HKSTAM

Hong Kong Society of Theoretical and Applied Mechanics

江苏省力学学会

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Jiangsu Society of Theoretical and Applied Mechanics

Proceedings of

The 21st Annual Conference of HKSTAM 2017

The 13th Jiangsu - Hong Kong Forum on Mechanics and Its Application

April 8, 2017 (Saturday)

The Hong Kong Polytechnic University, Hong Kong SAR

Editors

Zhongqing SU and Li CHENG

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PREFACE

The 21st Annual Conference of HKSTAM (2017) in conjunction with the 13th Jiangsu – Hong Kong Forum on Mechanics and Its Application is held on April 8, 2017 at the Hong Kong Polytechnic University. This conference is co-organized by the Hong Kong Society of Theoretical and Applied Mechanics (HKSTAM), the Jiangsu Society of Theoretical and Applied Mechanics (JSTAM), and The Hong Kong Polytechnic University (PolyU). The conference topics cover mechanics and its applications in all science and engineering disciplines.

This one-day 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 50 abstracts including 4 Distinguished Lectures by Prof. Alfonso Hing Wan NGAN from The University of Hong Kong, Prof. Maosen CAO from Hohai University, Prof. Quan WANG from City University of Hong Kong, and Prof. Jinxing LIU from Jiangsu University. The conference is structured into 8 parallel sessions with 46 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) and Yaozhong Liao (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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Table of Contents

Technical Papers

Session B2 [Seminar Room Y304]

Session C1 [Seminar Room Y305]

Session C2 [Seminar Room Y305]

Session D1 [Seminar Room Y306]

Session D2 [Seminar Room Y306]

The 21st HKSTAM Annual Conference in conjunction with The 13th Jiangsu-HK Forum on Mechanics and Its Application

Conference Program (8 April 2017)

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

April 8, 2017, Saturday Morning (Y305, 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 Maosen CAO (曹茂森)** **Vice Secretary of JSTAM**
09:10 – 09:50 **[40 mins]**	**Chair**: Professor Li CHENG (成利), The Hong Kong Polytechnic University, President of HKSTAM **Distinguished Lecture I** **Professor Alfonso Hing Wan NGAN (顏慶雲)** Kingboard Professor in Materials Engineering, Chair Professor of Materials Science and Engineering, Department of Mechanical Engineering The University of Hong Kong **"When Mechanics Meets with Chemistry – Novel Redox Actuators Made from Nickel Hydroxide"**

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 Maosen CAO （曹茂森）** College of Mechanics and Materials Hohai University "**Wavelets-Driven Multiscale Dynamics Concepts for Structural Damage Detection**"
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 Quan WANG（王泉）** Chair Professor, Department of Architecture and Civil Engineering City University of Hong Kong **"Energy Harvesting from Ocean Waves by Piezoelectric Technologies"**
11:40 – 12:20 **[40 mins]**	**Chair**: Professor Maosen CAO (曹茂森), Hohai University, Vice Secretary of JSTAM **Distinguished Lecture IV** **Professor Jinxing LIU(劉金興)** Associate Head and Professor, Department of Engineering Mechanics and Science Jiangsu University "**Strain Gradient Elasto-Plasticity Meeting Some Newest Challenges**"
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 8, 2017, Saturday Afternoon (Lee Shau Kee Building, PolyU)

14:00 – 15:30 **[1 hr 30 mins]**	**Session A1** **[Seminar Room Y302]** **Chair: Prof. Haimin YAO**	**Session B1** **[Seminar Room Y304]** **Chair: Prof. Jidong ZHAO**	**Session C1** **[Seminar Room Y305]** **Chair: Prof. Xinrui NIU**	**Session D1** **[Seminar Room Y306]** **Chair: Prof. Hui TANG**
14:00 – 14:15 [15 mins]	**ZHAN Yuexing** (CityU) Effect of nanoparticle/polymer interphase on visco-hyperelastic behavior of nanocomposite hydrogels	**WANG Bin** (NUAA) Forward and inverse studies on scattering of the Rayleigh wave	**XIN Zhiqiang** (Hohai U) Suppression of the Wake Vortex of Self-propelled Locomotion of the Three Dimensional Travelling Wave Wall	**XU Shang** (CityU) Mechanical Behavior and Structural Stability of Au Nanostructures
14:15 – 14:30 [15 mins]	**GAO Libo** (CityU) High-entropy alloy (HEA) nanolattice composites and their mechanical properties	**SHA Ganggang** (Hohai U) CWT based damping estimation for condition diagnosis of RC structures	**GUAN Ben** (PolyU) Investigation on Shock Induced Stripping Breakup Process of A Liquid Droplet	**CHU Henry** (Cornell U) Accelerated Stokesian Dynamics Simulations of Active Microrheology: Microviscosity, Microdiffusivity and Suspension Stress
14:30 – 14:45 [15 mins]	**GAO Xiang** (HKUST) Molecular Dynamics Study of Ion Transport in Carbon Nanotubes	**HU Zhongyu** (PolyU) Vibro-acoustic System Modelling by the Condensed Transfer Function Approach	**KONG Yong** (HKUST) Understanding the Physics of Dead Zone in Debris Flow - Microstructure and Jamming Transition	**LUO Huahuang** (HKUST) Two-degree-of-freedom Nonlinear Mass-Damper-Spring Model to Predict the Capturing of Circulating Tumor Cells in Microfluidic-Elasto-Filtration Chips
14:45 – 15:00 [15 mins]	**YAO Zijian** (CityU) Role of particle primary aggregation on the mechanical properties of particle reinforced polymer composites	**ALABI Stephen Adeyemi** (CityU) Selection of Appropriate Rail-Sleeper-Ballast Modeling Method for Matching Field Test Time-Domain Data	**SHEN Lu** (PolyU) Application of Dielectric Barrier Discharge Plasma Actuator on Flow Control over a Delta Wing	**ZHANG Hongti** (CityU) Deformation mechanism transition in single crystalline gold nanowires with diameters below 100nm
15:00 – 15:15 [15 mins]	**MA Hei Lam** (PolyU) Mechanical properties of coiled carbon nanotube/epoxy adhesive at cryogenic environment	**CHENG Zhiliang** (UMac) Deflection measurement of thin-walled hollow tube with embedded FBG sensors	**LIU Chun-Ho** (HKU) On Plume Dispersion after Line Source in Crossflows over Rough Surfaces	**ZHOU Tong** (PolyU) Dynamic and Static Analysis of a Double-Layered Compound ‘Acoustic Black Hole’ Beamlike Structure
15:15 – 15:30 [15 mins]	**CAO Ke** (CityU) in-situ investigation of the mechanical properties of CNT yarns	**SHAN Shengbo** (PolyU) Detection of Breathing Cracks with the Second Harmonic Shear-Horizontal (SH) Waves	**AHMAD Shakeel** (PolyU) LBM Simulation of Successive Impingement of Two Droplets on an Inclined Surface	
15:30 – 15:45 **[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.			

15:45 – 17:15 [1 hr 30 mins]	**Session A2 [Seminar Room Y302] Chair: Prof. Wanhuan ZHOU**	**Session B2 [Seminar Room Y304] Chair: Prof. Yi-Kuen LEE**	**Session C2 [Seminar Room Y305] Chair: Prof. Wenjing YE**	**Session D2 [Seminar Room Y306] Chair: Prof. Yang LU**
15:45 – 16:00 [15 mins]	**NIU Xinrui** (CityU) Elastic Modulus of Rat Liver from 8 to 22 °C	**SUN Guangjun** (Nanjing Tech U) Multi-scale Modeling in Concrete Structure Seismic Damage and Collapse	**HE Bin** (Nanjing Tech U) 流體熱控針灸針的熱-流耦合特性分析	**LIANGWeijian** (HKUST) Hierarchical MPM-DEM couple model for granular material
16:00 – 16:15 [15 mins]	**LAM King Cheong** (PolyU) Room temperature methane gas sensor based on in-situ reduced graphene oxide incorporated with tin dioxide	**SENETAKIS Kostas** (CityU) Experimental contact mechanics of weathered tuff granules	**ZHANG Fu** (PolyU) Light/Heavy RM instability driven by cylindrical imploding shocks	**WANG Xiaoyi** (HKUST) Theoretical Modeling of Micro Thermal Accelerometer
16:15 – 16:30 [15 mins]	**JIANG Chenchen** (CityU) Robotic Aid Micro-Mechanical System for Microwire Torsional Testing	**MA Li** (PolyU) Vibration of a plate with central power law profile by wavelet decomposition Rayleigh Ritz Method	**PENG Huayi** (CityU) Wake Measurement of an H-Rotor Vertical Axis Wind Turbine via Wind Tunnel Testing	**Wang Jianbiao** (PolyU) Investigating the deformation mechanism of high entropy alloy $AlCuFeCrNi_{1.4}$ based on experimentally validated atomistic model
16:30 – 16:45 [15 mins]	**SONG Jian** (CityU) Flexural bending behavior of body-centred-cubic (BCC) meso-lattice structures	**HU Jun** (CityU) Investigation on the Modal Properties of a Footbridge under Strong Wind	**QADRI Muhammad Nafees Mumtaz** (PolyU) Energy Extraction through a Passively Oscillating Hydrofoil	**CHEN Yong-zhan** (UMac) Enhancement of the Strength Properties of Pb Contaminated Soil Using Nanoscale Zero Valent Iron (nZVI)
16:45 – 17:00 [15 mins]	**WANG Yongli** (CityU) Diameter Effect on Mechanical Behaviours of Human Hair	**DU Chunyang** (HKUST) Ground-motion amplification considering coupled soil-topography effects: region-scale 3D simulation for Hong Kong island	**ZHAO Fuwang** (PolyU) Experiments analysis of two-dimensional motion of a freely falling circular cylinder with non-uniform mass distribution	**ANSARI Talha Qasim** (PolyU) A Diffused Interface Model for Localized Corrosion
17:00 – 17:15 [15 mins]		**CHEN Weibin** (UMac) 3D DEM modelling on the interface directional shearing behavior between soil and structure	**SHANG Yuhe** (HKUST) Condensation Heat Transfer Modelling and Optimization of Biphilic Surfaces	
17:30 – 17:45 [15 mins]	**Closing Ceremony and Award Presentation [Y305, Lee Shau Kee Building, PolyU]** Attendees: All conference participants			
17:45 – 18:30 [45 mins]	**HKSTAM Annual General Meeting [Y305, Lee Shau Kee Building, PolyU]** Attendees: Representatives of all Institution Members and all Full HKSTAM Members			
18:30 – 20:30	**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 Alfonso Hing Wan NGAN

The University of Hong Kong

Professor Alfonso H.W. Ngan is currently Kingboard Professor in Materials Engineering, Chair Professor of Materials Science and Engineering, as well as Associate Dean of Engineering, at the University of Hong Kong. He obtained his BSc(Eng) degree from the University of Hong Kong in 1989, and PhD from the University of Birmingham in the U.K. in 1992. After a year of postdoctoral training at Oxford University, he joined HKU as a Lecturer in 1993, and was promoted through the ranks to Chair Professorship in 2011.

Professor Ngan's research work is focused on the microstructural basis of properties of engineering materials, and, in particular, crystalline defects and their modeling, and more recently, nanomechanics including applications to biological systems. He has published over 200 ISI papers, and co-authored two books. His main contributions include a method, the so-called "Feng-Ngan equation", for correcting viscoelastic effects in nanoindentation measurements of soft materials, which has been used by peer researchers in their work as reported in more than 100 ISI publications by now. His research-related honours include the prestigious Rosenhain Medal and Prize from the Institute of Materials, Minerals and Mining, U.K., in 2007 – he is the only non-British national so far to have received this award since its establishment in 1951. He was also awarded a higher doctorate (DSc) from his alma mater the University of Birmingham in 2008, the Croucher Senior Research Fellowship in 2009, and in 2014 he was elected to the Hong Kong Academy of Engineering Sciences. He is a well sought-after journal reviewer, winning the Outstanding Reviewer Award of Scripta Materialia five times, in 2006, 2008, 2011, 2015 and 2016. He has organized a number of key conferences, including Dislocations 2008 and Gordon Research Conference on Nanomechanical Interfaces in 2013, both held in Hong Kong. He is serving on the Gordon Research Conference Board for Hong Kong Conferences. Currently, he is serving as one of five Meeting Chairs in the Materials Research Society 2017 Spring Meeting to be held in Phoenix, USA, in April 2017.

When mechanics meets with chemistry – novel redox actuators made from nickel hydroxide

Alfonso H.W. Ngan[1,*], Kenneth K.W. Kwan[1], Yuqi Zhang1, Pingyu Wang[1], Chuan Cheng[1, 2]

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In this paper, we report a novel electrochemical actuating property of nickel hydroxide, with the actuation mechanism mainly due to reversible faradic redox reactions. Benefiting from the stable Ni(II)/Ni(III) redox couples in an electrolyte medium, highly reversible and stable actuation is observed under triggering voltages of less than 1 volt. By appropriate design of the actuating material with respect to the passive materials in a device, high actuation strains that can rival conducting polymers or even human muscles can be achieved. Also, by conditioning the structure of the actuator into a nanowire network morphology that facilitates ion transport, record high strain response time in the order of 0.1 second can be obtained, which is more than two orders faster than the current metallic based actuators.

To model the actuation mechanism, a multi-scale, multi-field simulation approach is used to model the above electrochemical actuation behavior. Specifically, molecular dynamics simulations with reactive force-field potentials and a modified charge-equilibrium (QEq) method are used to calculate the surface stress built up in Ni(100) surface in contact with water electrolyte due to a voltage applied across the interface, as a result of capacitive charging of the double layer in the contacting electrolyte as well as redox reaction of the Ni surface. The calculated surface stress is then used as input in a meso-scale finite-element (FE) model to compute the actuating stress set up in a single unit cell of a Ni nano-porous structure. The single-unit actuating stress is eventually used in a continuum FE model at a larger scale, to calculate the bending of an entire bilayered cantilever which replicates experimental conditions. This is the first successful attempt to simulate the electrochemical actuation of a real-sized, nano-porous metallic structure in an electrolytic environment.

Distinguished Lecture II

Speaker of Distinguished Lecture

Professor Maosen CAO

Hohai University

M. S. Cao is a professor at the Engineering Mechanics Department and director at the Central Experimental Laboratory of Mechanics and Materials at Hohai University, China; Scientist in Chief at the Center of Jiangsu Province's Cooperative Innovation Research on Structural Safety and Health; Chair professor of "Qing Lan" innovation program for science and technology; Jiangsu Province Youth Science and technology innovation leading talent; Marie Curie Fellow – Experienced Researcher at the Polish Academy of Sciences. He received his PhD degree in hydraulic structural engineering from Hohai University in 2005 and obtained a Top-100 Excellent Doctoral Dissertation Award. He has six years' experience of conducting research in The Hong Kong Polytechnic University, Washington State University in the United States, and the Polish Academy of Sciences in Poland. He is the author of 110 journal and conference papers. He was twice awarded the second-class Natural Science Prize of the Ministry of Education (both ranking first) in 2013 and 2015, respectively. Also in 2015, he was awarded the first-class prize of EU-China Outstanding Scientific Cooperation Innovations (ranking first). He was the Chairman of the 19th International Conferences on Vibration Science and Technologies of Infrastructure Engineering. His research interests include structural acoustics and vibration, structural health monitoring, applied soft computing, wavelet analysis, and multiscale dynamic modeling and simulation.

