the inverse relationship between the electroporation efficiency and Erlotinib resistance is likely due to the fact that NSCLC cell lines with higher drug resistivity appear to have lower cortical tensions and hence make it harder for membrane pores to be created, consistent with existing electroporation theories.

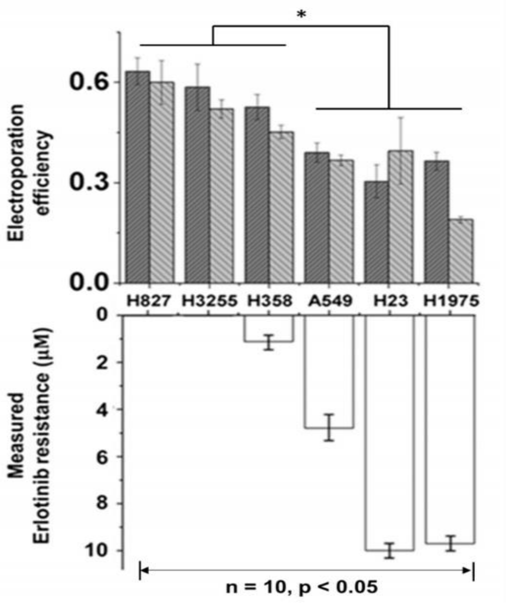

Figure 1. The correlation between electroporation efficiency and Erlotinib resistance in non-small cell lung cancer (NSCLC)

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Topology optimization design of broadband elastic hyperbolic metamaterial

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Metamaterials with delicately engineered architectures have been attracting considerable attention because of their unique properties and/or capabilities for wave manipulation. One such an example is metamaterials with hyperbolic dispersion, which have many promising applications such as negative refraction, partial focusing and super-resolution imaging [1]. However, compared with their acoustic and electromagnetic counterparts, the design of elastic hyperbolic metamaterials are more challenging due to the presence of both longitudinal and transverse waves [2].

In this talk, we present a computational approach for designing elastic hyperbolic metamaterial with a broad operation frequency band. Based on the features of the hyperbolic equal-frequency contour (EFC), a two-step topology optimization formula is proposed and solved by a gradient-based optimizer. In the first step, the material is designed to achieve broadband highly anisotropic dispersion with a complete band gap in one direction and a single propagating state in the other direction. Then, the curvature of EFC is optimized with proper constraints to avoid multiple mode interference in the designed frequency band. Because the structural worthiness could be hampered by the perforation introduced in the design, the static effective modulus is incorporated into the optimization algorithm as a constraint in order to maintain a certain level of stiffness.

Using the proposed optimization formulation, our designed metamaterial exhibits hyperbolic dispersion over a broad relative frequency range of 77%. Negative refraction, and super-resolution imaging are also demonstrated to verify the proposed design.

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Tensile properties and fracture behavior of high porosity nickel foams

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The tensile properties of nickel foams are investigated for the application of flexible devices and energy storage. The results show that the tensile properties of nickel foam have strong anisotropy because of the straightening process in the production process. To investigate the tensile property of nickel foam, different factors include relative density, strain rate and anisotropy are considered in this paper. The obtained tensile strength is compared to the predictions of Gibson and Ashby's model and Liu's model prove that the existence of anisotropy. The tensile properties of nickel foams have strong anisotropy due to the structure of the open-cell nickel foams. In-situ tensile tests are also done to observe the fracture behaviour of nickel foams. There also have some differences between the in-situ experiment and macro tensile experiments.

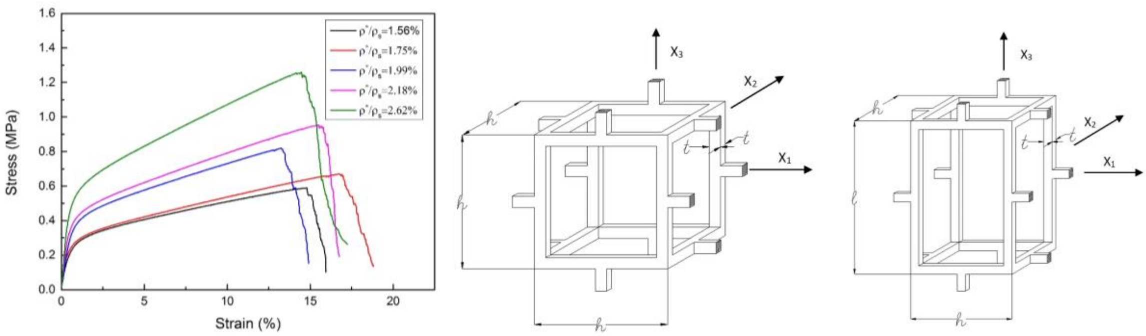

Figure 1. The stress-strain curve of the tensile test of nickel foams and their structures.

