HKSTAM
Hong Kong Society of Theoretical and Applied Mechanics

Shanghai Society of Theoretical and Applied Mechanics

香港科技大學
THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

Proceedings of

The 20th Annual Conference of HKSTAM 2016
The 12th Shanghai – Hong Kong Forum on Mechanics and Its Application

April 9, 2016

Hong Kong University of Science and Technology, Hong Kong

Editors

Gang WANG and Yi-Kuen LEE

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PREFACE

The 20th Annual Conference of HKSTAM (2016) in conjunction with the 12th Shanghai – Hong Kong Forum on Mechanics and Its Application is held on April 9, 2016 at Hong Kong University of Science and Technology. This conference is co-organized by The Hong Kong Society of Theoretical and Applied Mechanics (HKSTAM), The Shanghai Society of Theoretical and Applied Mechanics (SSTAM), and The Hong Kong University of Science and Technology (HKUST). The 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 51 abstracts including 4 Distinguished Lectures by Prof. Shantung TU from East China University of Science and Technology, Prof. Xin ZHANG from Hong Kong University of Science and Technology, Prof. Dongqiang LU from Shanghai University, and Prof. Zikang TANG from University of Macau. The conference also contains 8 parallel sessions with 43 presentations.

The Society appreciates all the speakers and contributors for their efforts to make this event a successful one. Special thanks go to Ms. Huiling WU of SSTAM and Dr. Duruo HUANG 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.

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Secretary of HKSTAM
Associate Professor
Department of Civil and Environmental Engineering
Hong Kong University of Science and Technology

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香港科技大學 THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

The 20th HKSTAM Annual Conference in conjunction with The 12th Shanghai-HK Forum on Mechanics and Its Application

Conference Program (9 April 2016)

Conference Venue: Institute for Advanced Study (IAS) at Hong Kong University of Science and Technology (HKUST)

April 9, 2016, Saturday Morning (IAS Lecture Theatre, HKUST)

08:30 – 09:00 **[30 mins]**	**Registration and reception [IAS Lobby, HKUST]**
09:00 – 09:20 **[20 mins]**	Opening addresses, souvenirs presentations (MC: Professor Gang WANG (王剛), HKUST, Secretary of HKSTAM) **Professor YK LEE (李貽昆)** **President of HKSTAM** **Professor Shan-Tung TU (涂善東)** **Vice President of SSTAM**
09:20 – 10:00 **[40 mins]**	Chair: Professor Y.K LEE (李貽昆), HKUST, President of HKSTAM **Distinguished Lecture I** **Professor Shan-Tung TU（涂善東）** Changjiang Chair Professor, School of Mechanical and Power Engineering East China University of Science and Technology “**Some Aspects on High Temperature Fracture**”

10:00 – 10:40 **[40 mins]**	Chair: Changjiang Chair Professor Yuehong QIAN (錢躍竑), Shanghai University **Distinguished Lecture II** **Professor Xin ZHANG（張欣）** Swire Professor, Department of Mechanical and Aerospace Engineering Hong Kong University of Science and Technology **“Broadband Noise Simulations for Aero-Engines”**
10:40 – 11:10 **[30 mins]**	Photo Taking Coffee Break (IAS Lobby, HKUST)
11:10 – 11:50 **[40 mins]**	Chair: Professor Li CHENG (成利), Hong Kong Polytechnic University, Vice President of HKSTAM **Distinguished Lecture III** **Professor Dongqiang LU（盧東強）** Professor, Shanghai Institute of Applied Mathematics and Mechanics, Shanghai University “**Hydroelastic Wave Responses of a Thin Plate Floating on a Two-layer Fluid**”
11:50 – 12:30 **[40 mins]**	Chair: Professor Gang WANG (王剛), HKUST, Secretary of HKSTAM **Distinguished Lecture IV** **Professor Zikang TANG（湯子康）** Chair Professor, Institute of Applied Physics and Materials Engineering, Faculty of Science and Technology University of Macau **“Wrinkled Graphene for Ultra-sensitive Pressure Sensor Application”**
12:30 – 14:00 **[1 hour 30 min]**	Lunch at Bistro, HKUST Speakers of the following sessions please load their presentation files onto the computers in this break.

April 9, 2016, Saturday Afternoon (IAS Building, HKUST)

14:00 – 15:30 [1 hr 30 mins]	**Session A1 [Lecture Theatre, G/F] Chair: Yongzhong HUO**	**Session B1 [IAS, Seminar Room 1, 1/F] Chair: Prof. Hannah WH ZHOU**	**Session C1 [IAS, Seminar Room 2, 2/F] Chair: Prof. CK CHAN**	**Session D1 [IAS, Seminar Room 3, 4/F] Chair: Prof Hui TANG**
14:00 – 14:15 [15 mins]	LI Yinfeng Surface hydrogenation manipulated mechanical properties of two dimensional carbon nanomaterials	HUANG Jun An Introduction to ÅDEM, An open software for discrete materials	WANG Zhengdao Bifurcation of Flapping Flexible Filament in a uniform flow using IB-LBM	GONG Ze Measuring the Viscoelastic and Adhesion Properties of Neurite by Forced Peeling
14:15 – 14:30 [15 mins]	LI Peifeng In situ TEM Investigation on 4H Au Nanowires under Mechanical and Thermal loadings	HUANG Duruo A New Ground-motion Simulation and Modification Method Considering Spectral Acceleration, Cumulative Arias Intensity and Ground-motion Duration	HUANG Hao Multiscale simulation of the mechanical behaviour of the irradiation swelling in nuclear fuel element	XIAO Lanlan Effects of flowing red blood cells on adhesion of a rolling circulating tumor cell in microvessels
14:30 – 14:45 [15 mins]	XU Shang Self-healing of damaged ultrathin Au nanowires assisted by mechanical manipulation	ALABI Stephen Adeyemi Nonlinear modelling of dynamic behaviour of railway track system	MO Ziwei Wind tunnel experiments for flow and pollutant dispersion in turbulent boundary layer over urban areas	ZHAO Cong Personalized Micro-Elasto-Filtration (pMEF) Chips for Detecting Circulating Tumor Cells in Cancer Patients
14:45 – 15:00 [15 mins]	YAO Zijian Ultrasound Driven Nanoparticle Coalescence - A Molecular Dynamics study	DU Chunyang Influence of 2D Mountain Ridge and Surface Soil Conditions on Design Response Spectrum	WU Zhangquan Study of Chemically Reactive Pollutant Transport over Urban Roughness in the Atmospheric Boundary Layer	TIAN Shuang Numerical study of the correlation between skin blood flow oscillation and radial pulse at wrist
15:00 – 15:15 [15 mins]	ZHOU Yueting The interaction of two stamps over the surface of multiferroic materials	YAO Ye Finite Element Simulation for Residual Stresses in Cold-Formed Steel Tubes	PENG Huayi Study of Dynamic Stall Behaviours of a Straight-Bladed Vertical Axis Wind Turbine by Large Eddy Simulations	FANG Chao Modelling Cellular Blebbing with Boundary Integral Method
15:15 – 15:30 [15 mins]	SUI Wenshu Analysis of Capacitive MEMS Microphones on Sensitivity, Noise and SNR	PAN Wei Road Blockage Impact on Local Air Pollutants at Causeway Bay		ADEMILOYE A.S. Numerical studies on the elastomechanical characteristics of human erythrocyte membrane
15:30 – 15:45 **[15 mins]**	Coffee Break (IAS Lobby, HKUST) Speakers of the following sessions please load their presentation files onto the computers in this break.			