Wavelets-Driven Multiscale Dynamics Concepts for Structural Damage Detection

Maosen Cao

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Wavelet transforms have been widely used in structural health monitoring as an advanced signal processing tool. In essence, wavelet transform is an integral transformation, similar to but over that of Fourier transform, holds promise for providing innovative damage identification theories, due to its intrinsic connection with structural dynamics. Nevertheless, this space of using wavelet transform in structural damage detection has not been sufficiently explored to date. To this end, the study investigates the use of wavelet transforms to retrofit conventional structural dynamics concepts, typically modal curvatures. Modal curvatures have been extensively used in structural damage detection, allowing not only indication of damage occurrence but also determination of damage location, with no need for prior knowledge of the structure being inspected. Notably, modal curvatures have an intrinsic deficiency of susceptibility to noise involved in measurement, the noise effect easily masking genuine damage feature in the modal curvature. To overcome this deficiency, a new philosophy of adopting wavelet transform theory to create wavelet modal curvatures is formulated, from which a series of new concepts are derived, including 1D wavelet modal curvature for beams, 2D wavelet modal curvature for plates, and complex wavelet modal curvature. The multiscale property of wavelets endows these newly developed modal curvatures with the predominant characteristics of robustness against noise together with intensification of slight damage. A set of experimental cases is provided to demonstrate the capability of wavelet modal curvatures to identify complex damage in aluminum and composite structures.

Distinguished Lecture III

Speaker of Distinguished Lecture

Professor Quan WANG
City University of Hong Kong

Dr. Wang is a chair professor at the City University of Hong Kong. He is active in practical studies on structural damage detection with smart materials. He uncovered the potential of smart materials in effectively removing stress concentrations at the tips of cracks and delaminations in engineering structures for the first time. Dr. Wang has also contributed to advancing applications of nano-materials in engineering and medicine. Besides, he also works on engineering designs of piezoelectric structures for energy harvesting from wind, sea waves, and other ambient vibration sources. His creativity has contributed to both the academia and industry. Dr. Wang was elected to the Canadian Academy of Engineering in 2015 and the Royal Society of Canada in 2016.

Energy Harvesting from ocean waves by Piezoelectric Technologies

Quan Wang
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Piezoelectric materials have been widely used to harvest energy from ocean waves. This presentation is to introduce and review the development of the technologies. First, by comparison among the three major energy conversion techniques namely electrostatic, electromagnetic and piezoelectric technologies, in terms of power generation capability, transmission efficiency, and structural installation and economic costs, the advantages of applying piezoelectric energy conversion technology is first identified. Second, the talk sums up different methodologies and designs of harvesting energy from ocean waves based on different piezoelectric effects from Dr. Wang's group. In particular, the designs and efficiencies of available harvesters based on the piezoelectric effects are introduced and discussed. Finally, the futuristic research directions and methods for improving the efficiencies of the harvesters are discussed profoundly in this area.

Distinguished Lecture IV

Speaker of Distinguished Lecture

Professor Jinxing LIU
JIANGSU University

Prof. Jinxing Liu got his bachelor degree of theoretical and applied mechanics from University of Science and Technology of China in 2002, and obtained his doctoral degree of philosophy from Institute of Mechanics, Chinese Academy of Sciences, in 2007. Since then Liu had been conducting scientific research in several foreign countries such as Singapore, Canada and Saudi Arabia, until he returned to China and began his present duty in Jiangsu University in 2013.

Jinxing Liu has been working on two main fields, i.e. plasticity, damage and fracture mechanics. (1) In the field of plasticity, he studied the constitutive modeling of ductile fracture due to void growth and coalescence in metallic materials, with a special attention to the scattering of void sizes. In order to predict the characteristics of micron-scaled plastic deformation such as size effect, anomalous Bauschinger effect and plastic softening, Jinxing Liu established a new theory of strain gradient elasto-plasticity based on Fleck and Hutchinson's SGP theory, where issues of thermodynamical inconsistency and unreasonable discontinuous evolution in higher-order stresses are solved, and his new theory shows a good capability in capturing key features in micron-scale plastic deformations. (2) In the field of damage and fracture mechanics, Liu has built a meso-mechanics model for simulating quasi-brittle failures in heterogeneous media such as concrete, rock, ceramic and bone. Mohr-Column criterion with a tensile cut-off is adopted, and separation/contact of crack surfaces have been considered. A simple algorithm has been proposed by Liu to model shrinkage-induced cracking in concrete. By taking fiber breakage and fiber-fiber bond failure as the basic damage mechanisms, a 2-D lattice model has been built to simulate the failure of paper.

Strain gradient elasto-plasticity meeting some newest challenges

Jinxing Liu[1,*], Ai Kah Soh[2]

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We have developed a theory of strain gradient elasto-plasticity to address some interesting micron-scale phenomena that have recently attracted intensive investigations, that include size effects around the elastic limit and in plastic hardening, the anomalous Bauschinger effect, plastic softening and the unconventional load-unload hysteresis loops. We adopt a type of strain gradient elasticity including only three elastic length scales to calculate the higher order stresses. Both strain and strain gradient are decomposed into elastic and plastic parts based on the associative rule, leading to the thermodynamical consistency. A new Taylor-based yield rule is proposed with considerations of hardening effects due to elastic deformations and reversibility of both statistically stored dislocations and geometrically necessary dislocations. An evolution law is built for reversible effective strain and strain gradient under cyclic loading conditions. Problems of wire torsion, foil bending and film bulge are used as examples, to validate the good capability of the proposed theory in interpreting the above-mentioned phenomena by comparison with experimental data.

Keywords: Strain gradient elasto-plasticity, cyclic loading, Bauschinger effect, dislocation reversibility, Taylor plasticity.

Effect of nanoparticle/polymer interphase on visco-hyperelastic behavior of nanocomposite hydrogels

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Nanocomposite (NC) hydrogels are widely used in tissue engineering, medical treatment and healthcare industry for their high water content, desirable mechanical properties and biocompatibility. The nanoparticle/polymer interphase plays an important role in the visco-hyperelastic behavior of NC hydrogels. However, since the structures of NC hydrogels are highly complex, it is always a comprehensive task for people to understand the deformation mechanisms of NC hydrogels and extract the behavior of nanoparticle/polymer interphase from the overall mechanical response. To gain in-depth understanding on the visco-hyperelastic behavior of NC hydrogels, especially the behavior of nanoparticle/polymer interphase, NC hydrogels with different nanoparticle and polymer contents were fabricated in this work. Mechanical tests with different loading rates were conducted to characterize the visco-hyperelastic behavior of NC hydrogels. The obtained stress-stretch curves were analysed using an analytical model, which considered hyperelasticity and different terms of viscoelasticity. With the help of mechanical experiments and analytical modeling, the deformation mechanisms, especially the behavior of nanoparticle/polymer interphase, were revealed. This work not only explains comprehensive deformation mechanisms of NC hydrogels but also is in light of providing guidance to the design of hydrogel-related applications, especially those endure large range of loading rates.

Acknowledgements

This work is supported by Hong Kong Research Grant Council (HKRGC) Early Career Scheme grant 138713 and National Natural Science Fund of China (NSFC) General Fund 11472235.

High-entropy alloy (HEA) nanolattice composites and their mechanical properties

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Ordered Micro/nano lattice is of great intensive interest recently because of its tremendously potential application in photovoltaic gadgets, hierarchical structure materials and scaffold for cell cultivation as well as drug delivery based on its unique and superior mechanical property compared to stochastic foams, in terms of the high strength and fracture toughness deduced from its synergetic coupling effect of the geometry structural with functional constituent materials. Herein, we report the fabrication, characterization and mechanical properties of periodically arranged HEA ($CoCrFeNiAl_{0.3}$)-polymer nanolattice composite with the dimensions of individual components spanning from nanometers to tens of micrometers for the first time via two-photon lithography. More importantly, to the best of our knowledge, the $CoCrFeNiAl_{0.3}$ HEA film fabricated via this novel radio frequency (RF) magnetron sputtering methodology has not been reported yet. Additionally, the compression strength (σ_f) and the Young's modulus (E) of the nanolattice composite is remarkably 2.5 and 4 times higher than that of the pure polymer nanolattice, respectively.

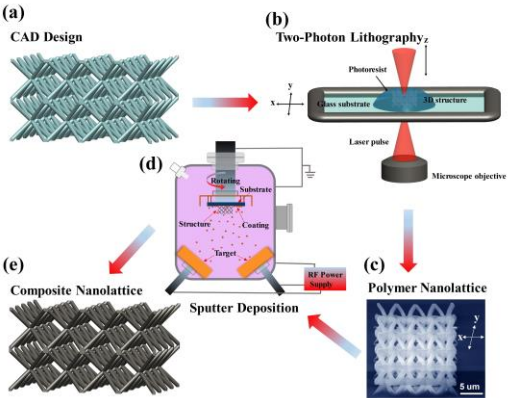

Figure 1 Schematic illustration of the fabrication of the composite nanolattice

Acknowledgements

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Molecular Dynamics Study of Ion Transport in Carbon Nanotubes

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The study of ion transport in CNTs is critical in many applications including sensing, energy storage/generation, separation, and lab-on-chip devices. Experiments of ion transport in single-walled CNTs show that ionic conductance inside CNTs can be two orders of magnitude larger than the theoretical predictions from bulk conductance (Liu *et al*. 2010, Pang *et al*. 2011). However, the underlying mechanism of such high ionic conductance remains unclear. Here, we employ molecular dynamics (MD) simulations and theoretical analyses to investigate water and ion transport in CNTs. It is found that the fluid flow in CNTs undergoes a transition under certain conditions, which can significantly enhance the ion mobility in CNTs and lead to the ultrahigh ionic conductance in CNTs. This study provides new insights for the understanding of ionic transport in CNTs, which are helpful for the design of CNT based nanofluidic devices.

Acknowledgements

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Role of particle primary aggregation on the mechanical properties of particle reinforced polymer composites

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Polymer composites have been widely used as structural materials due to their great flexibility and enhanced mechanical properties. Examples include rubber filled by carbon black for producing vehicle tires and resin filled by ceramic particles for dental restoration purposes. For small particles in these composite, especially nanoparticles, the surface related phenomena will have more profound influences on the overall composite behaviors. Recently, it was demonstrated experimentally that aggregation is beneficial to reinforcing composite materials [1].

In this work, a novel representative volume element for polymer composites has been built to study the effect of particle primary aggregation on the mechanical properties of composites. Aggregates with different sizes were generated and the spherical particles were bonded together. Elastic modulus of composites and stress concentration in the composites were evaluated using finite element method for different aggregate sizes. The conclusions of this work could be used as guidance when designing and manufacturing future composite materials for structural purposes.

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Mechanical properties of coiled carbon nanotube/epoxy adhesive at cryogenic environment

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Coiled multi-walled carbon nanotube (CCNT), with its special helical configuration, has been recently proposed to be the reinforcement for nanocomposites in the aerospace industry. Previous studies proved that CCNTs enhance the interfacial bonding and thus the mechanical properties of polymer-based nanocomposites. However, studies on the behaviour of CCNT reinforced nanocomposites at cryogenic temperature, an environment that will be encountered during their service at the low earth orbit, are still very limited.

In the present study, hardness, tensile and lap joint shear tests were performed for pure epoxy, straight multi-walled carbon nanotube (MWNT)/epoxy and CCNT/epoxy adhesives at room temperature (RT) and cryogenic temperature (CT). Results revealed that all samples had greater Vickers hardness value and Young's modulus at CT as their stiffness increased. Among the three kinds, CCNT/epoxy adhesive had the best performance at CT, with the greatest Vickers' hardness value, Young's modulus and lap joint shear strength. The mechanical interlocking effect between CCNTs and epoxy was greatly enhanced at low temperature due to the thermal expansion mismatch between the matrix and reinforcement. Hence, a strong interfacial bonding was established. Yet, the tensile strength of CCNT/epoxy adhesive was lower than that of MWNT/epoxy adhesive at both RT and CT in consequence of its inherent topological defects and the strong interfacial bonding.

Acknowledgements

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In situ micro/nano-mechanical characterization of carbon nanotube yarns

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Carbon nanotube (CNT) has attracted extensive research due to its extremely high tensile stress and elastic modulus (at around 150 GPa and 1TPa[1]), high thermal and electrical conductivity. Yet to maintain the outstanding mechanical properties of CNT for micro and macro-scale CNT structures remains a great challenge. CNT yarns are one of macroscale CNT structures and can be prepared via directly drawing or spinning from CNT arrays, which can be used for many engineering applications. Here, we investigated the mechanical properties of CNT yarns at micro and nanoscales. *In situ* micro-tensile tests were firstly carried out inside a SEM to investigate their deformation and fracture mechanisms. We investigated the effects of diameters and twisting angle on the mechanical properties of the CNT yarns. We also carried out in situ TEM study of the CNT bundles to reveal their interfacial strength and failure mechanisms.

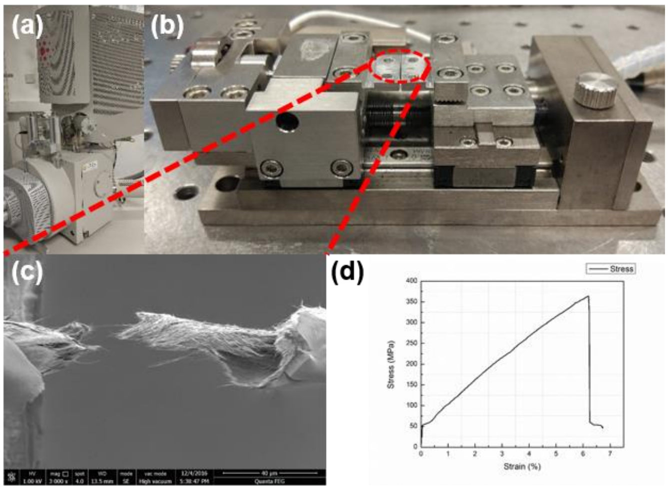

Figure 1. (a-d) *in situ* SEM tensile testing of a CNT yarn.

Acknowledgements

This work was supported by City University of Hong Kong under the ARG grant # 9667117 and Hong Kong RGC for the GRF grant #CityU 11207416.

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Elastic Modulus of Rat Liver from 8 to 22 °C

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Preservation temperature plays important role on viability of liver grafts. This work studied effect of preservation temperature on mechanical properties of rat liver in temperature range of 8 to 22 ºC which is the liver graft preservation temperature for liver transplantation. To minimize tissue damage, nanoindentation was selected as the test method to evaluate mechanical properties of rat livers. Elastic modulus of liver was adopted as the quantitative biomarker.

Experimental results demonstrated that in the temperature range of 8 to 22 ºC, elastic modulus of rat liver positively correlates with temperature. Furthermore, it had little dependency on its heating-cooling history which implied that, variation of preservation temperature in the range of 8 to 22 ºC did not induce permanent damage to rat livers. In addition, finite element analysis has been conducted to interpret structural implication of the measured modulus. Results of this work may serve as a convenient mechanophenotype which can examine viability of liver graft.

Acknowledgements

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Room temperature methane gas sensor based on in-situ reduced graphene oxide incorporated with tin dioxide

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We report on the relationship between the degree of reduction of graphene oxide (GO) and its room-temperature methane gas-sensing response by comparing four in situ reducing agents of GO: D-glucose, sodium borohydride, L-ascorbic acid and hydrazine hydrate. We found that gas sensors based on D-glucose and L-ascorbic acid had a higher gas response than those based on sodium borohydride and hydrazine hydrate because the residues contained oxygen functional groups. The poorly conductive GO was successfully reduced in situ by L-ascorbic acid to achieve high electrical conductivity and high methane gas response. The incorporation of tin dioxide (SnO_2) into the reduced GO (RGO) further increased the gas response by the p-n junction effect. The heterostructure of L-ascorbic acid-reduced RGO-SnO_2 had the highest increase in methane response due to the synergistic effect between dehydroascorbic acid and the SnO_2 surface. This was inferred from density functional theory calculations with self-consistently determined Hubbard U potentials (DFT+U). Compared with the current room-temperature methane sensors and fabrication technologies, the sensor reported here is cheaper to produce and more environmentally friendly while retaining high sensitivity.