Acknowledgements

The authors wish to thank the National Natural Science Foundation of China (Grant # 51301147), the Research Grants Council of the Hong Kong Special Administrative Region of China (GRF # CityU 11209914) and City University of Hong Kong (Grant # 9680108). The work was also supported by the Innovation and Technology Commission via the Hong Kong Branch of National Precious Metals Material Engineering Research Center.

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Mechanically assisted self-healing of ultrathin gold nanowires

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Ultrathin gold nanowires (diameter < 10nm), one of the most promising candidates for next-generation interconnects in nanoelectronics, has captured researchers' attention. Also, due to their ultra-small dimensions, however, the structures and morphologies of ultrathin gold nanowires are more prone to be damaged during practical services, for example, Rayleigh instability, hindering their applications as interconnects. Here we developed a simple method, using moderate mechanical manipulation at room temperature, to quickly restore nanowires' uniform diameter and smooth surface. By examining the local self-healing process through in situ high-resolution transmission electron microscopy (HRTEM), the underlying mechanism is revealed and also evidenced by molecular dynamics (MD) simulations. In addition, mechanical manipulation could assist the atoms to overcome the diffusion barriers, as suggested by ab initio calculations, to activate more surface atoms to diffuse and consequently speed up the self-healing process. This method could provide a facile method to repair ultrathin metallic nanowires directly in functional devices, and quickly restore their uniform structures and morphologies by simple global mechanical perturbations.

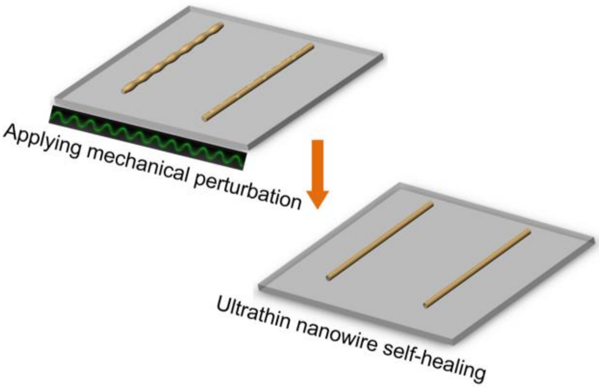

Figure 1. Schematic diagram of mechanically assisted self-healing of ultrathin gold nanowires

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Recent Advances in In-situ Mechanical Characterization of Bamboo

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We perform experimental mechanical characterization of structural biomaterials coupled with advanced in situ microscopic imaging. This is critical for understanding the deformation and failure mechanisms in engineering applications. The in-situ results show that the hierarchical microstructural phases, including fibers, parenchyma cells and vessels, play an important role in determining the remarkable mechanical behaviors of bamboo. The results suggest that the superb flexural properties are attribute to the concurrent graded distribution of tougher constituent (mainly fibers), along with weaker constituent (such as parenchyma cells). Another important observation is that the fractural behavior of bamboo is due to that the functionally graded structure of bamboo distracts the crack growth and absorbs the cracking energy. These works provide insights for designing and optimizing bamboo-inspired composites with desired properties for various engineering applications.