15:45 – 17:15 [1 hr 30 min]	**Session A2 [IAS Lecture Theatre, G/F] Chair: Prof Xinrui NIU**	**Session B2 [IAS Seminar Room 1, 1/F] Chair: Prof. Yuan LIN**	**Session C2 [IAS Seminar Room 2, 2/F] Chair: Prof Chih-Yung WEN**	**Session D2 [IAS Seminar Room 3, 4/F] Chair: Prof. Paul H.F. LAM**
15:45 – 16:00 [15 mins]	GAO Libo Design and Fabrication of composite micro-cage via Two-Photon Lithography	JING Xueying Modelling soil-structural interface shear test using discrete element method	MO Jingwen Molecular dynamics simulation of passive fluidic diode for simple fluids	CHI Tianxi Spectral Analysis for Vasomotion under the Skin Blood Flow Oscillation and radial pulse at wrist
16:00 – 16:15 [15 mins]	XU Wei Numerical Simulation of Packaging Effect on the CMOS MEMS Calorimetric Flow Sensor	ZHU Huaxiang On the interaction between force-chains and confining meso-structures in two-dimensional granular material of biaxial loading path	LI Chu A Simple Relation for Nanodroplet Diffusion on Supported Graphene	HU Jun Ambient Test and Numerical Modeling of a Metal Roofing System
16:15 – 16:30 [15 mins]	LI Mingpeng Non-isothermal Martensitic Transitions and Spatiotemporal Patterns—Effects of Driving Rate	WEI Jiangtao DEM analysis of initial fabric effects on undrained cyclic behaviors of sands	RIAZ Kashif Electric Field Enhancement of 3D Nano-spikes Devices for Energy Efficient Biological Manipulations	NG Puilam Behaviour of Normal and Lightweight Reinforced Concrete Tensile Members Subjected to Sustained Loading
16:30 – 16:45 [15 mins]	NARAYANA Harishkumar Stress Memory Polymers: A Novel Approach towards Constituent Analysis and Implication in Smart Compression Stockings	ZHU Fan A peridynamic approach for numerical modelling of sand grain crushing	ZHAO Linshuang A Simplified Solution for the Column-Supported Embankment System	ZHANG Hongti Mechanical properties of CoCrCuFeNi high-entropy alloy micro/nanopillars
16:45 – 17:00 [15 mins]	LIAO Weibing Mechanical properties of Co-based metallic glassy fibers	LUO Xiaodong On the critical state of granular material: the role of grain shape	LIU Xiaodi Liquefaction and Extensive Viscous Flow in Metallic Glass at Room Temperature	JIANG Chenchen Digital Micromirror Device (DMD)-Based in situ Nano-Fatigue Characterizations of 1-D Nanostructures
17:00 – 18:00 [60 mins]	**HKSTAM Annual General Meeting [IAS Lecture Theatre, HKUST]** Attendees: Representatives of all Institution Members and all Full HKSTAM Members			
18:30 – 20:30	Conference banquet at G-Restaurant, HKUST (香港科技大学南北小厨)			

Distinguished Lecture I

Speaker of Distinguished Lecture

Professor Shan-Tung TU
East China University of Science and Technology

Professor Tu Shan-Tung received his B.Sc degree in 1982 and Ph.D degree in 1988 from Nanjing Tech University. Driven by the need of development of process and energy equipment, Professor Tu has been searching for knowledge of thermal effect on materials, structures and processes. His research spans time-dependent fracture mechanics, structural integrity, and energy materials in particular for high temperature applications. He contributed significantly to high temperature structural integrity which has helped the industries to reduce the failures and prevent accidents. His research also led to the invention of some compact heat exchangers of high reliability. He is an author of more than 300 papers and received a number of distinguished awards, including China National Science and Technology Progress Award, National Invention Award, National Teaching Achievement Award, China Youth Science and Technology Award, ASME Best Paper Award and so on. He is currently the chairman of China Structural Integrity Consortium, honorary professor of University of Nottingham, the honorary President of Chinese Pressure Vessel Institution and the honorary President of Chinese Materials Institution (CMES), Chairman of Asian Oceanic Regional Committee of International Council for Pressure Vessel Technology, TC member of IFToMM and an editorial member of a number of journals, including Int J Pres Ves and Piping, J Applied Energy, J of Materials Science & Technology, European Journal of Computational Mechanics, Frontier of Mechanical Engineering, Advances in Mechanical Engineering.

Some aspects on high temperature fracture

Shan-Tung TU*

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For decades there has been an increasing need of structural integrity technology due to the construction of high temperature installations (eg. aeroengine, ultra- supercritical power plant, ethylene cracking plant and advanced nuclear power station). To ensure the safe design and long term reliable operation of the high temperature components, some fundamental issues concerning the deterioration and failure of the materials and structures should be investigated. The lecture summarizes the progresses in recent years in the development of constraint fracture theory and failure assessment techniques for high temperature applications, which includes: (1) Determination of creep properties. Testing principles are proposed to determine creep properties by use of non-traditional specimens. (2) Constraint effect on high temperature fracture. The influences of in-plane and out-of-plane constraints on high temperature fracture are studied. A unified constraint parameter is proposed to modify the current creep crack growth law. (3) Damage mechanics based failure assessment. A new multiaxial creep-damage model considering the cavity growth and microcrack interaction. Special emphasis is put on developing and validating the multiaxial creep ductility factor.

Keywords: High temperature; Structural integrity, Constraint fracture, Damage model, non-traditional specimen

Distinguished Lecture II

Speaker of Distinguished Lecture

Professor Xin ZHANG
Hong Kong University of Science and Technology

Prof. Xin Zhang is the Swire Professor of Aerospace Engineering at the Hong Kong University of Science and Technology. Xin Zhang holds a Ph.D degree in fluid mechanics from the Cambridge University, UK and B.Eng in aerospace engineering from Beijing University of Aeronautics and Astronautics, China. He is a fellow of the Royal Aeronautical Society. Dr. Zhang lectures in aerodynamics and aeroacoustics, in particular aircraft aerodynamics and noise. He has performed experimental and computational research in the area of unsteady aerodynamics, ground effect aerodynamics, aeroacoustics, and aircraft noise. He now works in the area of aircraft noise including both airframe and propulsive unit noise. His research over a period of 25 years led to the establishment of Airbus Aircraft Noise Technology Centre (ANTC) at Southampton in 2008. The centre is the only Airbus university based technology centre in the world. ANTC works in the areas of airframe noise, engine noise, physics-based aircraft noise models, computational aeroacoustics, aircraft interior noise modelling, sound transmission, and noise control, all with Airbus. Airbus, a company that produces around half of the world's aircraft and employs more than 60,000 people across the EU, has integrated the outcomes of Zhang's research into its key design processes. He was the Airbus Professor of Aircraft Engineering and served as the director of ANTC between 2008 and 2014. Xin Zhang is now the director of Aviation Industry Corporation of China Advanced Aircraft Noise Technology Centre at HKUST.

Broadband Noise Simulations for Aero-Engines

X. Zhang*[1], J. Gill[2], and F. Gea-Aguilera[2]

[1]Department of Mechanical and Aerospace Engineering, The Hong Kong University of Science and Technology, Hong Kong, China

[2]Airbus Noise Technology Centre, University of Southampton, Southampton, UK

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Aero-engines are a major source of noise in the current generation of commercial aircraft. Tonal noise generated at the blade passing frequency and its harmonics is well understood. Today, the challenge is to also reduce broadband noise through computationally efficient simulations of turbofan and contra-rotating open rotor engine noise.

In turbofan engines, the dominant source of broadband noise is related to interactions between fan wakes and the outlet guide vanes (OGVs) [1]. Fan wake statistics can be reproduced by a synthetic turbulence method and interactions between the wakes and the OGVs are modelled by computational aeroacoustics (CAA) simulations that solve the linearised Euler equations [2]. Figure 1 shows contours of non-dimensional vorticity in fan wakes, and the acoustic pressure from OGVs.

Contra-rotating open rotor engines (CRORs) are being considered for next generation aircraft because they can offer improvements in propulsive efficiency when compared with turbofans. Unfortunately, CRORs emit strong tonal and broadband noise, which must be mitigated before their entry into service. Improvements have been made in tonal noise emissions via the use of technologies such as cropped rotors and mismatched blade numbers [3]. However, broadband noise, particularly at high speeds, requires further study [4] for a more complete understanding. The described CAA method is also applied to high-speed CROR broadband noise simulations to better understand the noise mechanisms.