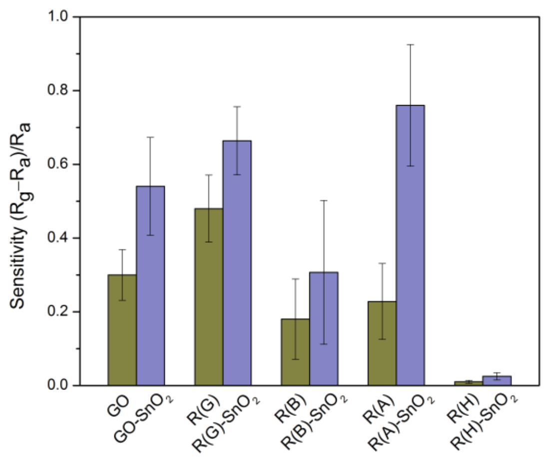

Figure 1. Sensitivity of GO, R(G), R(B), R(A), R(H) and their heterostructures with SnO_2 towards methane (1%) at room temperature.

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Robotic Aid Micro-Mechanical System for Microwire Torsional Testing

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One-dimensional microstructures, such as metallic, semiconductor and polymer microwires and carbon fibers, have stimulated great interest due to their importance in various structural and functional applications. Despite that substantial research efforts have been made on the mechanical characterization of those microwires, the mechanical properties of microwires under torsion loading have not been studied sufficiently, due to several challenges, such as the detection of torsion angle, quantitative measurement of the torsional load, and the alignment between the specimen and torquemeter. Therefore, we developed a novel robotic aid mechanical testing system inside SEM to perform sample alignment and apply well controllable torque on the microwire/microfiber specimens for quantitative testing. By taking bulk metallic glass (BMG) microwires as an example, *in situ* SEM torsional tests on the BMG microwires were demonstrated and provided unprecedented details on their fracture surface, very different from that of tensile loading. Our platform may provide critical insights in understanding the deformation mechanisms of 1D metallic microstructures under torsional loading, and be also used for micro-manufacturing.

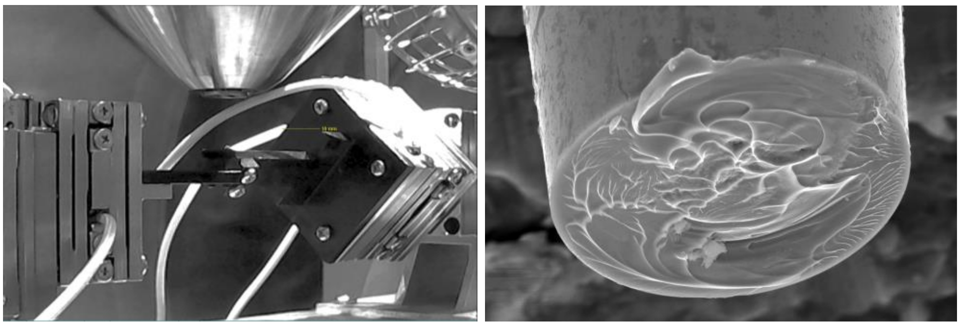

Figure 1. The robotic aid system inside SEM and the fracture surface of a metallic glass microwire.

Acknowledgements

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Flexural bending behavior of body-centred-cubic (BCC) meso-lattice structures

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Structural components with remarkable light weight can be fabricated by additive manufacture (3D printing), an optimized approach which conveniently enables the establishment of more complicated parts, than that can be achieved conventionally. In this work, we designed and constructed the meso-lattice structures with body-centred-cubic (BCC) unit cells (Figure 1) by advanced 3D printing, with bio-inspired concept for functional gradient configuration[1-3], as well as exploring their flexural bending behavior for potential use in construction, automobile, aeronautics and aerospace applications. We observed that the gradient distribution of BCC unit cells along the thickness direction is mainly responsible for the exhibited asymmetric bending behavior. Additionally, the effect of unit-cell size plays a critical role in enhancing the overall bearing capacity of parts. A finite element (FE) analysis was likewise adopted to quantitatively investigate the tension-compression deflection mechanisms. This work could provide insights to help the development of ultra-light design of advanced structural parts such as aircraft structural components.

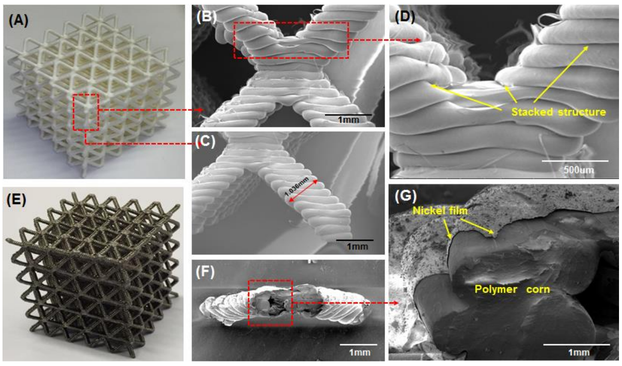

Figure 1. Cellular architecture of meso-lattices. (A) Polymer meso-lattice with BCC configuration. (b)-(d) SEM photographs of local magnification zooms of polymer lattice. (e) Nickel-coated polymer meso-lattice. (f) and (g) SEM photographs of two fractured trusses.

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Diameter Effect on Mechanical Behaviours of Human Hair

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Human hair is a sophisticated bio-composite hierarchically constructed by cuticle, cortex and medulla. This unique structure endows human hair with outstanding mechanical properties. Diameter of hair fiber was selected as a structural factor and its effect on mechanical properties of hair was investigated. As a standard method of evaluating mechanical properties of fibers, uniaxial tensile tests were conducted to obtain tensile properties of hair fiber. Besides, fracture patterns and failure mechanism of hair fibers after tensile tests were also explored. It was demonstrated that human hair had a typical elastic-plastic constitutive behavior. Diameter showed significant effects not only on tensile properties but also fracture patterns of human hair. Therefore, diameter is highly related to hair structure and knowledge in this part has potential to be utilized in designing bioinspired tougher fibers

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Forward and inverse studies on scattering of the Rayleigh wave

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Rayleigh wave has been frequently applied in geological seismic inspection and ultrasonic non-destructive testing, due to its low attenuation and dispersion. A thorough and effective utilization of Rayleigh wave requires better understanding of its scattering phenomenon. The paper analyses the scattering of Rayleigh wave at the canyon-shape flaws on the surface, in both forward and inverse aspects. Firstly, we suggest a modified boundary element method (BEM) incorporating the far-field displacement patterns into the BEM equation. Results show that the modified BEM is an efficient and accurate approach for calculating far-field reflection coefficients. Secondly, we propose an inverse reconstruction procedure for the flaw shape using reflection coefficients of Rayleigh wave. By theoretical deduction, it can be proved that the objective function of flaw depth $d(x_1)$ is approximately expressed as an inverse Fourier transform of reflection coefficients in wavenumber domain. Numerical examples are given by substituting the reflection coefficients obtained from the forward analysis into the inversion algorithm, and good agreements are shown between the reconstructed flaw images and the geometric characteristics of the actual flaws.

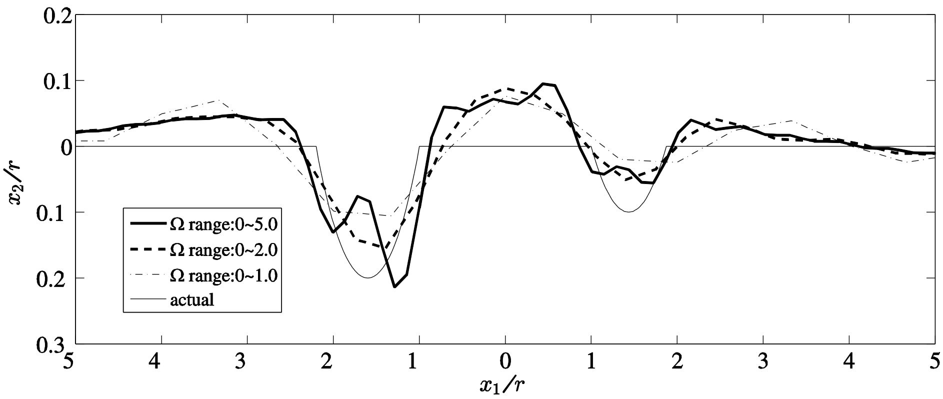

Figure 1. An example of reconstruction by Rayleigh wave

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CWT Based Damping Estimation for Condition Diagnosis of RC Structures

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Abstract: The use of damping as a dynamic property to monitor condition of reinforced concrete structures is discussed in the paper. Damping is not often used in condition diagnosis comparing with natural frequencies and mode shapes. While damping is a somewhat sensitive indicator of structural integrity than natural frequencies and mode shapes in some situations. Thus, an analysis of periodical damping measurements can be used to monitor structural condition. Considering the significance of damping estimation in damping-based condition diagnosis, continuous wavelet transform based damping estimation methods are presented first. Then damping extracted from vibration responses is used for condition diagnosis of reinforced concrete beams. Factors which could limit successful application of damping for condition diagnosis are also discussed. Finally, the future research directions for advancing damping-based condition diagnosis are recommended.

Keywords: damping estimation, continuous wavelet transform, condition diagnosis, reinforced concrete structures

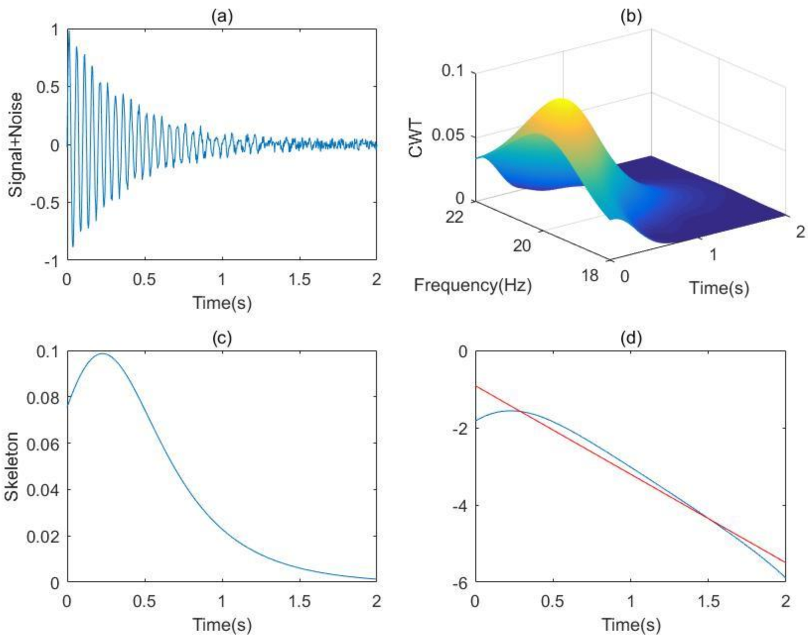

Figure 1. Basic procedures of CWT based damping estimation.

Acknowledgements

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Vibro-acoustic System Modelling by the Condensed Transfer Function Approach

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The analysis of vibro-acoustic systems in the mid-to-high frequency range is important and particularly challenging. In the present paper, an improved condensed transfer function (CTF) approach[1] is proposed to tackle this problem. In the improved CTF approach, the uncoupled subsystems are firstly modelled separately, by approximating the force and velocity on the coupling surface between subsystems in terms of decompositions over a set of CTFs. The whole system can then be assembled and solved by applying the force equilibrium and velocity continuity conditions over the coupling surface. The modelling efficiency is shown to be greatly increased by properly selecting the condensation functions, in both their type and size. Owing to a better match between the wavy feature of the condensation functions and the wavelength of the vibroacoustic system, the coupled response can be constructed using only a few terms within a prescribed frequency range of interest. This allows the system to be modelled piecewise in terms of frequencies and leads to a significant reduction in the computational cost. Figure 1 shows the calculation results, in which each curve is from different a different set of condensation functions to only focus on a specific frequency band.

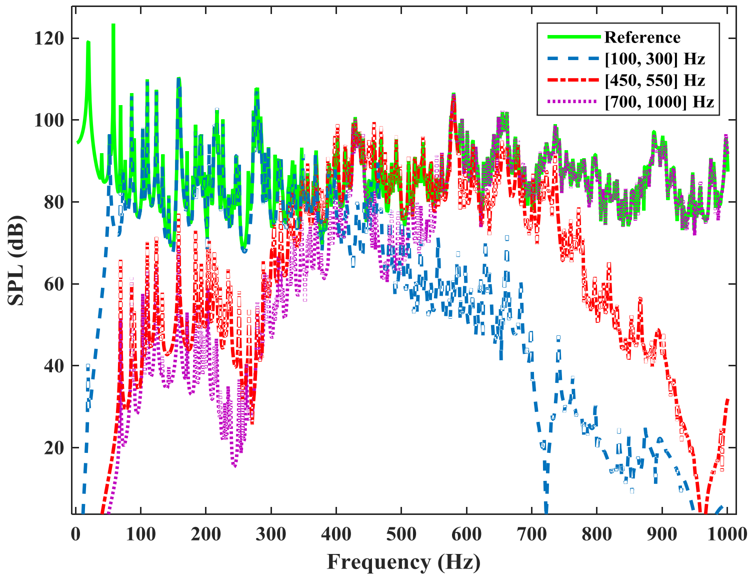

Figure 1. Examples on piecewise calculations of the sound pressure level (SPL) within a plate-cavity system.

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Selection of Appropriate Rail-Sleeper-Ballast Modeling Method for Matching Field Test Time-Domain Data

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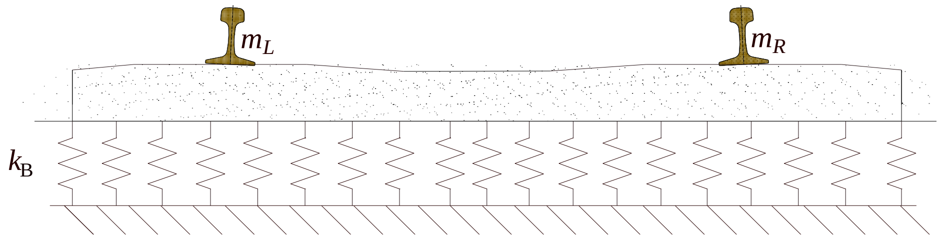
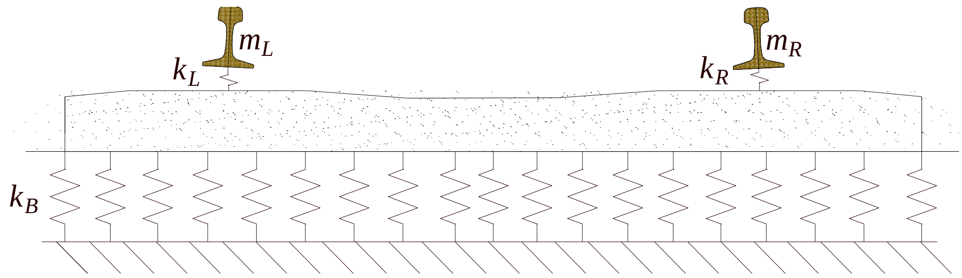
The selection of suitable class of model capable of reproducing the time domain test data following MCMC-based Bayesian approach is presented. The rail-sleeper-ballast modeling method, which has been used for modal-based model updating, was used to fit the measured time-domain vibration from the field test. However, the match between the measured and model-predicted responses was not good at some measured locations. Based on the observed discrepancy, the rail-sleeper-ballast modeling method was modified in this paper for suitable use in time-domain model updating. Based on the field test data and the modified modeling method, this study puts forward the time-domain Markov chain Monte Carlo (MCMC)–based Bayesian model updating method for identification of the rail-sleeper-ballast system.