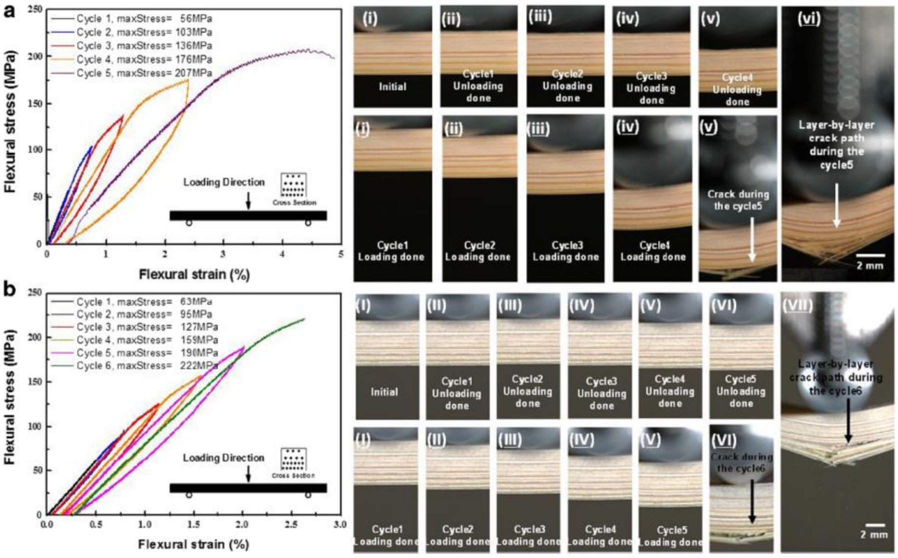

Figure 1. In situ loading-unloading processes for samples with 3.7 × 3.7 mm2 areas (a) and 5.4 × 5.4 mm2 areas (b) subjected to flexural loading

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基于正交展开的非线性振子系统多项式随机最优控制

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在土木、机械工程领域，一类具有硬化或软化特性的非线性振子系统常用于表征非线性结构系统，随机激励作用下这类振子系统的性态控制近年来受到了广泛关注。基于多维 Hermite 正交多项式的经典均相混沌展开，本文考察了非线性振子系统多项式随机最优控制的正交展开方法，阐明了多项式系数演化与系统反应、最优控制力概率特性之间的联系。以随机地震动作用下一类硬弹簧 Duffing 振子的最优控制为例，进行了基于 Karhunen-Loeve 展开的随机地震动离散谱表现，建立了基于位移-速度范数准则的自适应混沌多项式展开策略。数值计算分析表明，受控后系统的随机涨落得到了明显降低、非线性反应性态得到了显著改善。同时，混沌多项式系数或各阶模态的演化过程与系统性态和最优控制力直接相关，表明非线性随机最优控制可以从确定性混沌多项式模态叠加的思路实现，这为非线性随机动力系统的最优控制提供了新的思路。

一个考虑出行时间和路径选择的二维连续型动态交通分配模型

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这一工作研究了考虑出行时间和路径选择策略的交通均衡问题，通过变分不等式方法建立了连续型预测动态用户最优模型。考虑具有多个中心商务区的城市，根据不同的目的地对出行者分类。我们假设城市交通路网足够稠密并将其视为二维连续的平面。给定交通需求分布，可以建立考虑路径选择策略的预测动态用户最优（PDUO）模型，该模型中出行者选择实际费用最小的路径行驶。在本工作中，我们将出行时间选择和 PDUO 模型相结合，研究同时考虑出行时间和路径选择的交通均衡问题。所提出的模型满足出行时间动态用户最优准则，即对任意起终点（OD），在任意时刻出发的出行者所花费的费用都是相等且最小的。我们采用变分不等式描述满足出行时间动态用户最优准则的交通均衡问题，并采用投影方法求解离散后的变分不等式。最后，给出一个具有两个中心商务区城市的数值算例，来验证所提出模型和数值算法的有效性。

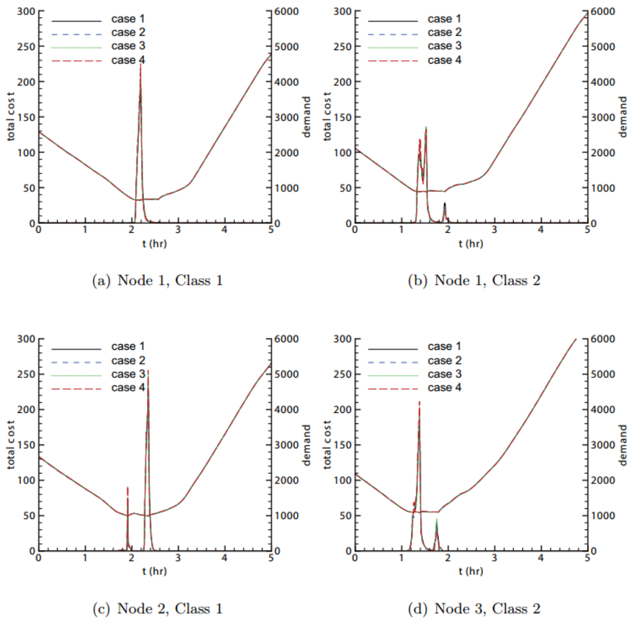

图 1．出行时间选择和总费用。

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Coefficient of Restitution of Spheroid Particles Impacting on a Wall