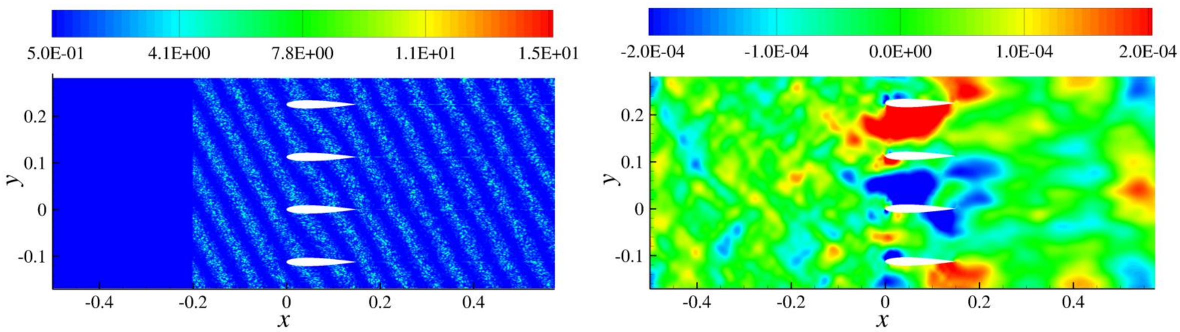

Figure 1. Fan wakes using synthetic turbulence (left) and sound pressure waves from OGVs (right)

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[3] P. R. Spalart, “Initial Noise Predictions for Open Rotors Using First Principles”, AIAA/CEAS Aeroacoustics Conference, AIAA 2010-3793, Stockholm, Sweden.

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Distinguished Lecture III

Speaker of Distinguished Lecture

Professor Dong-Qiang LU
Shanghai University

Dong-Qiang Lu obtained his BSc degree in Mechanics in 1995 from Fudan University and his MSc degree in Fluid Mechanics in 1998 from Shanghai University. He worked as an assistant lecturer for one year at Shanghai Institute of Applied Mathematics and Mechanics, Shanghai University before he went on pursuing a Ph.D. degree in Marine and Offshore Engineering at the Department of Mechanical Engineering, The University of Hong Kong. After obtaining his PhD degree in 2003, he returned to Shanghai University and advanced to the full Professor rank in 2009. At present, he is a member of the Committee of Fluid Mechanics in the Chinese Society of Theoretical and Applied Mechanics, a member of the Council of Singular Perturbation in the Chinese Mathematical Society, and the head of the Working Committee for Youths in the Shanghai Society of Theoretical and Applied Mechanics. He also serves as Editorial Board members for “Advances and Applications in Fluid Mechanics,” “Chinese Journal of Hydrodynamics,” “Chinese Quarterly of Mechanics,” “IAENG International Journal of Applied Mathematics,” “International Journal of Applied & Experimental Mathematics,” and “Journal of Hydrodynamics.” His current research interests include (i) the generation of hydroelastic, gravity, and capillary-gravity waves due to moving bodies, (ii) the interaction between ocean waves and marine structures, and (iii) mathematical methods for analytical hydrodynamics.

Hydroelastic Wave Responses of a Thin Plate Floating on a Two-layer Fluid

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A vast natural ice cover in the polar region and a man-made very large floating structure in the offshore region are usually the idealized as thin elastic plates floating on an inviscid incompressible fluid. To consider the effects of density stratification in the ocean, a simple but useful model, namely a two-layer fluid, is often employed. For the mathematical formulation, the Laplace equation is taken for the governing equation, representing the continuity of the mass. Under the assumptions of small-amplitude wave motion and small deflection of plate, the fluid–plate model is established within the linear potential theory. The dynamic condition on the fluid–plate interface indicates the balance among the hydrodynamic pressure of the fluid, the elastic and inertial forces of the plate, which forms a hydroelastic problem. Dynamical responses of the plate (namely the hydroelastic waves or flexural–gravity waves), which are the key concerns of the present study, occur as the structure is subjected to an external downward load or incident ocean waves.

The new analytical expression for the dispersion relation of the flexural–gravity waves in a two-layer fluid is explicitly derived. For the wave–plate interaction problems, the velocity potentials are expressed by the eigenfunction expansions in the frequency domain. A new inner product is introduced for the two-layer fluid to obtain the expansion coefficients. Thus the wave scattering and plate deflection are studied. In particular, the normal incidence with a semi-infinite and a finite plate, the oblique incidence with a semi-infinite plate, wave interaction with a floating circular plate and with a bottom-mounted circular cylinder clamped to an elastic plate are considered in details.

Acknowledgements

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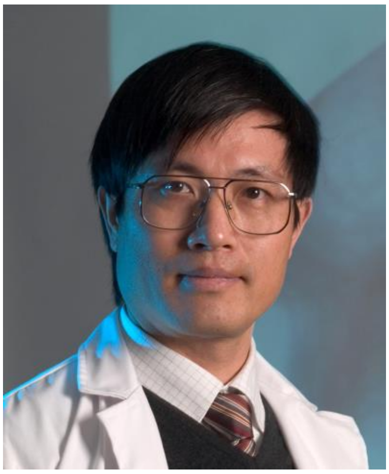
Distinguished Lecture IV

Speaker of Distinguished Lecture



Professor Zikang TANG
University of Macau

Prof. Zikang TANG received his Ph.D. degree in physics from Tohoku University in 1992. After worked for The Physical and Chemical Research Institute (RIKEN), Japan for about 2 years, he joined The Hong Kong University of Science and Technology as assistant professor in 1994 and promoted to professor in 2001. In 2016, he moved to University of Macau as Chair Professor and funding director of Institute of Physics and Materials Engineering. Prof. Tang is a renown materials scientist, his major achievements including (1) Discovery of ultraviolet lasing phenomena at room temperature from ZnO thin crystal films. This discovery triggered a worldwide booming in ZnO research. His pioneer research paper (Appl. Phys. Letters, 72 (1998) 3270) has been well received and cited over 2000 times. This paper was selected as one of the Top 50 of the Most Cited Papers in the Past 50 Years of Applied Physics Letters in the APL'S 50th Anniversary Celebration in 2012, and received the State Natural Science Award in 2003; (2) Development of a unique technique to produce mono-sized, single-walled carbon nanotubes (SWNTs), and fabricated the world-record small SWNTs with a diameter only 0.4 nm, constituting an almost ideal one-dimensional electronic system. This research work was selected as Top 10 World Scientific News in 2000 by 485 Chinese Academicians and was highlighted by Chem. Engin. News (USA) in 2000 as one of the four most important research achievements in the field of nano materials. Furthermore, in 2001, Prof. Tang and his colleagues observed novel one-dimensional superconducting phenomena at temperature below 15K from these ultra-small SWNTs, the first time observation of superconducting behavior from a non-superconducting element. This new observation was published in Science in 2001 and was highlighted by the physics web (http://physicsweb.org) as one of the 11 most important research achievements in 2001 in physics. Prof. Tang is the recipient of the Award for Outstanding Oversee Chinese Youth Fellowship (2004), Changjian Scholar (2005), Croucher Senior Research Fellowship Award (2007), and Thousand Talent Scheme Professor awarded from the Centre Government of mainland. His research is productive. Since jointed to HKUST, he awarded over 30 research project funds, and published over 200 papers in refereed journals with total cited times over 11300 (according to Google Scholar).

Wrinkled Graphene for Ultra-sensitive Pressure Sensor Application

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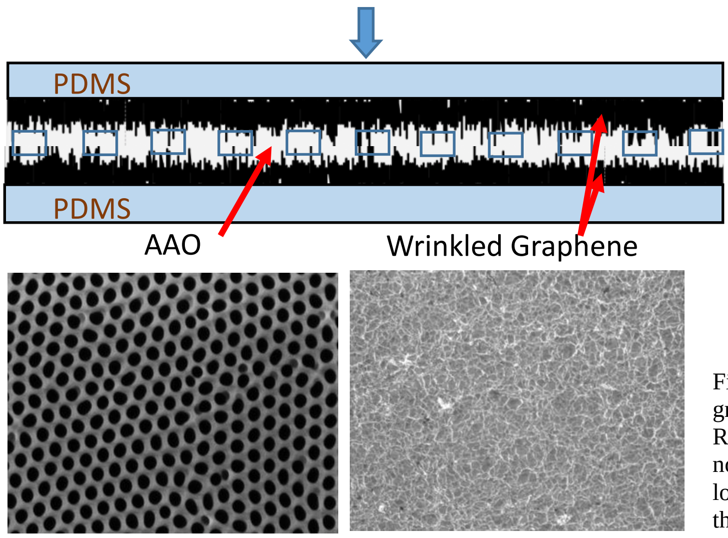
Human skin is an outstanding intuitive organ which is sensitive to tiny environmental changes in pressure, temperature and humidity etc.. To simulate human skin, investigation of electronic skins (e-skins) have been developing into a hot research field. In this presentation, we report wrinkled graphene for application as an ultra-sensitive pressure sensor. Single-layered Graphene was grown copper foil substrate by means of traditional chemical-vapour deposition technique. The ultra sensitive pressure sensor was constructed by sandwiching a thin anodic aluminium oxide (AAO) layer between two wrinkled graphene layers, as shown in the figure. The pressure sensor can detect in a broad range of pressure loading. The device is transparent in visible wavelength region, its sensitivity can be easily adjusted upon demands by tuning the thickness and the pore diameter of the AAO layer. The device is insulating if without a pressure loading. Under a pressure loading, electrical signals can be generated due to the contact of graphene wrinkles, which pass through the pores of AAO under compression. Sensors with 250 nm AAO are able to detect pressure less than 100 Pa, which is even more sensitive than the best record reported in the literature [1]. The device works very stable. No signal intensity decay is seen even after working thousand cycles of loading and release.