(a) Modeling rails as masses.



(b) Modeling rails as spring-mass systems.

Figure 1: Two modeling methods of the rail-sleeper-ballast system.

Acknowledgements

The work is supported by the Hong Kong Research Grants Council (Project No. CityU 115413 (GRF 9041889)).

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Deflection measurement of thin-walled hollow tube with embedded FBG sensors

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In recent decades, the Fiber Bragg Grating (FBG) sensor has been applied in many engineering fields owing to its advantages, such as high sensitivity and precision, remote control, corrosion resistance as well as electro-magnetic interference (EMI) immunity. FBG sensors can be used to measure various physical quantities such as stress, strain, temperature and displacement etc. Most of researches provide methods of deflection measurement mainly based on simple beam theory (Kim, 2004) or cantilever beam theory. Moreover, many problems need to be considered to measure the deflection under different conditions. When the force direction is not certain and the deflection is irregular, we need methods to determine the force direction and the deflection value precisely at different positions. To solve those problems, the thin-walled hollow tube with embedded FBG sensors is customized in this study. The thin-walled hollow tube is made of resin and three optic fibers are embedded in it. Ten FBG sensors with a spacing of 100 mm are connected in series in each optic fiber. The central angle of each optic fiber on the cross-section is 120 degrees. Many laboratory tests were performed to calibrate deflection of the tube with embedded FBG sensors, and a method to judge the direction of force was provided. It was demonstrated that deflection values under different conditions can be well obtained using FBG sensors.

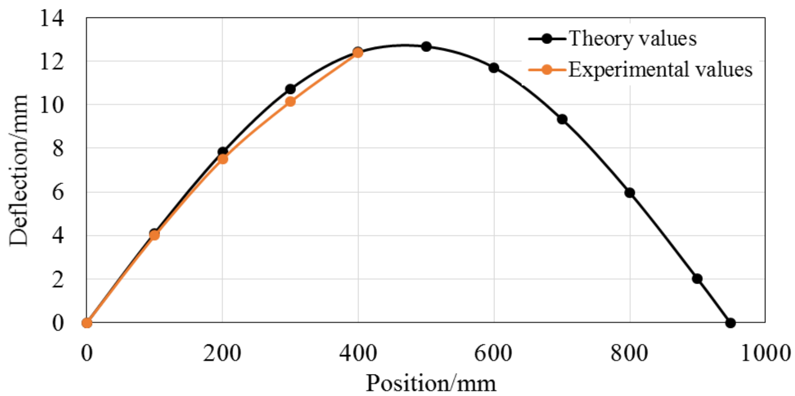

Figure 1. The comparison of deflection values at different positions

Acknowledgements

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Detection of Breathing Cracks with the Second Harmonic Shear-Horizontal (SH) Waves

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Structural health monitoring (SHM) techniques with nonlinear guided waves have been shown to exhibit high sensitivity to micro defects like breathing cracks, thus allowing the detection of damages in their early stage of development to ensure the structural safety. Motivated by this, a crack detection method is proposed using the second harmonic SH waves in this paper. Based on the theoretical analyses carried out in the first part, it is shown that material nonlinearity of the structure and the adhesive nonlinearity, which are both important nonlinear sources in the nonlinear-Lamb-wave-based SHM systems (Liu et al., 2013; Shan et al., 2016), will not induce significant second harmonic responses in the SH wave field. The proposed method takes advantage of this unique feature to offer the high identification capability of breathing cracks since the outstanding second harmonic responses in the captured SH waves (found in the tests) will be mainly caused by the cracks in the structures. In the second part, the proposed method is validated through finite element (FE) studies with the model illustrated in Figure 1. The second harmonic responses are extracted with the superposition method (Shan et al., 2016) in three cases where the material nonlinearity of the plate, adhesive nonlinearity and breathing cracks are separately introduced to the model (shown in Figure 1). Results show that the second harmonic response of SH waves due to the breathing crack are much stronger than those due to the material nonlinearity of the plate and adhesive nonlinearity, thus demonstrating the superiority of the proposed method for engineering applications.

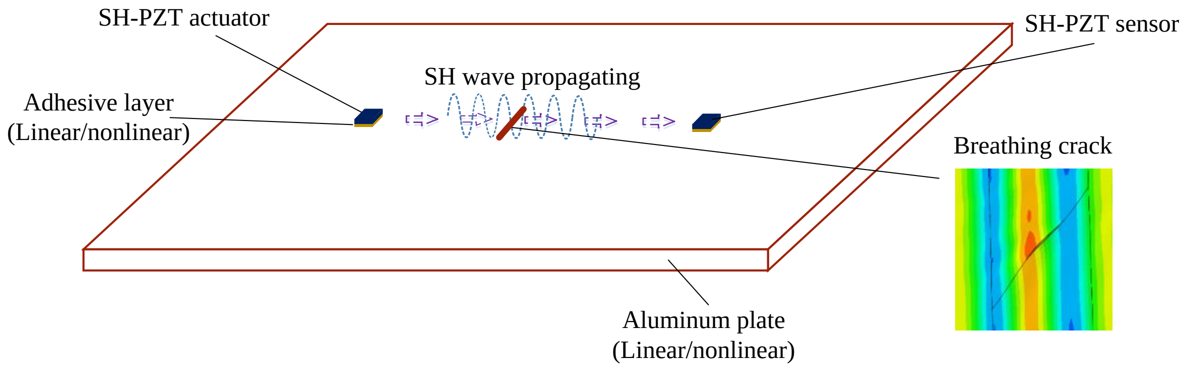

Figure 1. Sketch of the FE model.

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Multi-scale Modeling in Concrete Structure Seismic Damage and Collapse

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In order to improve the calculation efficiency of numerical simulation and simulate the concrete structure seismic damage process more accurately, the multi-scale finite element modeling is introduced in this paper firstly. Secondly, two different interface connection methods in multi-scale model of concrete component respectively by making use of force equilibrium condition and deformation compatibility condition are researched. Then, a multi-scale finite element model is implanted into a concrete frame structure to simulate the nonlinear hysteretic response and damage under cyclic loads to show the reliability and efficiency of multi-scale modeling in structure. Finally, a precise microscopic finite element model of a bridge collapsed in earthquake is established on the basis of multi-scale modeling. The seismic damage and the progressive collapse processes of bridge are simulated and compared with the actual seismic damage investigation to illustrate the applicability in engineering application. The research shows that making use of force equilibrium condition can not only avoid the interface stress concentration and the stresses are consistent with the results by single scale modeling, but also deformation compatibility can meets well at the interface between different-scale models. The multi-scale finite element model can be applied to reasonably and effectively simulate the local damage and progressive collapse of complex structure due to earthquake.

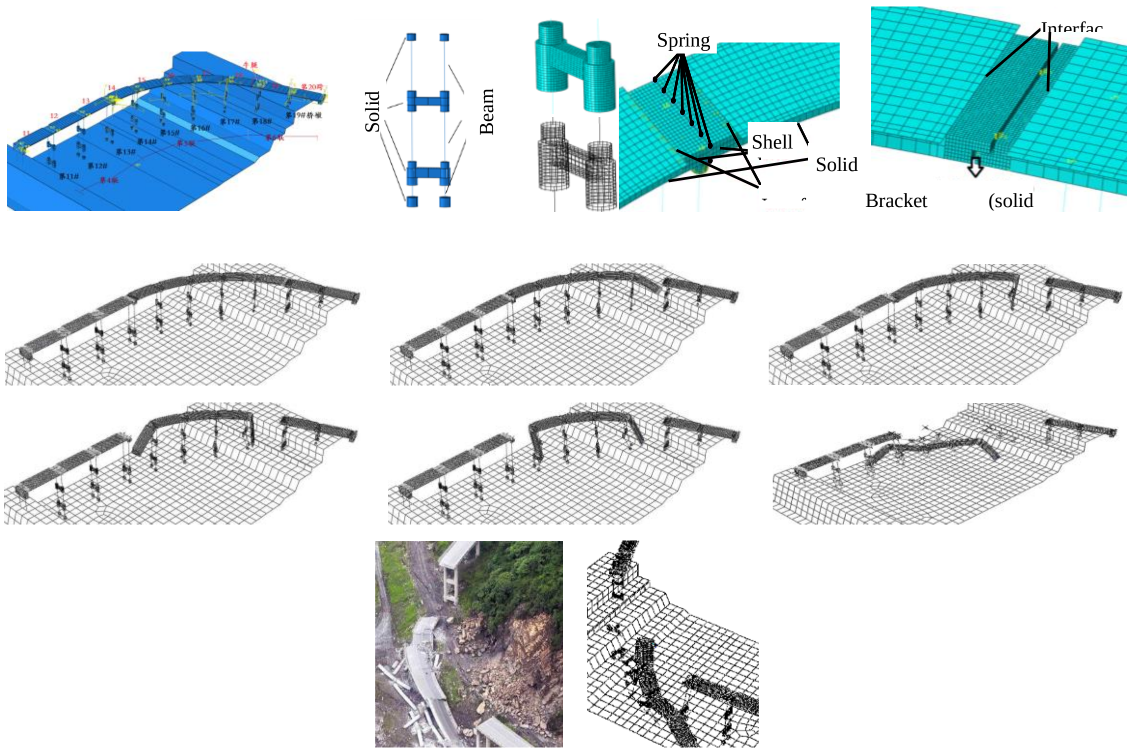

Figure 1. Numerical simulation of bridge damage and collapse

Experimental contact mechanics of weathered tuff granules

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The study reports on the normal load and tangential load – deflection responses of weathered tuff granules taken from a recent landslide in Hong Kong. A micromechanical sliding apparatus, shown in Figure 1, was used to study the contact mechanics behavior of sand sized granules in the normal and tangential to the shearing directions (Senetakis and Coop, 2014). Adjusting the Hertz model to the normal load – deflection response, it was found that the granules have much smaller contact modulus in comparison to other geological materials reported in the literature. It was interesting to notice that after the first loading cycle, where plastic response dominated the behavior, subsequent cycles showed almost elastic behavior. In the tangential direction (Figure 2), the results showed that the tuff granules had much greater friction in comparison to other types of materials. These results were partly attributed to the rough surfaces of the tuff granules (Senetakis et al., 2017). The results of the study are promising in developing accurate models for the study of debris flow mechanisms using DEM with particular interest in Hong Kong engineering applications.

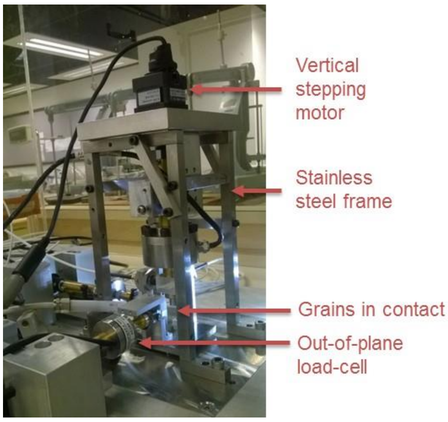

Figure 1. The micromechanical apparatus developed at the City University of Hong Kong capable of measuring contact properties of sand sized grains

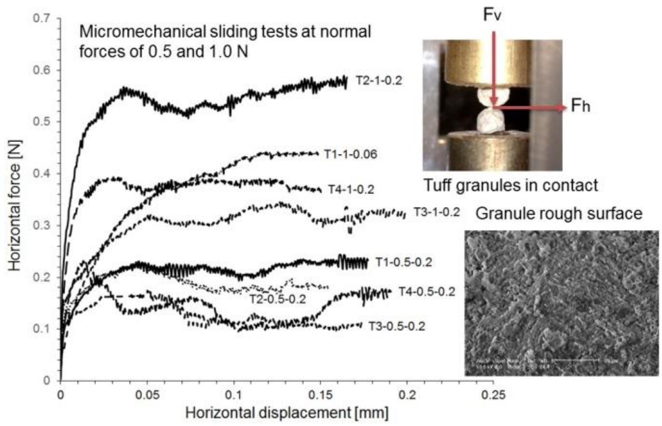

Figure 2. Image of tuff granules in contact, respected SEM image showing the rough surface of the material and representative test results of horizontal force – displacement at the granules contacts

Acknowledgements

The study is fully supported by a grant from the Research Grants Council of the Hong Kong Special Administrative Region, China (TRS) "Understanding Debris Flow Mechanisms and Mitigating Risks for a Sustainable Hong Kong" - Project No. CityU 8779012).

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Vibrations of a plate with power-law-profiled thickness by wavelet decomposed Rayleigh Ritz Method

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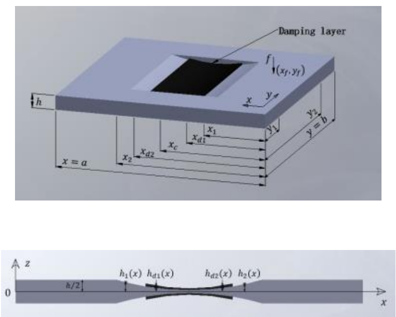
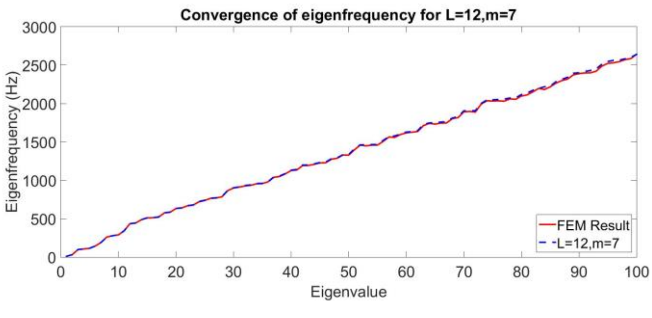
Abstract

The travelling speed of flexural waves reduces in thin-walled structures when their thickness is profiled according to a reducing power law. Reaching zero thickness and therefore zero sound speed, it would take infinite time for waves to reach the end, thus resulting in zero reflection. This phenomenon is referred to as Acoustic Black Hole (ABH) effect, which has been well demonstrated both theoretically and experimentally on ABH beams in the open literature. ABH effect in two dimensional structures, however, were mainly examined by experiments and FEM previously. In this paper, a semi-analytical plate model based on Kirchhoff theory is proposed to analyze the ABH effect in 2-D structures (see Fig.1). The displacement filed of the plate is approximated by a set of compactly supported Daubechies scaling functions that possess the property of orthogonality and high smoothness. A previously proposed Wavelet Decomposed Rayleigh Ritz Method(WMRM) on 1-D Euler-Bernoulli beam[1] is now extended to 2-D structures (Fig.2). The validity of the proposed model is first verified by FEM. Results show that WDRM is effective and accurate to solve vibration problems of the 2-D ABH plate. Using the model, the ABH effect in plates with central power law profiled indentation is examined. Parametric studies are conducted to evaluate the effect of thickness, length, location and material characteristics of the damping layers. It is shown that the combination of ABH plate and a thin piece of damping layer coated over the ABH tip region can significantly enhance the overall system damping and subsequently reduce the vibration level of the structure.