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Coefficients of restitution is a necessary parameter for discrete element modelling (DEM) simulations of granular flow.Impact experiments with spheroid particles show that the normal COR is not only decided by materials and impacting velocity but also where the contact point is. This article divides the normal COR at the contact point of a spheroid particle into two parts according to the translation motion and rotation motion after impact. A dimensionless parameter e^* consist of that two parts.The theoretical relationship between e^* and parameter ϕ which represents the position of contact point is derived and it shows a good agreement with experimental data.

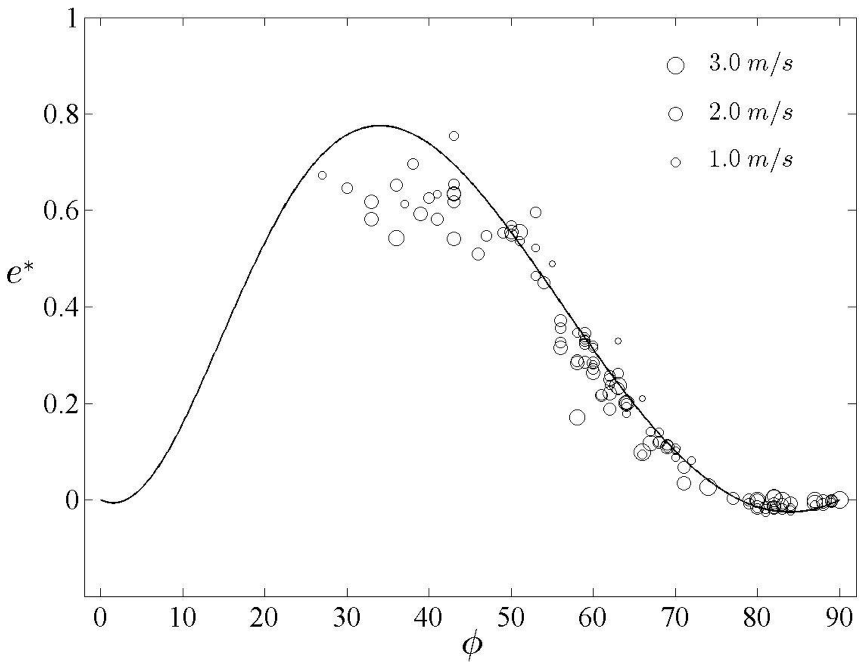

Figure 1. The relationship between e^* and ϕ.

Acknowledgements

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Droplet impact dynamics on convex nanotextured bumps

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This work presents a numerical investigation of fog droplet impact on dessert beetle inspired nanotextured bumps for water collection by employing the multiple-relaxation-time Lattice Boltzmann method (LBM). Fig.1 shows a schematic of the simulated problem. The parameters to be studied include: interpost spacing, post height, bump radius and Weber number. Three different droplet states subsequent to impact are captured, namely, suspended Cassie state, droplet rebound and sticky Wenzel state. Cassie state droplets are known to be favourable for water collection as they can be easily removed from the surface. In this work, geometrical parameters and a range of Weber numbers are investigated for the Cassie state. The results show that droplet impact yields favourable Cassie state for taller posts and larger bump radius for the whole range of studied Weber number. However, droplet rebound occurs by decreasing bump radius for larger Weber numbers. Besides, transition from the Cassie state to the Wenzel state occurs by decreasing the post height. On the other hand, smaller interpost spacing and higher post height at smaller Weber numbers are optimum for the Cassie state. Furthermore, increasing interpost spacing and decreasing post height result in the sticky Wenzel state even at small Weber numbers.