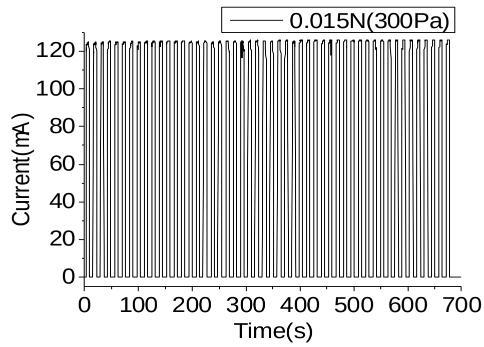


Figure Left top: Schematic show of wrinkled graphene-based ultra-sensitive pressure sensor. Right top: The pressure sensor works very stable, no signal decay is seen after a thousand pressure loading and release. Left bottom: SEM images of the AAO layer and the wrinkled graphene layers.

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Surface hydrogenation manipulated mechanical properties of two dimensional carbon nanomaterials

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With the rapid advancement of nanotechnology, various types of two dimensional nanomaterials have emerged with an ever increasing list of potential applications for next generation electronics, microchips, composites, barrier coatings, biosensors, drug delivery, energy harvesting and conversion systems, etc. A current problem of urgent concerns is how to manipulate the characteristics of nanomaterials for specific applications. This article aims to demonstrate that the surface functionalization can be effectively utilized for the manipulation of the mechanical properties of nanomaterials. In particular, the mechanics of surface characterized two dimensional carbon nanomaterials using atomistic molecular dynamics simulations of hydrogenated graphene are emphasized, from which a series of anomalous mechanical properties of graphene as well as defective structures and allotropies are reported.

Keywords: Carbon nanomaterials, hydrogenation, grain boundary, annulus, mechanical properties, molecular dynamics

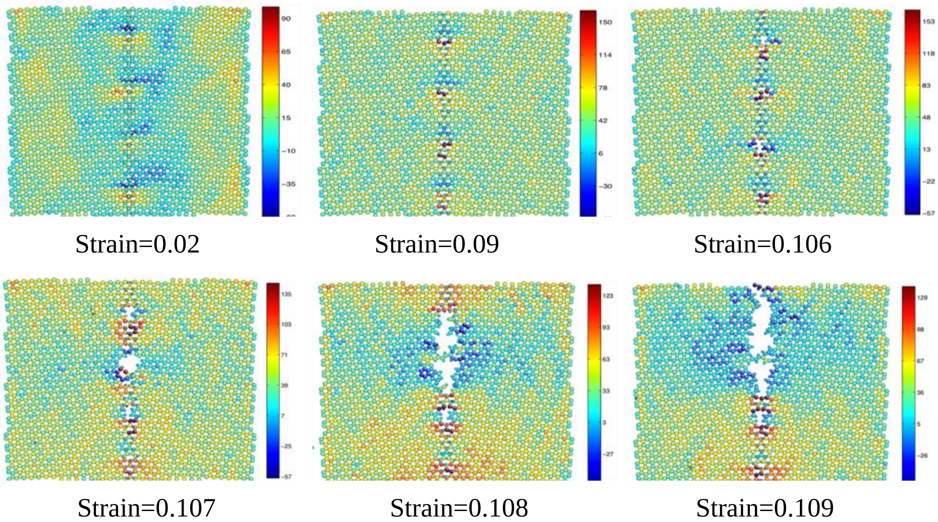

Figure 1. Tensile stress contour during the dynamic failure process of hydrogenated graphene grain boundary.

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In situ TEM Investigation on 4H Au Nanowires under Mechanical and Thermal loadings

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As a promising next-generation electronic interconnects, it is important and necessary to investigate the service behaviour of the ultrathin gold nanowires (NWs) under external loadings in their regular applications. Here, we chose to study a new kind of ultrathin Au NWs, 4H gold NWs, which have hexagonal structure and are arranged periodically with four atomic layers. Under the effect of the E-beam irradiation, the ultrathin 4H Au NWs with smaller thicknesses and widths can transit phase structures, and it is also a method to fabricate the ultrathin 4H Au NWs. We also studied their mechanical properties and deformation behaviour under in situ TEM loading for their future real device applications.

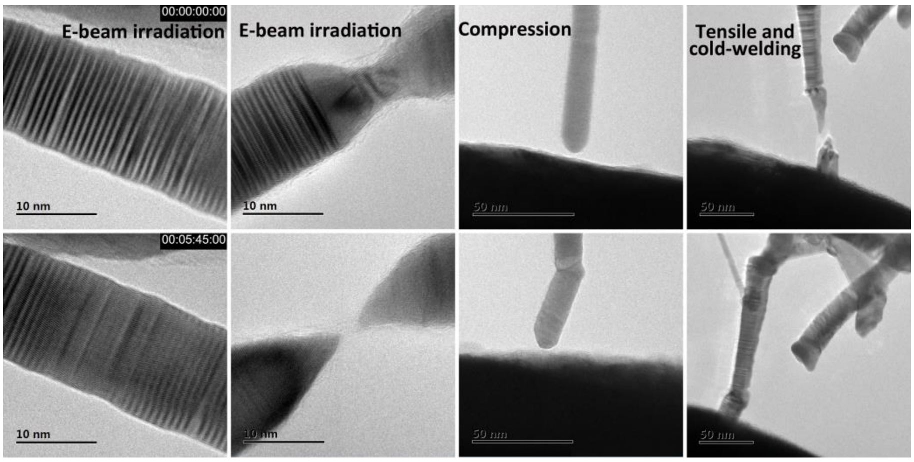

Figure 1. The deformation behaviour of ultrathin 4H Au Nanowires under E-beam irradiation and external forces

Acknowledgements

The authors wish to thank Dr. Z. Fan and Prof. H. Zhang of Nanyang Technological University for the 4H Au NRB samples. The authors also acknowledge support by the Grants NSFC and RGC CityU 11209914.

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Self-healing of damaged ultrathin Au nanowires assisted by mechanical manipulation

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As the critical feature sizes of integrated circuits (IC) approaching sub-10nm, ultrathin gold nanowires (diameters < 10nm) have emerged as one of the most promising candidates for next-generation interconnects in nanoelectronics applications. However, due to exceedingly small sizes, their structures and morphologies could be easily damaged under real service conditions, *e.g.* Rayleigh instability will significantly change their morphologies upon Joule heating, greatly hindering their applications as interconnects. By *in situ* high-resolution transmission electron microscopy (HRTEM), we found that mechanical manipulation could provide the necessary driving force to heal the geometry degradation. This result may provide a facile method to quickly repair ultrathin nanowires, even in functional devices, and restore their uniform structures and morphologies by simple global mechanical perturbations.

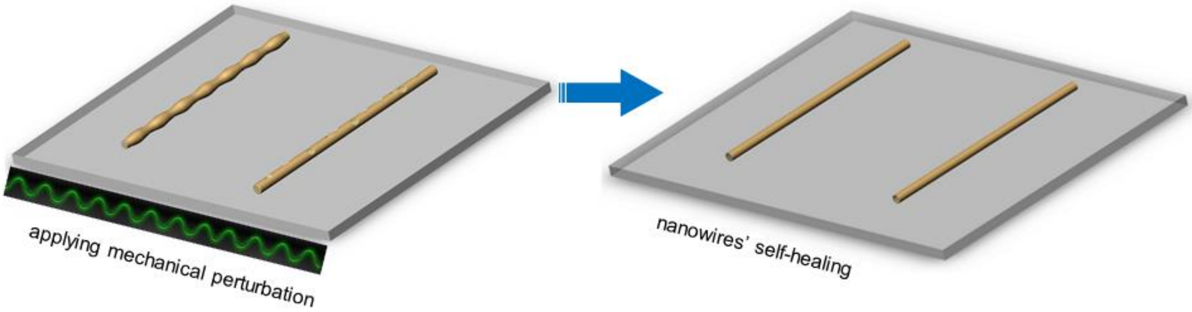

Figure 1 Rayleigh instability-induced surface damages of ultrathin gold nanowires could be recovered by global mechanical perturbations.