Fig.1 A Kirchhoff plate with symmetric central power law profile

a





b

Fig.1 A Kirchhoff plate with symmetric central power law profile Fig. 2 Comparison of first 100 eigenvalues for WMRM and FEM

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Investigation on the Modal Properties of a Footbridge under Strong Wind

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This paper presents the observations on the identified modal parameters of a campus footbridge utilizing ambient vibration response collected during a Typhoon event. The objective of this research is to conduct a structural health monitoring programme on the footbridge since it serves as a safety path between the main campus and the residence halls. As a typical steel truss system supported by two columns, the footbridge is very sensitive to the ambient vibration sources (i.e., walking pedestrian and passing-by vehicles), which raises concern about vibration serviceability problem of the footbridge. Therefore, investigation about the modal properties of the bridge under various circumstances is necessary. Under a Typhoon day, the dynamic behaviour of the footbridge was explored by a four-setup ambient test carried out on the deck. As a comparison, another set of test was carried out in the midnight to eliminate the human induced vibration. The fast Bayesian FFT method was adopted to extract the modal parameters from the two sets of ambient vibration test data. Based on the obtained measurement data, two sets of modal parameters were identified. The modal parameters under different vibration loadings were compared and discussed. Different dynamic behaviours of the footbridge can be observed from the Typhoon induced vibrations.

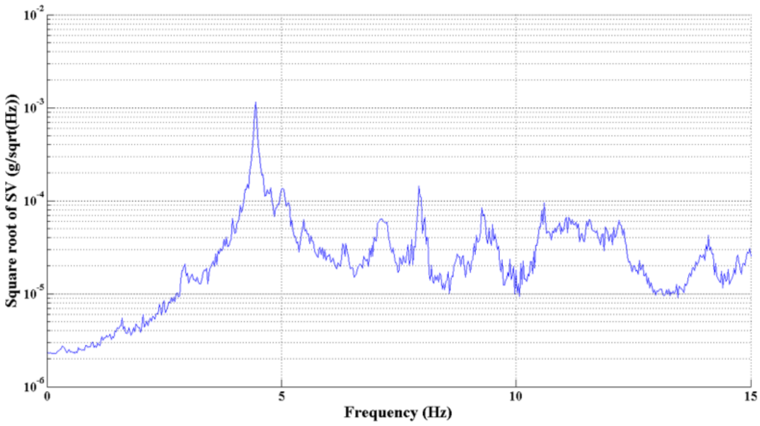

Figure 1: First singular value spectrum, setup 1.

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Ground-motion amplification considering coupled soil-topography effects: region-scale 3D simulation for Hong Kong island

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Amplification of seismic waves due to surface topography and subsurface soils has caused intensive damage during the past earthquakes. However, due to its complexity, topographic effects have not yet been considered in most seismic design codes. In this study, a region-scale 3D Spectral Element simulation was conducted using Hong Kong island as a testbed (Fig.1). Results show that topographic amplification of ground motions is frequency dependent and it can be parameterized using topographic curvatures smoothed over a characteristic length. Amplification of high frequency wave is correlated with curvature smoothed over a small length scale, while amplification of long-period waves is correlated with large-scale topography features. When subsurface soils are considered, the characteristic length becomes smaller with increasing soil depth. Finally, a prediction equation is derived, which decomposes the total ground-motion amplification ($AF^{3D}_{Layered}$ considering both 3D topography and layered soil cover) into "3D topography amplification effects" (AF^{3D}_{Homo} , only homogenous rock profile is modelled), "1D soil amplification effects" (AF^{1D}_{Soil}), and a term to account for coupling between topography and soil amplification, as follows:

$$AF^{3D}_{Layered} = AF^{3D}_{Homo} \times AF^{1D}_{Soil} \times \exp\left(a_{coupling} \times \theta\right)$$

where θ is slope angle (in radian), $a_{coupling}$ is a coupling coefficient, which is dependent on wave frequency and the depth of soil cover, as shown in Figure 2.

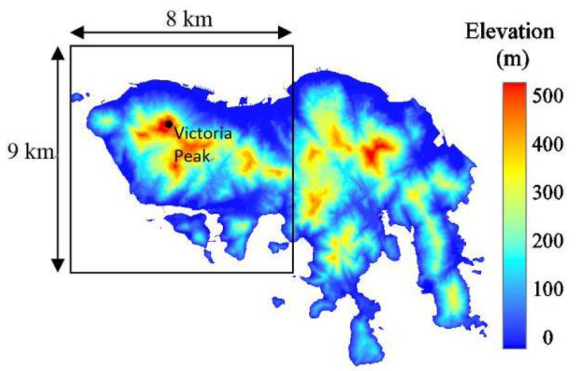

Figure 1 Region-scale computational domain and elevation map of Hong Kong island

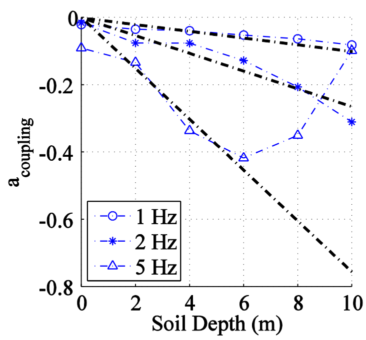

Figure 2 Coupling term for different wave frequencies and soil depths

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3D DEM modelling on the interface directional shearing behavior between soil and structure

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The interaction between soil and structure is a crucial problem in geotechnical engineering, such as soil-pile interaction and soil-retaining wall contact. The interface shear behavior is related to the structure's surface characteristics (Hu and Pu 2004, Chen et al. 2015). In practical engineering, a structural surface's geometry likely possesses a certain degree of intrinsic anisotropy due to the nature of the material as well as of the engineering skills. This irregularity distributing on the surface tends in certain directions. Accordingly, interface shearing behavior differs when soil is sheared from different directions. Using the discrete element code PFC3D, a series of three-dimensional numerical interface shear tests have been performed to study the effect of various shear directions. The numerical results are firstly validated by the laboratory experiments. Then the effects of shear direction on shear behavior are discussed. The results show that the shear stress increases with an increasing of the angle of shear direction, with the elastic perfect-plasticity observed when the angle of shear direction equals zero (as shown in Fig.1). All tests show bulk dilatancy during the shearing process. The largest dilatancy is observed when the specimen shearing on the perpendicular direction of the roughness anisotropy direction.

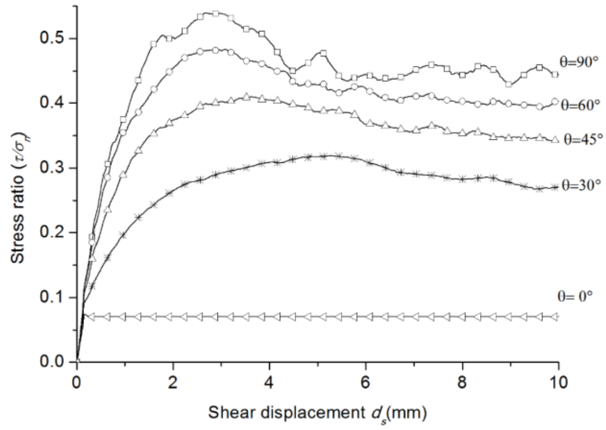

Figure 1. Stress ratio with respect to shear displacement for various angles of shear direction (σ_n = 300 kPa)

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Suppression of the Wake Vortex of Self-propelled Locomotion of the Three Dimensional Travelling Wave Wall

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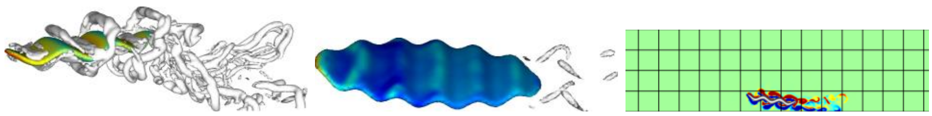
Many striking studies show that the traveling wave movement can reduce drag force and suppress turbulence production as an excellent flow control method. However, so far no theory is available to predict the optimal parameters of the flow control for the traveling wave motion. The physical mechanisms of the 3D traveling wave are especially unknown. The three-dimensional traveling wavy wall is just like a flying carpet. Through numerical simulation and analysis of self-propelled motions of the 3D flying carpet, it is found that the key parameter of the flow control for the traveling wave motion is the ratio of the wall motion phase speed $c = f\lambda$ to the motion velocity of carpet u, where f is frequency, and λ is the wavelength. Below a threshold value of $c/u = 1.0$, the large-scale wake vortices of the 3D flying carpet are reduced significantly. However, for the same c/u ratios, different wave frequencies f and wavelengths λ have great influences on wake vortex structures.

The λ_2 method of Jeong and Hussain was applied to illustrate the 3D vortical structure. As $c/u > 1.0$, nested vortex rings are shed from the body of flying carpet, and vortex rings that locate on the wave troughs of upper and lower surfaces of flying carpet are mutually connected, as shown in Fig. 1(a). The regions with relatively high vorticity in close proximity to the surface of the 3D traveling wave wall surround the flying carpet, and vortices are shed in to the downstream of the 3D flying carpet, as. As $c/u < 1.0$, It can be seen from Fig. 1(b) that no vortex are generated on the surface of three-dimensional wave wall. The high vorticity region surrounding the flying carpet is no longer close to the surface of the three-dimensional wave wall, especially far away from the wave trough. Thus, it would reduce resistance of self-propelled motion of the three dimensional flying carpet.



(a) vortex structure (b) vortex structure (c) vorticity

Figure 1. Fluid fields of self-propelled motion of the three dimensional flying carpet.

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Investigation on Shock Induced Stripping Breakup Process of A Liquid Droplet

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Stripping breakup process of a single liquid droplet under the impact of a planar shock wave is numerically investigated. Compressible Euler equations are solved using an in-house inviscid upwind characteristic space-time conservation element and solution element (CE/SE) method coupled with the HLLC approximate Riemann solver. A reduced five-equation model is employed to demonstrate the air/liquid interface. Numerical results accurately reproduce the water column and axi-symmetric water droplet breakup processes in previous experiments. The present study confirms the validity of the present numerical method in solving the shock wave induced droplet breakup problem and elaborates the stripping breakup process numerically in a long period. Droplet inner flow pattern is depicted, based on which the drives of protrusions emerged on the droplet surface are clearly seen. The droplet deformation is proved to be determined by not only the outer air flow, but also the inner liquid flow.

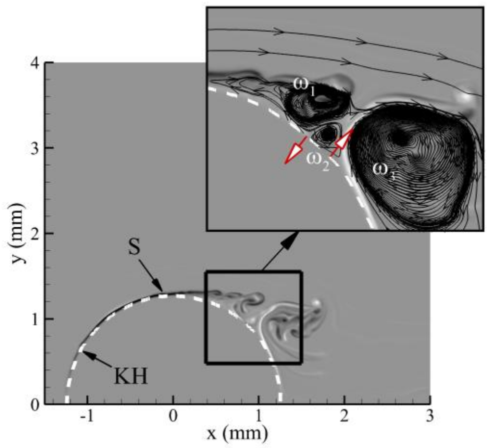

Figure 1. Vortices distribution at 20 μs, S denotes the separation point, KH the area where the KH instability emerges, ω_1, ω_2 and ω_3 three vortices. The white dashed line represents the air/water interface. Light colour indicates positive vorticity and dark colour negative vorticity.

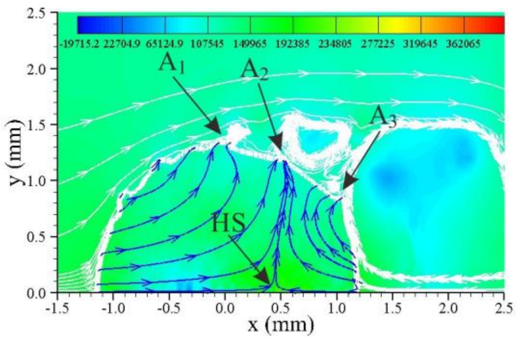

Figure 2. Numerical pressure distribution and streamlines at 50 μs. The white solid line denotes the air/water interface, A_1, A_2 and A_3 three obvious protrusions, HS the half saddle point

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Understanding the Physics of Dead Zone in Debris Flow - Microstructure and Jamming Transition

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The dead zone refers to a quasi-static stagnant domain formed at the upstream of a wall-like obstacle in a granular flow. This zone is considered to be mechanically metastable. It can absorb energy from the impacts and slow down the follow-up debris in a run-up process. Modelling dead zone is of considerable practical interest for a number of industrial processes, bridge pier design, vascular blockage and debris-mitigating check dam design. The dynamical nature of dead zone has been frequently investigated based on monodisperse dry granular flow in the presence of fluid and without considering Particle Size Distribution (PSD). In this study, a coupled Computational Fluid Dynamics and Discrete Element Method (CFD-DEM) approach is employed to study the effects of fluid–particle interaction and PSD in a typical stony debris flow on the physics of dead zone. A bi-disperse particle system with big size ratio is used to model the solid phase of a stony flow by DEM, and a fluid phase consisting of water and fine sediments is considered by CFD. The influences of the particle size ratio, slope angle, rolling friction, debris density and barrier height have been examined. The numerical results well capture experimental observations on the buildup and recirculation of dead zone, the run-up surface and flow jet. Microstructural information extracted from the simulations offers insights into the underlying mechanism of jamming transition in the dead zone and important role played by particle-fluid interactions. The study also provides useful reference for practical assessment and mitigation of debris impacts on a rigid obstacle.

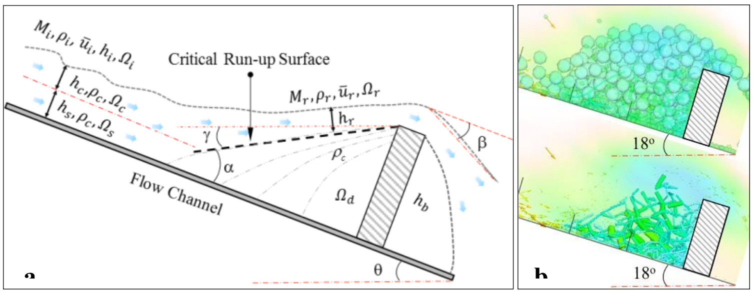

Figure 1. Schematic view of dead zone Ω_d : **a** the location of jamming transition is near the critical run-up surface, **b** force chain network in a simulation of bi-disperse particle-fluid flow.

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Application of Dielectric Barrier Discharge Plasma Actuator on Flow Control over a Delta Wing

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An experimental investigation of flow control over a slender delta wing with dielectric barrier discharge (DBD) plasma actuators is conducted. Smoke flow visualization, particle image velocimetry and 6-components force measurement are used in the wind tunnel test to illustrate the flow structure and the corresponding aerodynamic performance. The delta wing model has a chord length c of 280 mm, a swept angle of 75°, and a thickness of 5 mm. The leading edges at the windward side were beveled at 35° to fix the separation point. The DBD plasma actuators are installed at the leading edges. The angle of attack varies from 0° to 60°. The Reynolds number based on the chord length is from 50,000 to 200,000.

The smoke flow visualization reveals that the DBD plasma actuator can significantly modify the flow structure over the delta wing (see Figure 1). In the asymmetric control case (only DBD plasma actuator at the right semispan is ignited), the breakdown location of the leading edge vortex (LEV) at the right semispan is dramatically advanced while the one at the left semispan is delayed downstream. In the symmetric control case (DBD plasma actuators at both semispan are ignited), both breakdown locations of the LEVs are slightly delay downstream. PIV measurement shows the similar result and provides more detail information of the flow structure transformation under the effect of DBD plasma actuators. The force measurement indicates that the control slender influences the lift and drag. However, a relatively large roll moment and pitch moment are induced by the control. Therefore, it is concluded that the DBD plasma actuator is a promising technique for the delta wing flight control.