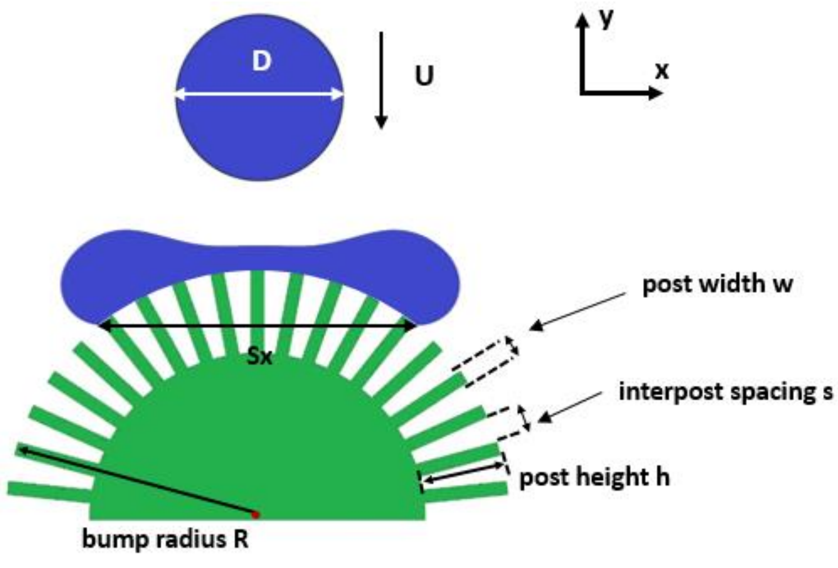

Figure 1. Schematic of a droplet impacting on hemispherical bump with nanoposts.

Performance Prediction for Mistuned Bladed Disk by Gaussian Process Regression

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Cyclic symmetric structures like bladed disks usually suffer to mistuning as the inevitable uncertainty exists in blades due to material variance or manufacture error. Mistuned bladed disks can have dynamic feature significantly different from the nominal perfect system. The frequency response can be enhanced and response amplification factor is an important dynamic performance index to reveal the mistuning effect under different mistuning parameters. This research provides an approach to predict amplification factor for mistuned bladed disk with statistical model built by Gaussian process (GP) regression. Samples of mistuned blades disks with different mistuning parameters, along with corresponding response amplification factors, are used as prior knowledge to establish GP model. Without calculating the entire structure, prediction on amplification factor can be made directly by GP model as new mistuned case comes. Case study proves that GP model can predict the amplification factors accurately and efficiently. Error analysis under different settings for GP model and different loading conditions are discussed in detail. This approach is promising for mistuned blade disk system if repeated calculation/prediction is required.

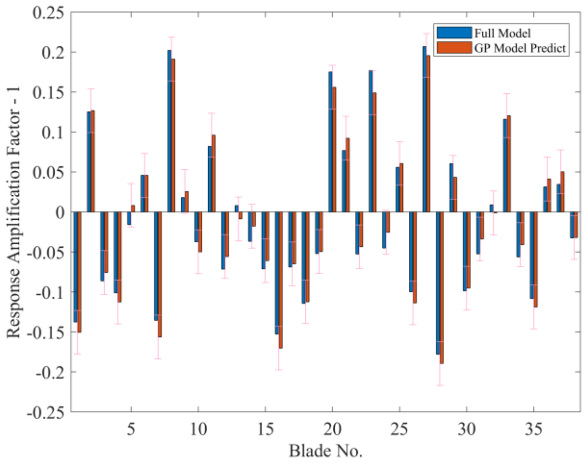

Figure 1. Sample of GP model prediction in response amplification factor

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RANS study of flows over surface across roughness transition