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The work described in this paper was partially supported by a grant from the Research Grants Council of the Hong Kong Special Administrative Region, China (Project # CityU 11209914). Y. Lu also thanks the support from the National Natural Science Foundation of China (Project # 51301147) and City University of Hong Kong (Project # 9610288).

Ultrasound Driven Nanoparticle Coalescence - A Molecular Dynamics study

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Nanoparticles (NPs) have been widely adopted as reinforcement phases in polymeric composites. NP aggregations formed by chemical bonding could enhance mechanical properties of composites. Ultrasonication is a cost-effective method to process NPs. Experiments [1-3] showed that NP aggregation could be formed by ultrasound induced interparticle collision. However, the aggregation mechanism is unclear.

This work investigates aggregation mechanism of ceramic NPs using molecular dynamics (MD) simulations. Critical velocity to form NP aggregations is evaluated. The study not only explains experimental phenomena observed in literature successfully, but also provides guidance to assemble NPs.

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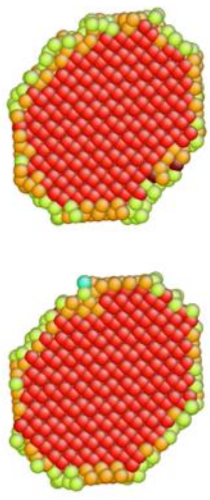

Fig. 1 Schematic of the interparticle collision between a pair of NPs.

The interaction of two stamps over the surface of multiferroic materials

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An exact analysis of two rigid stamps over the surface of multiferroic materials is conducted. The general solutions of related governing equations are given based on the generalized Almansi's theorem, which is feasible for general cases including distinctive and repeated eigenvalues. Singular integral equations are obtained and solved analytically. For two rigid flat stamps and semi-cylinders, various surface stresses, surface electric displacements and magnetic inductions can be obtained explicitly. When two rigid semi-stamps combine as a single stamp, full-field stresses, electric displacements and magnetic inductions can be derived. Figures are plotted to show how the interaction of two stamps affect the distributions of various physical quantities.

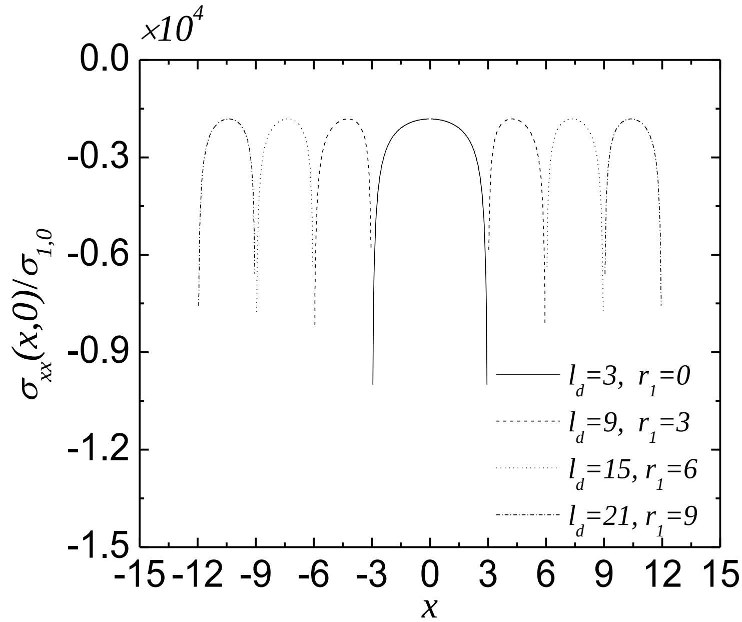

Fig. The surface in-plane stress $\sigma_{xx}(x,0)/\sigma_{1,0}$ ($\sigma_{1,0} = P_1/\pi$) under two collinear flat punches with different distances between them with $|P_1| = 10^5|P_2| = 10^5|P_3|$.

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Analysis of Capacitive MEMS Microphones on Sensitivity, Noise and SNR

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Abstract: With the development of microfabrication technology, micromachined capacitive microphone has been widely studied, and moreover, owning to the advantage of low cost, high sensitivity and low power consumption, they have been used in both consumer electronics and aerospace engineering. A 1D model of silicon capacitive microphones has been developed to describe the performance of the device, and here we demonstrated the scaling analysis of the MEMS microphone fabricated by PolyMUMPS process (MEMSCap Inc., NC, USA). Constrained by the design rules of the process, the radius of the diaphragm was studied as the dominant parameter and scaled from 200μm to 800μm. At the frequency of 1 kHz, the sensitivity was plotted as a function of radius as shown in Figure 1. No preamplifier was adopted in this study. The sensitivity of microphone increases with radius of the diaphragm. We have also developed a semi-empirical noise model to describe the noise of capacitive microphone. In this model, the mechanical noise mainly from the damping of the diaphragm during vibration can be considered as a resistor which generates thermal noise in terms of a typical equivalent circuit model. Figure 2 demonstrates the scaling analysis of the noise with the radius of diaphragm varying from 200μm to 800μm. The noise voltage density function was modified by a correction factor based on experimental results. Taking the radius of 300μm as an example, the sensitivity is about –76 dBV/Pa at 1 kHz and the noise spectral density is about 27nV/√Hz. This results in a SNR of about 75 dB. In the practical experiment with an amplifier, additional electronic noise will be introduced, resulting in the decrease of SNR to about 60 dB for the whole sensor system.

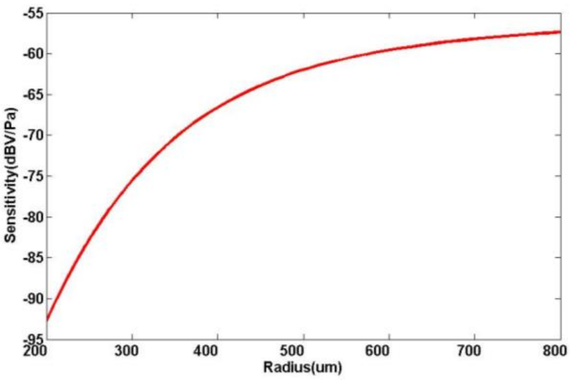

Figure 1. Sensitivity as a function of diaphragm radius.

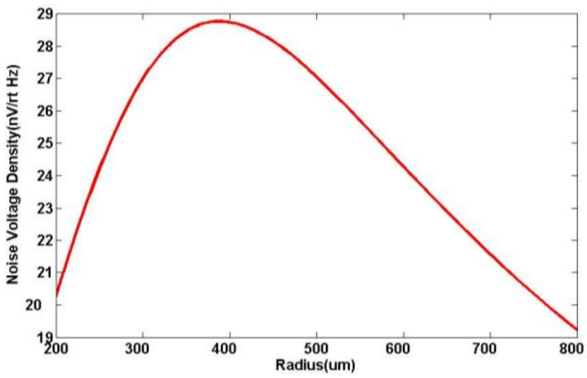

Figure 2. Noise voltage as a function of diaphragm radius.

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Design and Fabrication of Composite Micro-Cage via Two-Photon Lithography

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The combination of geometry-including lattice type, topology, and scale-with material properties determines the ultimate behavior of architected materials. Nanolattices fabricated by two-photon lithography (TPL) enable a size reduction by three orders of magnitude from microlattices while still being amenable to coating and scaffold removal. These architected materials have dimensions down to the nanoscale. Their mechanical properties depend on a combination of size-dependent material properties and structural response and cannot be predicted solely by scale-free continuum theories. In our work, a 3-dimensional (3D) micro-cage is first designed using CAD software and then replicated into a polymer pattern using two-photon lithography. After development, the polymer structure is conformally coated with a thin gold layer for 2 min (～10 nm) via sputtering. Finally the composite micro-cage was obtained and will be characterized by in situ Nanoindenter for their mechanical properties.