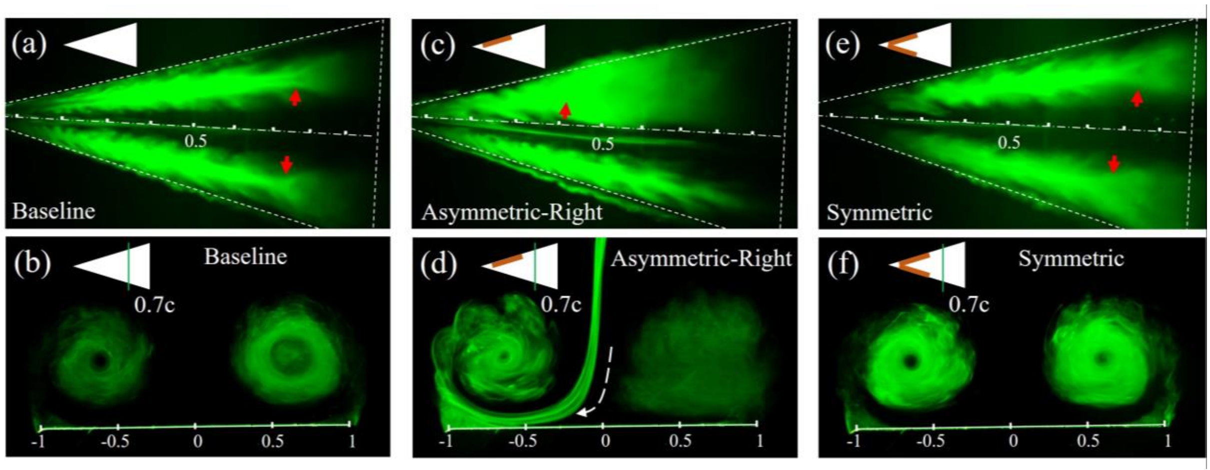

Figure 1. Smoke flow visualization results showing: a) and b) baseline case; c) and d) asymmetric control case; and e) and f) symmetric control case. The upper row is the traversal cross section and the lower row is the spanwise perpendicular cross section. (α = 34°, Re = 50,000)

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On Plume Dispersion after Line Source in Crossflows over Rough Surfaces

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Urban air quality is a public concerned problem nowadays because of the large number of stakeholders and the heavy anthropogenic pollutant emissions in close proximity. Gaussian plume models have been well received in the industry for pollutant concentration estimates. Whereas, their application to urban setting must be careful because most dispersion coefficients are determined empirically based on atmospheric stability (only) but overlook the effect of rough urban surfaces. In this paper, we report our study of transport processes over hypothetical rough surfaces in attempt to examine the pollutant plume dispersion after a ground-level line source in crossflow over urban areas. Analytical solution shows that the dispersion coefficient σ_z is proportional to $x^{1/2}\times\delta^{1/2}\times f^{1/4}$. A complementary approach, consisting of both wind tunnel experiments and large-eddy simulation (LES), is then adopted to verify the theoretical hypothesis (Figure 1). Although mild discrepancies are observed among different datasets, the above proportionality is clearly depicted. The results unveil the weaknesses of the conventional Gaussian plume model and the importance of buildings on pollutant transport. The newly proposed formulation also suggests a new parameterization of dispersion coefficient for pollutant plume dispersion over urban areas.

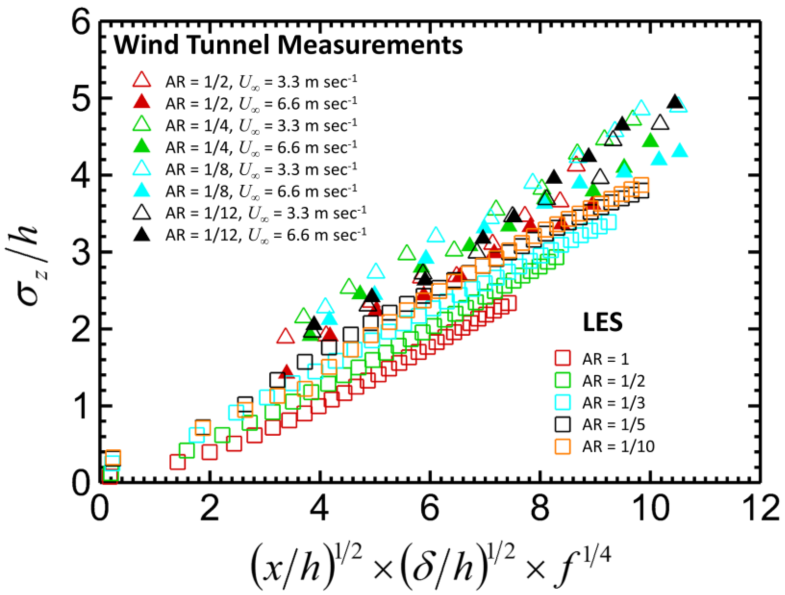

Figure 1. Dispersion coefficient σ_z over rib-type rough surfaces of different aspect ratio (AR). Results are collected from wind tunnel measurements and large-eddy simulation (LES). Here, f is the friction factor, h the size of roughness elements, U_∞ the freestream wind speed, x the streamwise distance after the line source in crossflows and δ the thickness of turbulent boundary layer.

Acknowledgements

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LBM Simulation of Successive Impingement of Two Droplets on an Inclined Surface

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Simulations using a three-dimensional Lattice Boltzmann method (LBM) have been conducted to investigate successive impingement of two droplets on a smooth, dry and inclined solid surface. The time histories of contact line motion and droplet morphology at different surface inclinations are analysed. To model the surface roughness and chemical inhomogeneity, the contact angle hysteresis is taken into account. The effect of reducing contact angles on longitudinal spread length is also investigated. Furthermore, since droplet intermixing is important, passive tracer particles are seeded inside droplets to visualize the droplet intermixing. With this technique, we observed enhanced intermixing between two droplets with a slight offset that successively impinge on an inclined surface. Effects of other parameters such as viscosity, surface tension, surface wettability and lateral distance are also discussed.

As a preliminary result, Figure 1 shows the evolution of two droplets of the same density, diameter and viscosity impinging on surfaces of three different inclinations. The surface slope results in asymmetric droplet spreading, with the longitudinal spreading dominant over the lateral spreading. An increase in the slope leads to the reduction of lateral spreading and faster droplet sliding. Furthermore, the coalescence process of the two droplets is studied in details and interesting results will be presented in the talk.

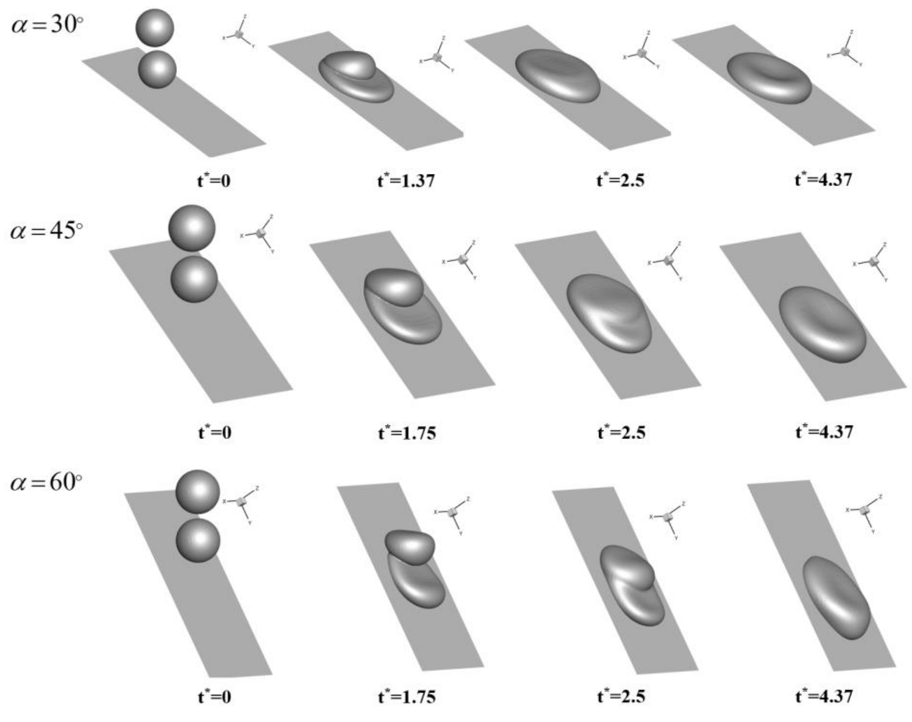

Figure 1. Evolution of droplet morphology after the impingement on surfaces of three different inclinations.

Analysis of the flow and heat transfer for coupling fluid-thermal control acupuncture needle for Chinese medicine treatment

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Abstract: Although medical equipment design have attracted more attention of scientific researchers and engineers, the medical equipment of traditional Chinese medicine is limited in a small selected range compared with Western medicine technology. For the warm acupuncture of traditional Chinese medicine, a new needle whose temperature can be controlled by the fluid with different states is designed in this investigation. On the basis of microscale heat transfer and fluid-solid coupling heat transfer theory, CFX module in finite element method (FEM) software ANSYS is adopted to analyze the flow and heat transfer characteristics of the fluid in the microscale tube of the acupuncture needle. The heat density of acupuncture needle surface and the temperature of the acupunctured skin can be adjusted by changing the inlet temperature and velocity to achieve the temperature curative effect of acupuncture. The new ideas, theory basis and selected range of parameters about acupuncture needle are put forward.

Key words: acupuncture needle; fluid; microscale heat transfer; fluid-solid coupling

流体热控针灸针的热-流耦合特性分析

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摘要：医疗器材设计吸引了很多科研工程人员的关注，与西医相比中医医疗器材可选余地较小。本文针对中医传统项目温热针灸用针，设计了含有流体热控制的针灸针体。基于微尺度传热和流固耦合传热分析方法，采用有限元软件 ANSYS 的 CFX 模块建模仿真分析针体内部流道中流体的流动与传热特性。发现可以通过改变流体的入口温度和流速，调节流控针表面的热流密度和皮肤进针点的温度，可有效实现针灸的温度效应，为针灸用针的创新提出了新思路、理论依据以及参数选择范围。

关键词：针灸针；流体；微尺度传热；流固耦合

Light/Heavy RM instability driven by cylindrical imploding shocks

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Richtmyer-Meshkov (RM) instability occurs when an initially perturbed interface separating two different fluids is impulsively accelerated by a shock wave, regarded as a central role for understanding the hydrodynamic processes involved in the inertial confinement fusion (ICF). Compared with the planar RM instability, which has been extensively discussed in past 20 years, the converging RM instability has less research progress for its fairly complex physical mechanism and many difficulties in experiments. Based on the fan-shaped cylindrical converging shock tube [1], several experiments have been implemented to study the interaction between cylindrical imploding shocks and single mode air/SF_6 interface. It is found that the development of disturbance is more quickly declined by the RT stabilization effect in the non-uniform deceleration process. Especially, when the initial amplitude of the disturbance is small, the RT stabilization effect even leads to an abnormal beforehand phase inversion. It is believed that it is a result of competition between the RM instability and the RT stabilization effect. However, due to the three-dimensionality in the experiment, detailed underlying flow physics can't be found.

A detailed numerical research is carried out in this work to study the above-mentioned phenomena observed in the experiment in the 2D geometry using the in-house upwind characteristic space–time conservation element and solution element (CE/SE) code [2]. Firstly, the numerical simulations show that, at a certain wave number k_0, a small initial amplitude a_0 will lead to abnormal beforehand phase inversion but a big one will not (Figure 1). A medium critical state is found between them, accompanied with the appearance of frequency doubling feature. Then a critical line is obtained in the (k_0, a_0) domain by finding the critical a_0 at different k_0. A special frequency-truncation phenomenon is found, coinciding well with Bell's model. The influences of several physical parameters are also examined. It is indicating that the truncation point of critical line is negatively related to the initial Atwood number and initial shock Mach number, but insensitive to the radius of initial interface.

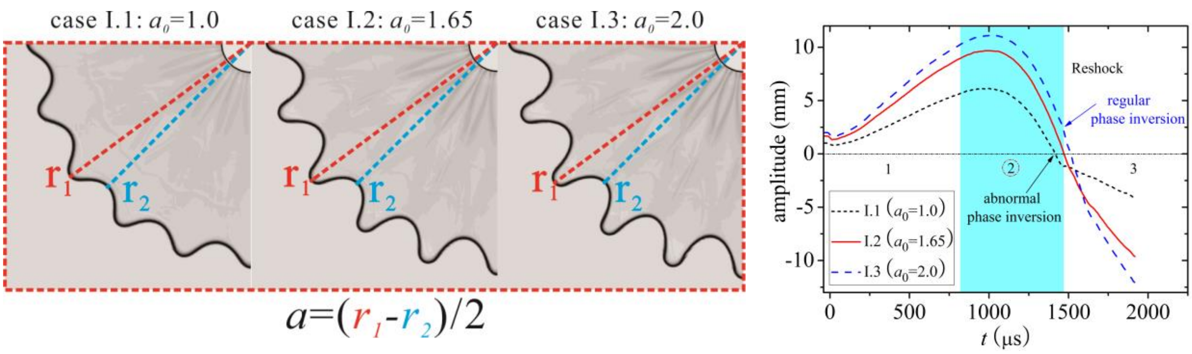

Figure 1. Numerical Schlieren pictures and development of the amplitudes of different initial amplitudes.

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Wake Measurement of an H-Rotor Vertical Axis Wind Turbine via Wind Tunnel Testing

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Wake aerodynamics are of critical importance for design of and micro-siting of standalone and multiple vertical axis wind turbines (VAWTs), respectively. Though there is a resurgence of interest in VAWTs, research on wakes of VAWTs is yet limited. In this study, the wake of an H-rotor VAWT was measured and investigated via wind tunnel tests. The wind tunnel had a uniform cross-section fit for the purpose of wake measurement. A blockage ratio of 1.8% was induced, implying a negligible blockage effect. The measured points were automatically covered by a four-hole cobra probe as far as 10 turbine diameters (10*D*) downstream. The wake was observed to show great asymmetry in the horizontal direction. In contrast, the wake was approximately symmetrical in the vertical direction. A pair of stationary counter-rotating vortices was discovered in the wake. The stationary vortical motions were believed to contribute to fast wake recovery, which suggests a potential increase of packing density. The integral length scale in the wake steadily grew, indicating the turbulence production process of the VAWT.

Figure 1. The VAWT in the wind tunnel.

Acknowledgements

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Energy Extraction through a Passively Oscillating Hydrofoil

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Energy extraction through flapping wings is a novel concept, especially when the system's locomotion is entirely passive and dependent only on hydrodynamic forces. In this study, a water-tunnel test rig was designed and fabricated in such a way that a hydrofoil is able to periodically plunge and pitch under the hydrodynamic forces exerted from surrounding water flow. Experiments were carried out at two different flow velocities, covering the Reynolds numbers of 0.9×10^5 and 1.1×10^5. The energy extraction was investigated systematically through simultaneous measurement of the hydrofoil's two degree-of-freedom motions and hydrodynamic forces/torques.

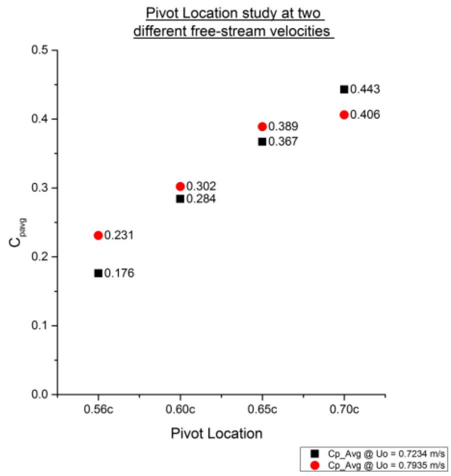

Figure 1: Variation of the mean power coefficient against pivot location at two freestream velocities

Experiments were conducted in a closed-circuit water channel. The hydrofoil was made of aluminium with a rectangular planform of chord length c = 140 mm and span b = 200 mm, and was mounted in a vertical cantilevered arrangement oscillating about a preseted pivot location. To maintain the two dimensionality of the study, end-plates made from acrylic sheets were introduced on the top and bottom of the hydrofoil. Three sensors were used to measure forces/torques, and angular/linear displacements, which were later used to calculate the performance parameters such as the time-averaged power coefficient $C_{p\text{-}avg}$ and the energy conversion efficiency η.