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Reynolds-averaged Navier-Stokes (RANS) modeling approach is carried out in this study to investigate the transition process while air is flowing over wavy surface across a change in roughness. Surface roughness is measured by drag coefficient C_d and roughness length z_0. The relation between roughness parameters and terrain feature (amplitude-to-wavelength ratio $2a/\lambda$) is examined through which the roughness of different sinusoidal wavy surfaces is quantified. Flows over homogeneous wavy surfaces are characterized first. Variations of wind profiles are observed at different streamwise positions, the maximum and minimum Reynolds stress appear at trough and crest, respectively, due to recirculating flows. It is shown that the current RANS modeling results compare favourably well with the water-channel experiment from Hudson et al. (1993). The effect of roughness change on flow structure is elaborated in this study. Flow transition process is illustrated through the adjustment of mean flows and turbulent momentum fluxes. Three smooth-rough simulations with different roughness parameters are conducted in which the downstream-to-upstream-roughness-length-ratio $z_{0,2}/z_{0,1}$ is equal to 3.98, 6.46 and 10.20. Computational fluid dynamics (CFD) modeling results show that after surface transition, both the turbulent kinetic energy (TKE) and the vertical momentum flux (u''w'') increase with increasing downstream surface roughness $z_{0,2}$. However, a reduction in vertical momentum flux is observed near the surface transition position. Moreover, the development of a new roughness sublayer (RSL) and a new inertial sublayer (ISL), which are induced by roughness change, could be clearly observed. In view of the surface roughness changes on flows, the depth of two ISLs and internal boundary layer (IBL) are defined quantitatively, finally the conceptual model of "two-layer" flow structure is proposed accordingly.

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Debris flow-structure interaction using coupled CFD-DEM simulation

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Abstract: A debris flow is a rapid moving mass of fluid-sediments mixtures that travels down a slope under the influence of gravity, one of the most threatening natural geo-hazards with destructive power. Both solid and fluid phases vitally influence the debris flow dynamics. In this study, the behavior of fluid flow is resolved by solving the Raynolds Averaged Navier-Stokes equation in CFD (Computational Fluid Dynamics), while the DEM (Discrete Element Method) is used to simulate solid materials by particle contact model. The coupled CDF-DEM simulation accounts for various solid and fluid interaction forces in debris flow, which consist of the buoyancy force, drag force and virtual mass force. Bonded particles are used to model structures, so structure damage due to debris flow impact can be assessed and evaluated, which help to enhance our understanding on debris flow-structure interaction mechanism.

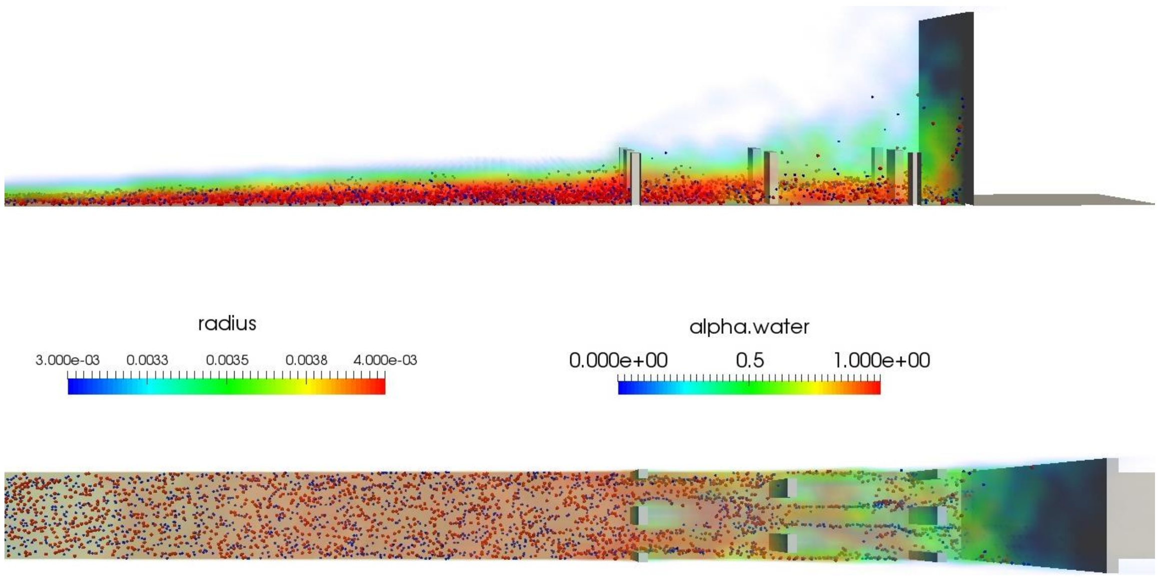

Figure 1. Mixture of flow and particles impacting on baffle and rigid barrier using coupled CFD-DEM method (side-view and top-view)

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Flexibility effect of a passively flapping hydrofoil on flow energy extraction