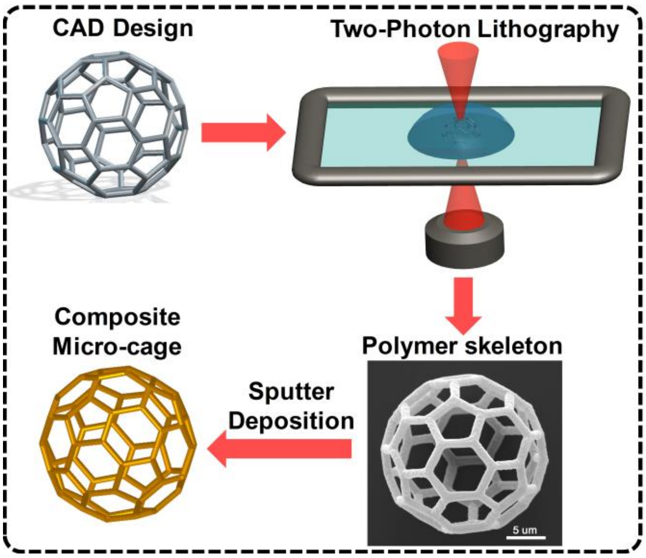

Figure 1. Process flow to create composite micro-cage

Acknowledgements

The authors wish to thank National Natural Science Foundation of China (Grant No. 51301147) and City University of Hong Kong (Project Nos. 9667117 and 9680108).

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Numerical Simulation of Packaging Effect on the CMOS MEMS Calorimetric Flow Sensor

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To achieve a well functionalized flow measurement system, considerable work in the packaging of thermal flow sensors is needed. To reduce the costly chip size in the CMOS process, the employment of housing structure is a practical solution. Previously, we reported the 2D CFD simulation (Steady analysis) and experimental studies to understand the packaging effect on our designed flow measurement systems, and build a relevant flow regime map for guiding a well packaged flow sensor design [1].

Here, we performed more detailed 3D CFD simulation by using both commercial code (Steady analysis) and self-developed code (Transient analysis). The simulation results is shown in Fig.1, where the normalized sensor position in the entrance length region is further used to study the boundary layer thickness effect. Compared to the 2D or 3D steady analysis in the commercial code, the specified self-code with the function of transient analysis shows a much stricter criterion in our experimental condition. And the experimental results is out bound of the new criterion, which validated the separation flow. It is reasonable that the experiment results is away from the new criterion, since the sensor only occupied a portion of chip area. More simulation cases are ongoing to get a refined packaging criterion latter.

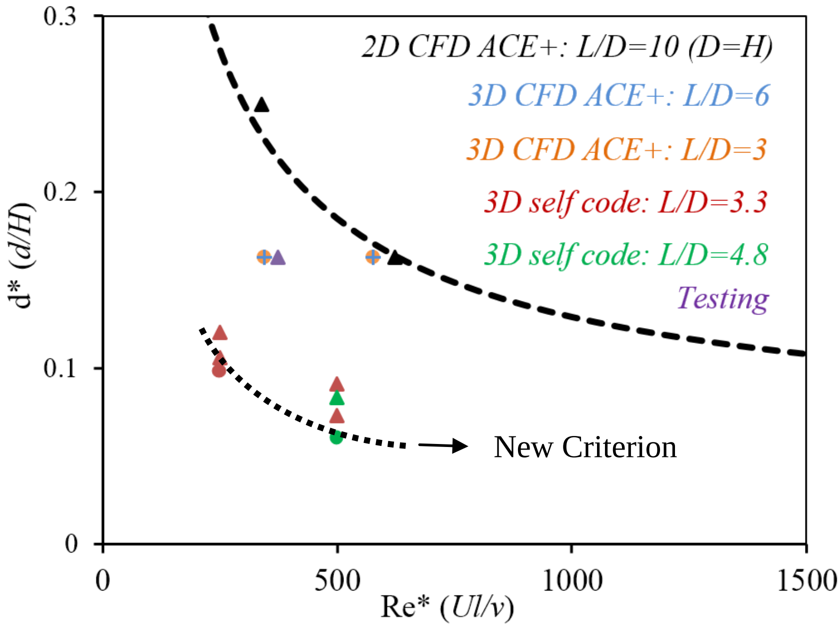

Figure 1. An enhanced flow regime map indicating the separated flow over the sensor chip based on the normalized parameters *d** and reduced *Re**; attached flow (circles or cross), separated flow (triangles).

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Non-isothermal Martensitic Transitions and Spatiotemporal Patterns—Effects of Driving Rate

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Effects of driving rate on non-isothermal martensitic transition modes and spatiotemporal patterns are studied based on Ginzburg-Landau theory and heat equation. We find that the traditional nucleation-growth paradigm breaks down due to fast self-heating under high driving rate as far as the adiabatic elastic modulus becomes positive. With the increase of driving rate, the mode of phase transition gradually changes from the traditional nucleation-growth of scattered domains to emergence of periodic domain patterns and eventually to stable and homogenous deformation. Such changes is essentially governed by the ratio of external time scale of driving (heat release) and internal time scale of heat conduction. Moreover, the scaling law of the spatiotemporal patterns and the experiment verification using Digital Image Correlation method on nano-gained polycrystalline NiTi thin strips are presented.

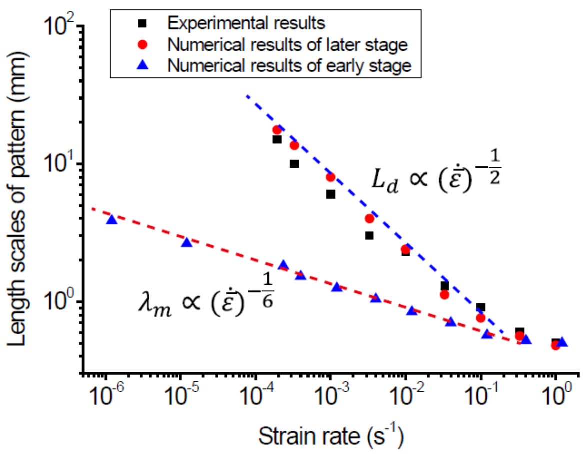

Figure 1. Scaling law of the spatiotemporal patterns under external driving.

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Stress Memory Polymers: A Novel Approach towards Constituent analysis and Implication in Smart Compression Stockings

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Shape memory polymers (SMPs) are an exciting class of smart/adaptive materials and have attracted a lot of research interest in recent years. SMPs can be deformed and fixed into a temporary shape and subsequently recovered its permanent shape upon suitable external stimulus. With an unprecedented approach, novel stress memory behaviour in a smart polymeric system has been discovered recently. In which, stress of a material can be programmed and retrieved reversibly upon an external stimulus of temperature at desired level of magnitude. A distinct switch-spring-frame model is developed to elucidate this unique concept. An impending approach of constituent analysis has been led to quantitatively unveil the total stress-strain components in a tensile programming condition. This represents a benchmark to predict the definite stress memory behaviour. The discovery being presented is emanated from an authentic study into smart polymeric fibres in medical compression stockings for chronic venous disorders. The current revelation of stress memory and quantitative analysis could help in engineering the products more precisely for numerous applications in multidisciplinary arenas, where needing the stimuli responsive forces.

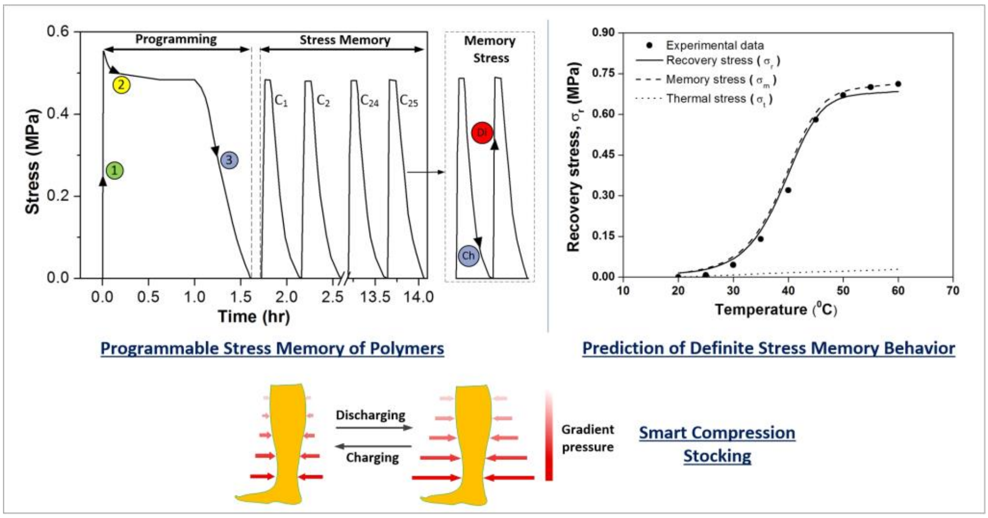

Figure 1: Stress memory, quantitative analysis of smart polymers and its application

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Mechanical properties of Co-based metallic glass microwires

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Bulk metallic glasses (BMG) show excellent mechanical and physical properties due to their random atomic packing [1,2]. As a new kind of potential engineering material, metallic glasses also challenged the traditional processing methods. In this work, continuous Co46Fe20B23Si5Nb6 metallic glassy wires at micrometer scales with a smooth surface and negligible fluctuation in diameter were prepared by the melt-spinning method. Their mechanical properties were critically evaluated by carrying out in situ optical and SEM tensile tests. The Co46Fe20B23Si5Nb6 metallic glassy wires show high tensile fracture strength of the order of 4 GPa and perform unusually large elastic strain prior to fracture. The tensile failure mechanism of the glassy wires was also studied by post-SEM and TEM analysis.