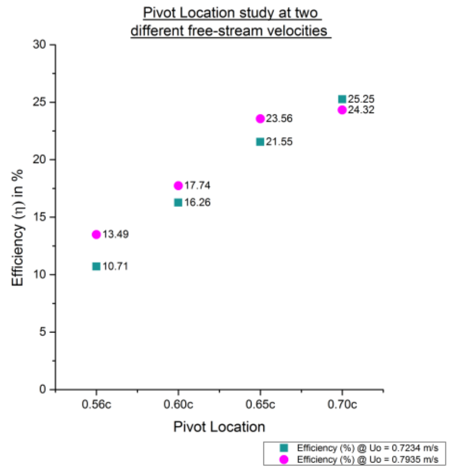

Figure 2: Variation of the efficiency against pivot locations at two freestream velocities

Studies were conducted by varying the pivot location (x_p) ranging from 0.55c to 0.70c. Heaving amplitude (y_o) was kept constant for all experiments. In the initial phases of the experiments, it was found that the test rig only starts to perform self-sustained flapping motion in water flows with speed greater than a critical value, known as the cut-off speed ($U_{o\text{-}cut\text{-}off}$). Force and motion measurements revealed that by moving the pivot location aft of the mid-chord, the mean power coefficient ($C_{p\text{-}avg}$) and efficiency (η) increased, as shwon in Figures 1 and 2. Detailed examinations on the instantaneous forces and motions further revealed that the energy extraction performance at various conditions is very dependent on the ratio of the in-phase operation portion to the anti-phase operation portion of the passively oscillating hydrofoil in the water flow.

Dynamics of a freely falling circular cylinder with non-uniform mass distribution

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Dynamics of freely falling or rising bodies moving in still fluid has attracted a lot of attention. Their trajectories are often not rectilinear, and the aerodynamic/hydrodynamic forces are usually time dependent. In this study, we investigated the dynamics of a freely falling circular cylinder with non-uniform mass distribution. Unlike in the previous study (Horowitz & Williamson 2006) where the cylinder has uniform mass distribution, a torque induced by the offset between the gravity center and the buoyancy center plays an important role. We first conducted experiments with a cylinder whose center of gravity is right under its center of buoyancy. Analyses of the images taken from a high-speed camera revealed that the cylinder descends in almost a rectilinear path but slightly deviates from its falling plane, as shown in Fig. 1(a). However, if rotated by 180°, the cylinder experiences significant transverse oscillation as shown in Fig. 1(b). This transverse oscillation is caused by the cylinder's self-induced rotation motion. On the other hand, the translating motion of the cylinder can induce vortex shedding. If the cylinder's falling velocity reaches a threshold value, asymmetric vortex shedding will occur, which in return causes the cylinder's transverse motion. From the particle image velocimetry (PIV) measurement results, we also found that asymmetric vortex shedding of different intensity occurs at the same falling height in these two cases. Different wake structures also indicate quite different dynamics. More analysis results will be revealed in our talk.

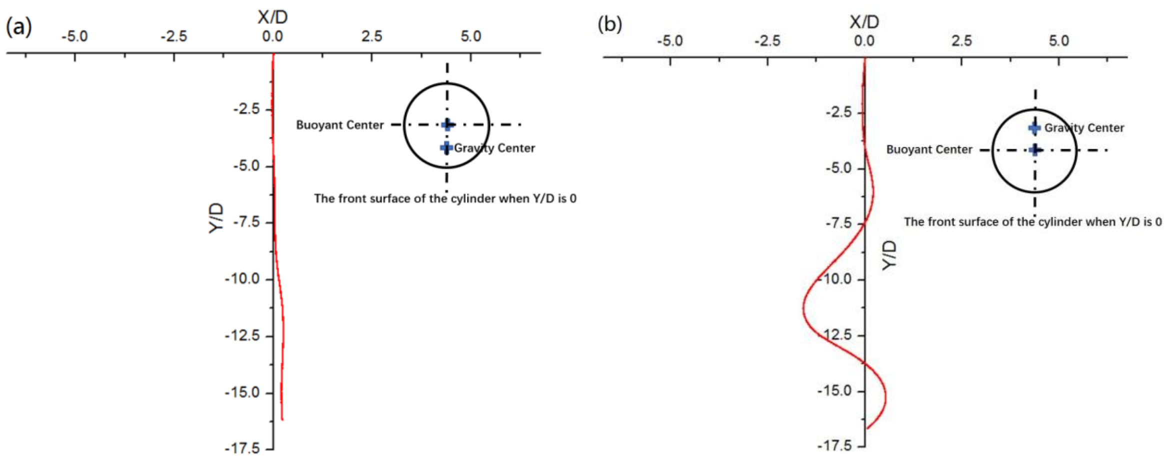

Figure 1. Trajectories of a freely falling cylinder: (a) the center of gravity is right under the center of buoyancy; (b) the center of gravity is right above the center of buoyancy.

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Condensation Heat Transfer Modelling and Optimization of Biphilic Surfaces

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Condensing surfaces with heterogeneous wettability (e.g., hydrophobic/hydrophilic patterns) are demonstrated with superior thermal performance due to decreased nucleation energy barrier, spatial control of water condensation, and self-jumping of mobile droplets. However, the complex characters of nucleation and droplet shedding, which seemingly require opposite wetting properties of the surface, generate several trade-offs in designing such biphilic surfaces. Here, we demonstrate the optimization of the biphilic surface design through the modelling and simulation of droplet distribution, growth and heat transfer. The investigated biphilic surfaces are composed of hydrophilic pillars scattering on superhydrophobic nanograss. The diameter of the hydrophilic pillar d ranges from 1 m to 4 m, and the centre-to-centre space between adjacent pillars l are the control parameter. The theoretical models that predict the jumping velocity is based on the balance between the released surface energy, viscous dissipation, interfacial adhesive work and kinetic energy. The result shows that the biphilic surfaces with l/d = 4 and 5 achieve the highest jumping velocity (~ 0.6 m/s) as well as the smallest radius of the jumping droplets (≲10 m). The high jumping efficiency engenders a rapid surface refreshing and consequently allows more small droplets to nucleate and grow on the surface. Fig. 1 shows the droplet distribution that derived from the population balance model and size distribution established by Rose [1] and the overall heat flux. The surface with l/d = 4 and 5 attains the larger amount of small droplets, and thereby provides the preferable overall heat flux (~700 KW/m2). Our simulation results show a fairly good agreement with the characterization of biliphic surfaces developed in previous work [2], therefore our model may guide the design and optimization of condensation surfaces.

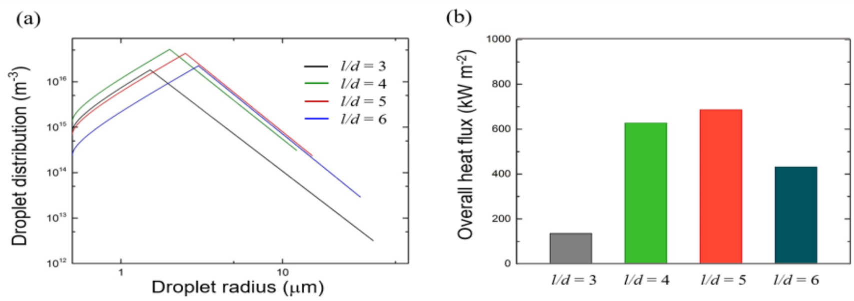

Figure 1. Simulation results of the droplet distribution (a) and the overall heat flux (b) of the biphilic surfaces with the hydrophilic pillar diameter d = 1μm and various centre-to-centre space l.

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基於 B 樣條插值方法的旋轉內接柔性懸臂梁動力學研究

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摘要：採用B樣條插值方法對旋轉內接懸臂梁的動力學特性進行研究。考慮柔性梁的縱向拉伸變形和橫向彎曲變形，計入由於橫向彎曲變形引起的縱向縮短，即非線性耦合項。利用B樣條插值方法對柔性梁的變形場進行離散。採用Lagrange方程建立系統的動力學方程，並編制旋轉內接柔性懸臂梁動力學模擬軟體。進行動力學模擬，將B樣條插值方法的模擬結果與假設模態法、有限元法進行比較分析，驗證了提出的方法的正確性，並表明B樣條插值方法作為變形體離散法在柔性多體系統動力學中具有優良性能和應用價值，同時得出旋轉內接柔性懸臂梁存在動力柔化效應。

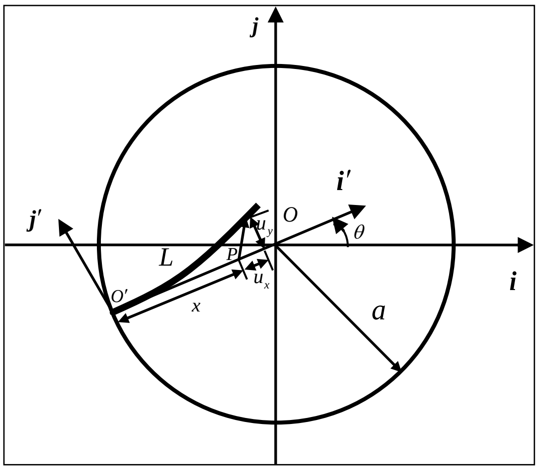

圖 1. 旋轉內接柔性懸臂梁物理模型

致謝

國家自然科學基金(11502098，11272155，11132007)和江蘇省高校自然科學研究面上專案（15KJB130003）資助專案

Structural Stability of Ultrathin Gold Nanostructures under Heating

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Comprehensive understanding of the nanomechanical behavior and structural stability of ultrathin (diameter < 20 nm) gold (Au) nanostructures is prerequisite for their potential applications when employed as building blocks in functional nanoelectronics or nano-electro-mechanical systems (NEMS) devices. By using *in situ* transmission electron microscopy (TEM) technique, we explored the thermal stability of ultrathin Au nanowires and discovered Rayleigh instability phenomenon, a heating-induced structural evolution to form sinusoidal shape, in ultrathin Au nanowires under controlled electron beam irradiation-induced heating effect. In addition, Rayleigh instability of ultrathin 4H hexagonal Au nanoribbons was also studied, and we found that even though their shape evolution is quite different from common ultrathin Au nanowires, their 4H crystalline structures remain quite stable under sustained E-beam irradiation.

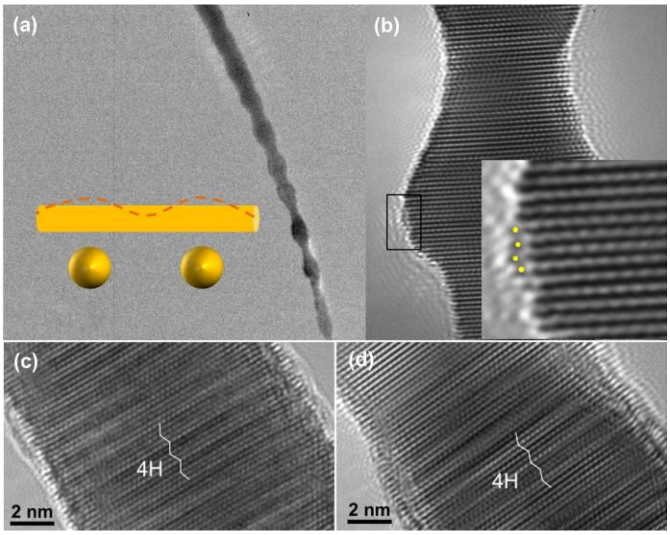

Figure 1. (a-b) *in situ* observation of Rayleigh instability in ultrathin gold nanowire; (c-d) 4H Au nanoribbon during Rayleigh instability process

Acknowledgements:

This work was supported by the Research Grants Council of the Hong Kong Special Administrative Region, China (Project # CityU 11209914) and the National Natural Science Foundation of China (Project # 51301147). 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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Accelerated Stokesian Dynamics Simulations of Active Microrheology: Microviscosity, Microdiffusivity and Suspension Stress

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The non-equilibrium rheological response of colloidal suspensions is studied via active microrheology utilizing Accelerated Stokesian Dynamics simulations. In our recent work, we derived the microrheological theory for micro-diffusivity and suspension stress, in the dilute limit, for suspensions of hydrodynamically interacting colloids. This work revealed that force-induced diffusion is anisotropic, with qualitative differences between diffusion along the line of the external force and that transverse to it, and connected these effects to the role of hydrodynamic interactions. This work also revealed that hydrodynamics play a similar qualitative role in the anisotropy of the normal stresses, and in the non-equilibrium osmotic pressure. Here, we show that these behaviours hold for suspensions ranging from dilute to near maximum packing. In this work, simulations are for monodisperse suspensions of Brownian hard-spheres as a function of Peclet number, *Pe*, which measures the relative importance of hydrodynamic and Brownian forces, over a range of volume fraction $0.05 < \phi < 0.4$.

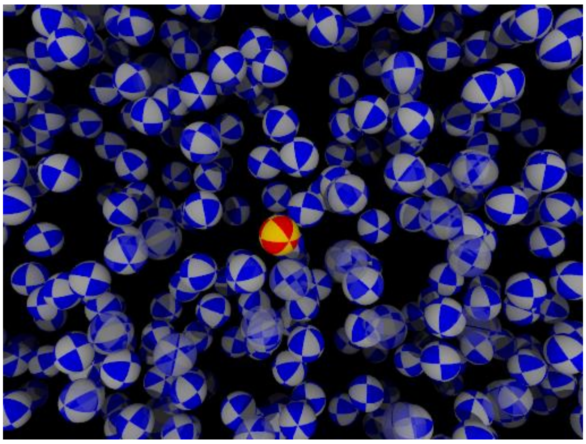

Figure 1. Accelerated Stokesian dynamics simulations of active microrheology.

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Two-degree-of-freedom Nonlinear Mass-Damper-Spring Model to Predict the Capturing of Circulating Tumor Cells in Microfluidic-Elasto-Filtration Chips

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Detection of low-concentration Circulating Tumor Cells (CTCs) in human blood is a promising noninvasive technique for cancer diagnostics and prognostics. Recently, we propose Microfluidic-Elasto-Filtration (MEF) chips that fully utilize the differences in flow-dependent cell size and elasticity of CTCs and white blood cells (WBCs) for CTC isolation, to overcome the bottleneck of low purity in conventional size-based microfiltration. For designing a MEF system with high efficiencies of CTC capturing and WBC depletion, a new two degree-of-freedom (2-DOF) nonlinear mass-damper-spring (*m*-*c*-*k*) model to predict the cell capturing in MEF has been proposed in Fig.1, based on two key dimensionless parameters, Capillary number (*Ca* is the ratio of viscous force to the cell's effective elastic force) and the normalized cell diameter (d^*) with respect to the pore diameter. The nonlinear cell stiffness as a function of cell deformation in a filter pore was first identified by finite element method (FEM). By introducing the identified nonlinear cell stiffness into the 2-DOF *m*-*c*-*k* model, the *Ca* effects on the capturing of CTC and WBC have been identified and verified by the experimental results. An optimized Ca^* = 0.043 (regarding CTCs) has been identified to enhance the capture efficiency of CTCs and depletion of WBCs. The MEF under Ca^* can also separate the CTC and WBC with the same size, which can hardly be achieved in the size-based filtration. With the reduced computational cost, this 2-DOF *m*-*c*-*k* model is useful to directly guide the design of MEF system with high efficiencies in CTC capturing and WBC depletion.