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The rapid rise of energy consumption brings a great challenge to the sustainable development of our world. Under such circumstances, it is an urgent subject to look for new power sources and new ways of energy extraction. Inspired by birds' and fishes' marvellous capability in utilizing flow energy, a flapping hydrofoil is designed to harvest energy from air/water flows. Compared with other conventional techniques, it has the advantages of better performance at low Reynolds numbers, better filling factor, more structurally robust, better environmental adaptability and less three-dimensional losses. Previous studies have also suggested that energy harvesting efficiencies of flapping hydrofoils can be comparable to traditional rotary turbines [1]. Up to now, however, most of existing works were focused on fully prescribed or semi-passive systems, and research on fully passive systems was severely limited. To fill this gap, we designed and fabricated a fully passive rigid flapping hydrofoil energy harvester [2]. By investigating its performance with various parameters and flow conditions, we found that, without using a power take-off system, a power efficiency as high as 60% can be achieved. In the present study, the hydrofoil flexibility is considered since previous studies have shown that wing/fin flexibility can be beneficial for propulsion. The flexibility is realized through adding a rigid tail plate that is connected using torsional springs. Experiments were conducted on this new system in the water tunnel, where the instantaneous motions and hydrodynamic forces were measured to evaluate the system performance.

The experiment revealed that the new system can perform sustainable flapping motions even when the hydrofoil pivot location is at $x_p = 0.5c$, where c is the total chord. On the contrary, at this pivot location the system with only one rigid hydrofoil would get stuck. Fig. 1 shows the variation of the system performance against the spring stiffness. At a given freestream velocity $U_0 = 0.642$ m/s and fixed pitching amplitude θ_0, the mean power extracted from the heave motion (i.e., $\overline{C}_{ph}$) monotonically increases with the spring stiffness, while the mean power extracted from the pitching motion (i.e., $\overline{C}_{p\theta}$) monotonically decreases. Consequently, when the stiffest spring was applied, the mean heaving power becomes significantly larger than the mean pitching power. The mean total power extraction, i.e., $\overline{C}_p = \overline{C}_{ph} + \overline{C}_{p\theta}$, shows a peak at moderate and high pitching amplitudes (i.e., θ_0 = 43° and 60°), while it decreases very slightly at the lowest pitching amplitude (i.e., θ_0 = 30°). This indicates that an optimal stiffness exists for power extraction when the pitching amplitude is not too small. Additionally, it is found that, at any given pitching amplitude, the most flexible hydrofoil always experiences the largest flapping frequency (represented by Strouhal number St). As the pitching amplitude increases, St increases (see Fig. 2). In addition to motion and force measurements, time-resolved PIV measurements were also conducted to relate key flow structures with the hydrofoil's motions and forces. More results will be revealed in our talk.

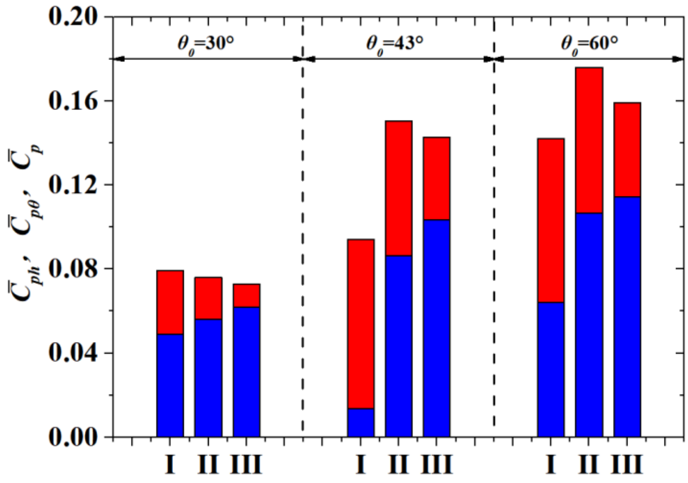

Figure 1. Variation of mean heaving power ($\bar{C}_{ph}$, blue bars) and mean pitching power ($\bar{C}_{p\theta}$, red bars), and the mean total power extraction ($\bar{C}_p = \bar{C}_{ph} + \bar{C}_{p\theta}$, summation of the blue and red bars) from the system against spring stiffness in a flow of velocity U_0=0.642 m/s, where I, II and III are Very Flexible(I), Flexible (II) and Less Flexible (III) separately.