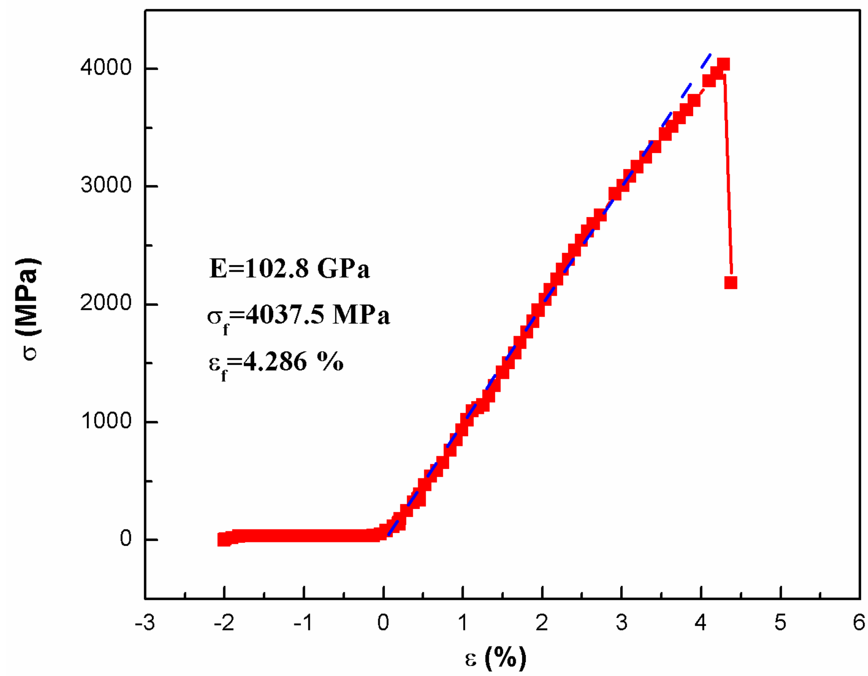

Figure 1. Stress-strain curve of Co-based metallic glass microwires with a diameter of 60 μm

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Acknowledgements

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An Introduction to ÅDEM, An open software for discrete materials

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ÅDEM (Åpen Discrete Element Method) is a software for solutions to discrete materials developed by FORTRAN based on discrete element method (DEM) in our group. The code is released as free and open source software under the GNU licence. It can be used to simulate the dynamic problems of particles in complex geometry, as shown in Fig.1 [1]. On the other hand, the codes can be coupled with CFD codes for simulation of multiphase flow [2]. Furthermore, the users can improve the codes or choose subroutines to save CPU time [3].

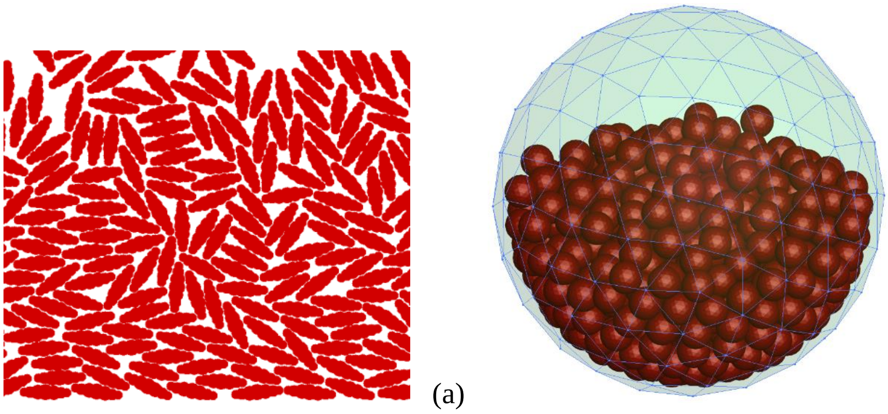
(a) (b)

Figure 1. Results of densely packed complex shaped particles: (a) elliptical particles [1] and (b) spherical particles.

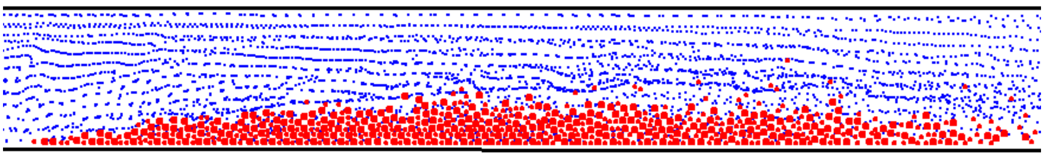

Figure 2. Coupled with SPH (smooth particle hydrodynamics) for solid-liquid flow. Red bigger particles for fluid phase and blue smaller particles for liquid [2].

Acknowledgements

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A New Ground-motion Simulation and Modification Method Considering Spectral Acceleration, Cumulative Arias Intensity and Duration

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A new ground-motion simulation and modification procedure is presented that allows the generation of energy-compatible and spectrum-compatible (ECSC) ground motions through wavelet-packet characterization and modification. The wavelet-packet transform has basis functions that are orthogonal and localized in time and frequency domains. The salient feature allows for ground-motion time histories to be flexibly adjusted in frequency domain and time domain simultaneously, thus, modifying their response spectrum and cumulative energy. The ECSC procedure was demonstrated by one-to-one comparison of several important intensity measures (e.g. peak ground acceleration, peak ground velocity, peak ground displacement, Arias intensity, duration) between simulated ECSC ground motions and actual recorded NGA ground motions. Extensive numerical simulations were also performed to compare the nonlinear responses of elasto-plastic oscillators using the simulated ECSC ground motions and recorded motions. The tests validated the general performance of the simulated ECSC ground motions are comparable with that of the recorded motions.

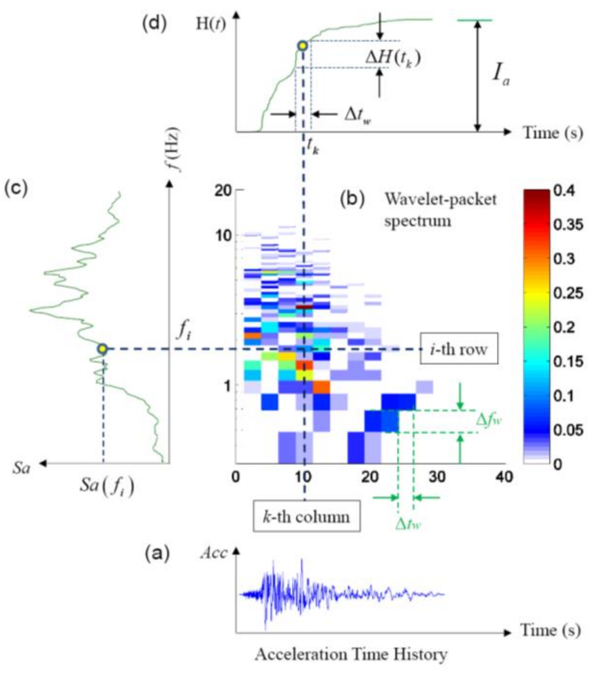

Figure 1. Wavelet-packet spectrum, showing the distribution of squared wavelet-packet coefficients of the recorded acceleration time history at the San Valley – Roscoe Blvd station in the 1994 Northridge earthquake.