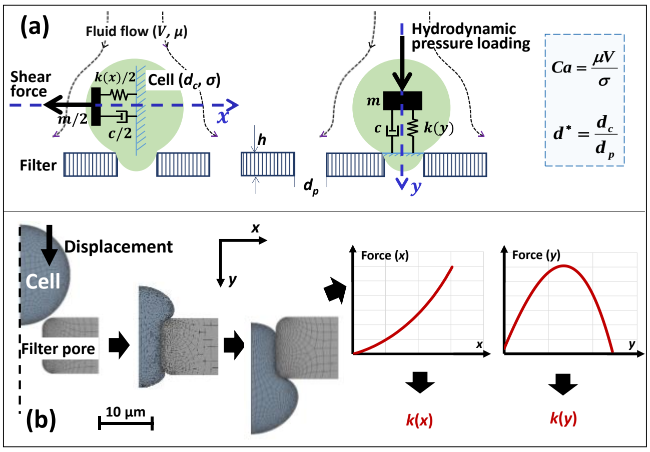

Fig 1. The 2-DOF nonlinear *m*-*c*-*k* model to predict the cell capturing in MEF. (**a**) Modeling based on two dimensionless parameters for characterizing the MEF of cells, *Ca* and d^*. (**b**) FEM simulation to determine the nonlinear cell stiffness as a function of cell deformation during filtration.

Deformation mechanism transition in single crystalline gold nanowires with diameters below 100nm

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Understanding the deformation mechanisms (especially plasticity) of single crystalline gold nanowires could be of help for their device applications as well as the nanomechanics of FCC metals. Even though an obvious "the smaller the strong" Hall-Petch law relationship was observed on thicker (diameter above 100 nm) gold nanowires, for ultrathin nanowires with diameters below 20 nm, the deformation mechanism deviated significantly. For investigating the deformation of gold nanowires with diameters ranged from 20 to 100 nm, with an unknown gap in plasticity mechanism transition, *in situ* TEM tensile tests were performed based on a high resolution picoindenter assisted with a push-to-pull micromechanical device. Results show with the decrease of nanowire diameters, the "smaller is stronger" Hall-Petch law become inconspicuous. The deformation mechanisms also transferred from classic dislocation dynamics into surface dislocation nucleation and diffusion as observed on ultrathin gold nanowires. This work could pave the way for understanding the plasticity of other crystalline metallic/semiconductor nanostructures at the relevant size domain.

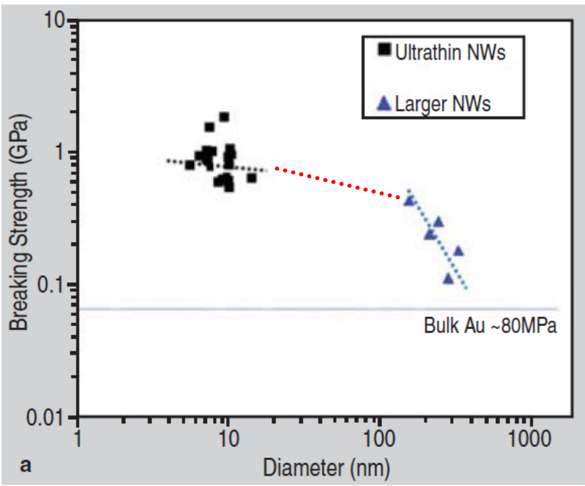

Figure 1. Size dependence of mechanical behavior of gold nanowires with decreased diameters

Acknowledgements

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Dynamic and Static Analysis of a Double-Layered Compound 'Acoustic Black Hole' Beamlike Structure

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'Acoustic Black Hole' (ABH) phenomenon shows it promises in suppressing flexural vibrations in beam and plate structures. It was shown that, through tailoring the structural thickness according to a power law profile, the local phase and group velocity of the bending wave gradually reduces, theoretically reaching zero in the tapered area when the thickness becomes zero. As a result, no energy will, in principle, be reflected at the wedge tip in the ideal case. The structural thickness, however, would never reach zero in reality due to the limited machining and manufacturing capability. This would result in a significant increase in the reflection coefficient, which can be countered, to certain extent, by the deposition of a thin damping layer only over the surface of the tapered wedge where the energy is focalized exhibiting large amplitude vibrations.

Conventional ABH structures, however, are tied with the inherent structural weakness due the low local stiffness required and possibly high stress concentration caused by the small residual cross-section thickness of the ABH taper, thus hampering their practical applications. In this study, the dynamic and static properties of a compound ABH beam are investigated through numerical simulations. It is shown that, whilst ensuring effective ABH effect, the compound ABH structure allows a significant improvement in the static properties of the structure. For the former, the compound design is shown to outperform its counterpart in the conventional ABH configuration in terms of damping enhancement and vibration suppression. For the latter, the compound ABH structure is also shown to provide much better static properties in terms of structural stiffness and strength.

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Multiscale modelling of large deformations in granular materials

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Effective modelling of a wide range of geotechnical problems requires the consideration of large deformation where the Material Point Method (MPM) has a clear edge over many other methods including. To avoid the necessity of phenomenological constitutive models in conventional MPM-based modelling of large-deformation problems, we propose a hierarchical multiscale approach by coupling discrete element method (DEM) and MPM in this study. The multiscale scheme follows the same conceptual methodology outlined by Guo and Zhao (2013, 2014, 2016) for DEM-FEM coupling. A DEM assembly is generated to serve as Representative Volume Element (RVE) and is attached to each material point of the MPM to capture the loading-history dependence and highly non-linear response of the granular material. The MPM is employed to solve a boundary value problem where large deformation is relevant. Figure 1 shows the coupling scheme between DEM and MPM. The proposed framework helps provide direct rich information from the microscale linking with interesting macroscopic response of the material, especially when large deformation occurs. We benchmark the proposed method by comparing its prediction on a single element drained test with pure DEM simulations. Further demonstrative examples on biaxial shear tests are also presented.

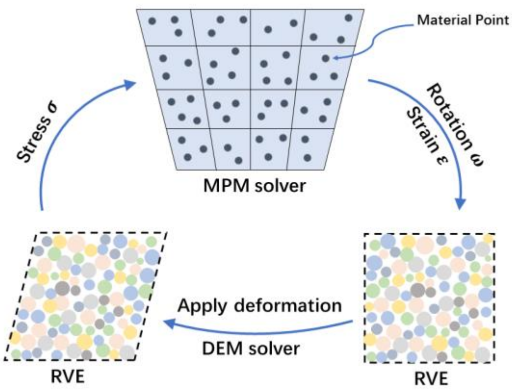

Figure 1. Schematic illustration of hierarchical multiscale coupling between DEM and MPM.

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Theoretical Modeling of Micro Thermal Accelerometer

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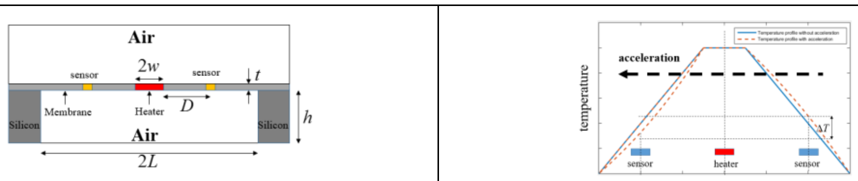
Low-cost reliable CMOS compatible Micro Thermal Accelerometers (MTA) [1] are useful for IoT smart building applications. We apply the boundary layer theory to construct a one-dimensional (1D) nonlinear compact MTA model, as shown in Fig. 1, to be used for system-level design of MTA with integrated microelectronics using CMOS MEMS technology. Based on the principle of energy conservation, due to the input acceleration a_x, the temperature profile of the fluid under free convection can be described as a second-order ODE of which the coefficients include the developed thermal boundry thickness δ, thermal conductivity and Grashof number (Gr) which is the ratio of the buoyancy force to viscous force, i.e., Gr is a function of input acceleration a_x:

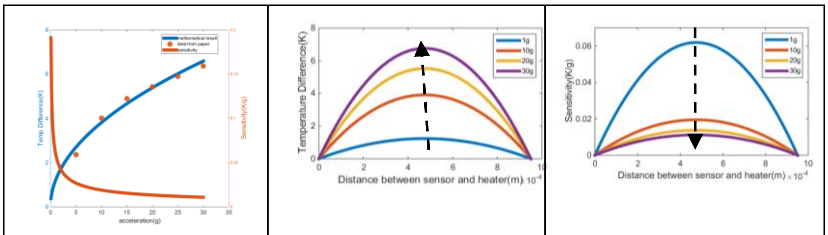
$$\frac{d^2T(x)}{dx^2}(k\delta+k_s t)-2\rho C_p u_x\frac{dT(x)}{dx}\frac{\delta}{20}-2k\frac{T(x)}{\delta}=0 \quad (1)$$



(a) (b)

Figure 1. (a) Schematic diagram of a thermal accelerometer which consists of a micro heater, a upsteam temperature sensor, T_u, and a downstream temperature sensor, T_d , (b) basic working principle of a thermal accelerometer.

The temperature profiles of a MTA with and without input acceleration a_x are shown in Fig. 1(b). With the presence of input acceleration, the temperature difference between these 2 temperature sensors, ΔT= T_u- T_d, could be related to the input acceleration. The 1D model is first validated with the released sensor parameters from Mailly's work [2], the model shows good agreement with the experiment results with a semi-empirical fitting factor as shown in Fig. 2(a). Cleary, the temperature difference ΔT increase with the increase of a_x (Fig. 2(a)), while the MTA's sensitivity decreases when a_x increase. Fig. 2(b) and (c) also show that an optimal distance D between 400 and 500μm could provide the highest output and sensitivity, which is also consistent with the results in the literature [2].



(a) (b) (c)

Figure 2. The mechanical output and the sensitivity of a MTA with ΔT_h=200K. L=2mm,W=100μm, t=8μm, h=150μm

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Investigating the deformation mechanism of high entropy alloy AlCuFeCrNi1.4 based on experimentally validated atomistic model

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High entropy alloy (HEA) is a very promising new class of alloy which generally possess ultrahigh strength and/or fracture toughness. The finding of this new class of alloy also brings about a new era of alloy design, since it indicates that the single-phase solid solution can also be of multiple elements with generally equiatomic composition (Zhang et al., 2014). However, the atomistic investigation of the deformation mechanisms in these alloys is more hampered by the difficulties in determining the force field of multiple components and in validating the atomistic model with experimental results than in conventional alloys. In this work, a hybrid potential, including eam/alloy, eam, and Morse, is designed for the simulation of HEA AlCuFeCrNi system. We show, for the first time, that the Young's modulus of the atomistic polycrystalline model of HEA $AlCuFeCrNi_{1.4}$ can agree excellently well with experimental results in the large temperature range of 20 – 1000 °C, which is obtained using the Impulse Excitation Technique (IET). Owing to the fundamentality of the elastic modulus in understanding microscale deformation mechanism of alloys, the atomistic model is thus verified and useful in studying microscale deformation mechanisms of HEA.

The further investigation shows the elastic deformation of HEA is non-linear owing to the non-affine deformation of disparate atoms in lattice sites and that the Young's modulus of a single crystalline HEA is much larger than that of polycrystalline counterpart owing possibly to effect of grain boundaries. These results explain the significantly different Young's modulus of same HEA obtained by different approaches. For example, the Young's modulus of FCC $AlCuFeCrNi_x$ is only 118 GPa based on tensile test (Li, Fang, Liu, Liu, & Liu, 2016), which is caused by the non-linear elastic deformation of polycrystalline HEA at large elastic strain, but become 184 GPa using nanoindentation(Sun, Zhao, Wen, Qiao, & Yang, 2014), which is consistent with our result of the Young's modulus of single crystal. Based on the established atomistic models, we further study the elastoplastic deformation mechanisms of single-crystalline and polycrystalline $AlCuFeCrNi_{1.4}$.

Acknowledgements

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Enhancement of the Strength Properties of Pb Contaminated Soil Using Nanoscale Zero Valent Iron (nZVI)

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Lead ions were proved to highly toxic carcinogens and were released into the ground and ground water in many ways which may intensify the accumulation in biotic communities. Current the application of nano-scale zero-valent iron (nZVI) was used for immobilizing and degrading contaminants like heavy metals and organics due to the superior reducing property and adsorption capacity (Azzam, 2016). As reusing of large areas of land, it is vital to reveal the treatment efficiency of polluted soils by nZVI. In this study, laboratory experiments were performed to study the removal efficiency and strength properties of lead contaminated soil treated by nZVI. In the case of lead nitrate contamination, the vane shear strength of soil reduced with additive of lead nitrate and increase evidently with the adding dosage of nZVI additive. The triaxial results show that the friction angle of lead contaminated specimens was same trend with vane shear tests. The SEM results shows that soil skeleton of each type was a big difference and become more crowded cluster distributions with the additive increase of nZVI.

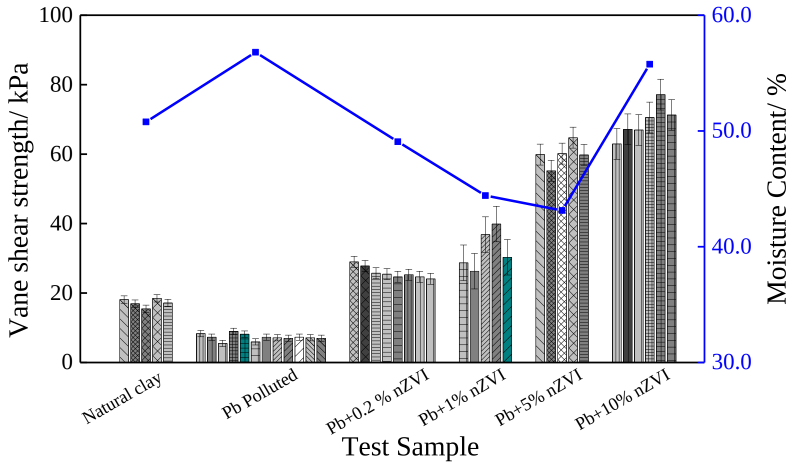

Figure 1. Relationship of additive, moisture content and vane shear strength.

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A Diffused Interface Model for Localized Corrosion

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Localized corrosion is one of the most destructive forms of corrosion which can lead to the accelerated failure of structures by thus increasing both the safety and financial concerns. Several numerical models have been developed in the last few decades to improve the understanding and prediction of this problem. These models range from classical diffusion based models to recent FEM, FVM, LSM, ALE, Peridynamic and Mesh free ones (Mai, Soghrati, & Buchheit, 2016; Tasker, 1988). These numerical models either incorporate the interface in the boundary condition or use advanced techniques to locate the interface position at each time step thus handling it as a sharp interface problem. One recent attempt has been made to simulate pitting corrosion for anodic reaction only (electrolyte effect was neglected) by a diffused interface model (Mai et al., 2016).

In this report, we present a Phase Field (PF) model (diffused interface model) for the localized corrosion by considering both anodic and cathodic reactions at the same time. It is possible to simulate the initiation of the pit by incorporating a random term in the phase field model (Ståhle & Hansen, 2015), but in our present work, we focused on the modelling of a phase field model starting from an initial pit which results from the partial break down of the protective film at the surface. This PF model is derived from KKS model (Kim, Kim, & Suzuki, 1999) in which each point of the material is considered to be a mixture of two coexisting phases and similar chemical potentials. The model is free from any limitation in the interface thickness which tolerates the assumption of a bigger interface region to lower computation cost without affecting the credibility of simulation results. A 2D model has been developed for the numerical modelling of pitting corrosion of SS304 in 1M NaCl solution by incorporating the important chemical reactions controlling the phenomenon. A small semi-circular initial pit is anticipated at the metal's surface which is in contact with the electrolyte while the remaining metal's surface is protected by a passive film. The results of this work are compared with the theoretical and experimental work in the literature.

Key words: localized corrosion, phase field model and SS304.

Acknowledgements

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CAMPUS MAP AND ROUTE TO CONFERENCE VENUE

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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