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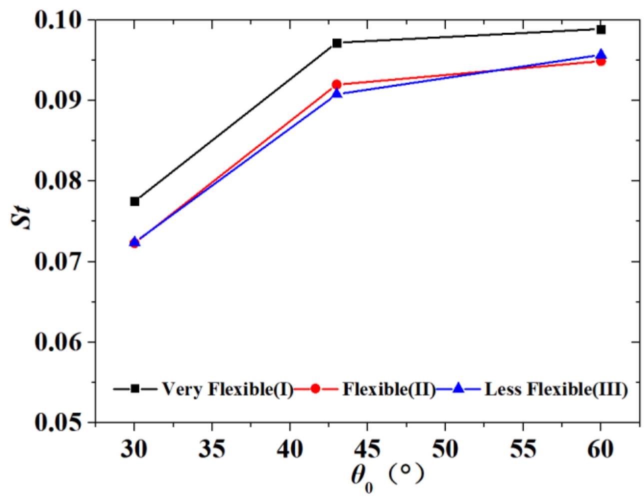

Figure 2. Variation of Strouhal number (*St*) against pitching amplitude in a flow of velocity U_0=0.642 m/s.

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Numerical Simulations and Model Reduction of a Building Model for the Design of Smart HVAC Control System

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Reduced open-loop model of indoor airflow is crucial for the design of smart Heating, ventilation, and air conditioning (HVAC) control system of building. In this work, we apply the proper orthogonal decomposition (POD) to the transient computational fluid dynamics (CFD) simulation data of our demo room to obtain such model. It's found that the top 12 modes can recover the flow field very well even the geometry and boundary conditions are very complex, as shown in Figure 1. To further extend this method to general cases, we also need to construct a simpler unified model that is applicable to different values of important physical parameters such as room size, inlet velocity, etc. As first step, we conducted CFD simulation on a turbulent free jet and performed POD model reduction on it. It's found that only 2 or 3 modes are sufficient to describe such a flow field. In the future, we will work on the turbulent jet in closed space which is essentially a simplified room model.

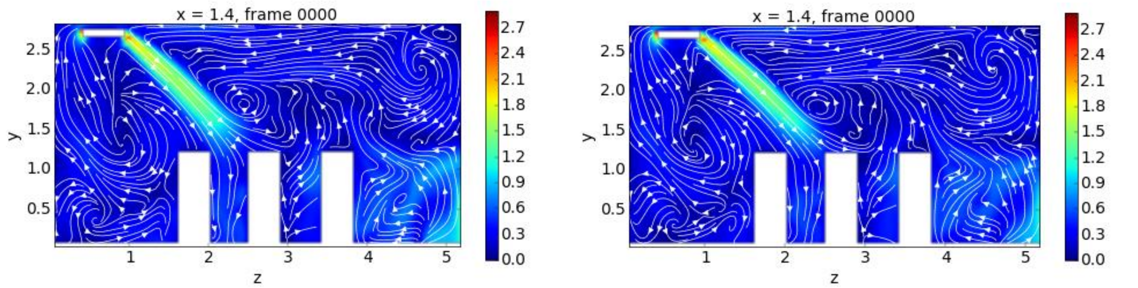

Figure 1. A snapshot of air velocity field on the 2-dimensional slice x=1.4 of a room with three persons (blank columns). Streamlines (white) and magnitude of velocity (in color) are shown. Left: CFD simulation. Right: approximation with 12 POD modes.

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CAMPUS MAP AND ROUTE TO CONFERENCE VENUE

Hotels and Accommodation:

We recommend the following hotels to conference delegates. These hotels are located close to PolyU campus, with a 40-minute taxi ride from Hong Kong International Airport, and a 10-minute walk to conference venue. Please contact the hotels to make your own reservation.

- Harbour Plaza Metropolis (都會海逸酒店), 7 Metropolis Drive, Hunghom, Kowloon, Hong Kong
- Regal Kowloon Hotel (香港百樂酒店), 71 Mody Rd, Tsim Sha Tsui, Hong Kong
- Park Hotel Hong Kong (富豪九龍酒店), 61-65 Chatham Rd S, Tsim Sha Tsui , Hong Kong