Acknowledgements

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Nonlinear modelling of dynamic behaviour of railway track system

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When the ballast under the railway concrete sleeper is damaged, the stiffness provided by the ballast in supporting the sleepers will be reduced. This change in stiffness will alter the vibration characteristics of the railway track. Therefore, an accurate prediction of the behaviour of ballast under dynamic loading conditions is important for the purpose of damage detection and stability of railway tracks. In this study, the rail-sleeper-ballast system is modelled as a Timoshenko beam on an elastic foundation. The dynamic effects of the two rails together with the rail-pads were modelled as individual two mass-spring systems. From the literature, many research works has been done on modelling of dynamic responses of the railway ballast within its linearly elastic region under very small amplitude vibration (Hu, et al 2015; Lam, et al 2016). It was found that the vibration will be quickly damped and the number of data points available for model identifications is very limited when the vibration amplitude is small (i.e., the impact force is small). This certainly reduces the accuracy of the identified model parameters. If one wants to increase the number of data points by increasing the magnitude of impact force, the behaviour of railway ballast becomes nonlinear. However, the nonlinear behaviour of railway ballast under the sleeper is not considered in existing ballast damage detection methods. In particular, stress-strain relation and load-dependent characteristics need to be incorporated into modelling of the dynamic characteristic of the railway track system. This paper presents a new FE rail-sleeper-ballast model which includes the nonlinear characteristics of railway ballast. This model uses a Ludwik material model to model the nonlinear behaviour of the ballast under the concrete sleeper.

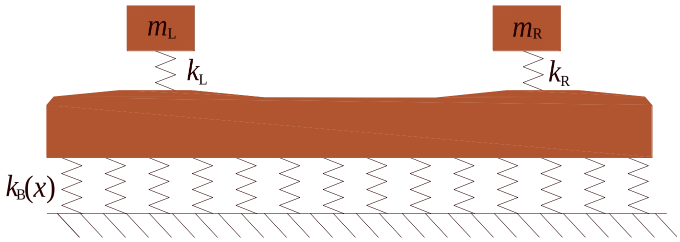

Figure 1: Proposed FE model of the rail-sleeper-ballast system

Acknowledgements

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Influence of 2D Mountain Ridge and Surface Soil Conditions on Design Response Spectrum

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Amplification of ground motions on hill-tops has been observed to cause great damages during the past earthquakes. Meanwhile, the weathered soft soil layer on mountain slope is often neglected in previous researches. In this study, software package SPECFEM2D is used to conduct the simulations. Equivalent linear method is implemented in the code to account for the nonlinearity of surface soils. To explore the effects due to both topography and soil layer, a parametric study is conducted for varying ridge height and surface soil depth. Results show that both topography and local soil conditions significantly affect the design response spectrum. The total amplification approximately equals to the amplification due to topography alone times the amplification due to soil amplification alone. When the period of the soil layer is close to that of the ridge, the total amplification can be as high as 4, while the peak ground acceleration is amplified by a factor of 2.

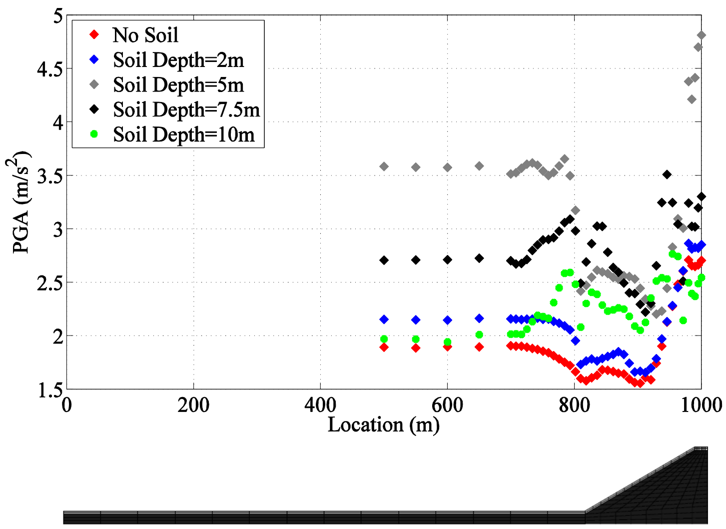

Figure 1. Peak ground acceleration along model surface for different weak surface layer depth

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Finite Element Simulation for Residual Stresses in Cold-Formed Steel Tubes

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Abstract

The cold-rolling process is often used to produce steel tubes. The entire manufacturing process can be divided into three major stages. In the first stage, an uncoiled steel sheet is cold-bent transversely into an initial circular shape. In the second stage, welding is applied to close two longitudinal edges of the circular tube resulted from the first stage. In the final stage which is so-called shaping, the welded circulate steel tube is then cold-formed into the final cross-sectional shape (e.g., circular, rectangular, elliptical shapes) by rolling. This paper aims to investigate mechanical behavior induced by the shaping process in different cold-formed steel tubes with various cross-sectional shapes. A nonlinear finite element-based method is presented for predicting the residual stresses and equivalent plastic strains in cold-formed steel hollow sections. In this method, residual stresses and equivalent plastic strains induced by the coiling, uncoiling and transverse bending processes are predicted analytically, and then the results were specified as the initial state for the subsequent nonlinear finite element simulation of the shaping process. Through the finite element simulation, residual stress distributions over the cross sections can be determined accurately. The finite element predictions can show a good agreement with the existing laboratory measurements, which demonstrates the validity and accuracy of the method. This method can also provide the predictions of residual stress variations throughout the thickness which are too complicated to be precisely measured in laboratory. Through the finite element-based method presented in the paper, the influence of different forming parameters on the residual stresses and strain hardening of materials can be investigated more efficiently.

Keywords

Residual stresses; Hollow sections; Cold forming; Shaping; Finite element simulation.

Road Blockage Impact on Local Air Pollutants at Causeway Bay

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Continued traffic flow is always considered to take most responsibility for the air quality deterioration in urban areas. While traffic control and line rerouting are assumed to be the most effective ways to better the situation as they cut off the emission directly. Because of the acute behaviour lead road blockages during the Hong Kong protest, it offers an unexpected chance to evaluate the influence of emission control oriented traffic reroute plan on local air pollutant. Hence, we investigate the autocorrelation and multifractality of six trace pollutants concentration sequences that measured in the time before, during and after the road blockages period. Results show that the influence on periodicity and long-term persistence varies differently to each pollutants, and reduction of emission source followed top-down rule may not be the best way to relieve the air quality problem.

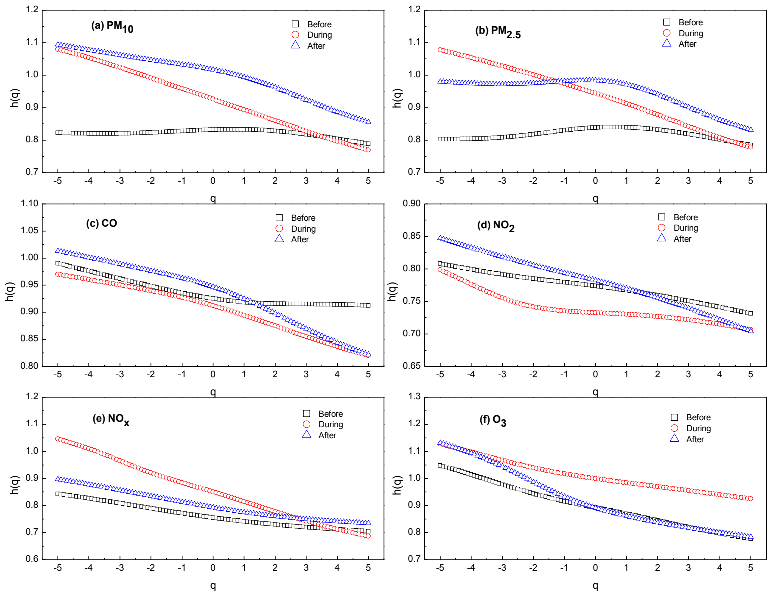

Figure 1. Generalized Hurst exponents of trace pollutants at Causeway Bay station.

Acknowledgements

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Compressed Gas Cause of Shenzhen Landslide of December 20, 2015

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The author has independently investigated the Shenzhen landslide that happened at 11:40 on December 20, 2016 at Guangming New Districty, Shenzhen, China. He will present his finding that this catastrophic landslide was caused by compressed gas in the ground.

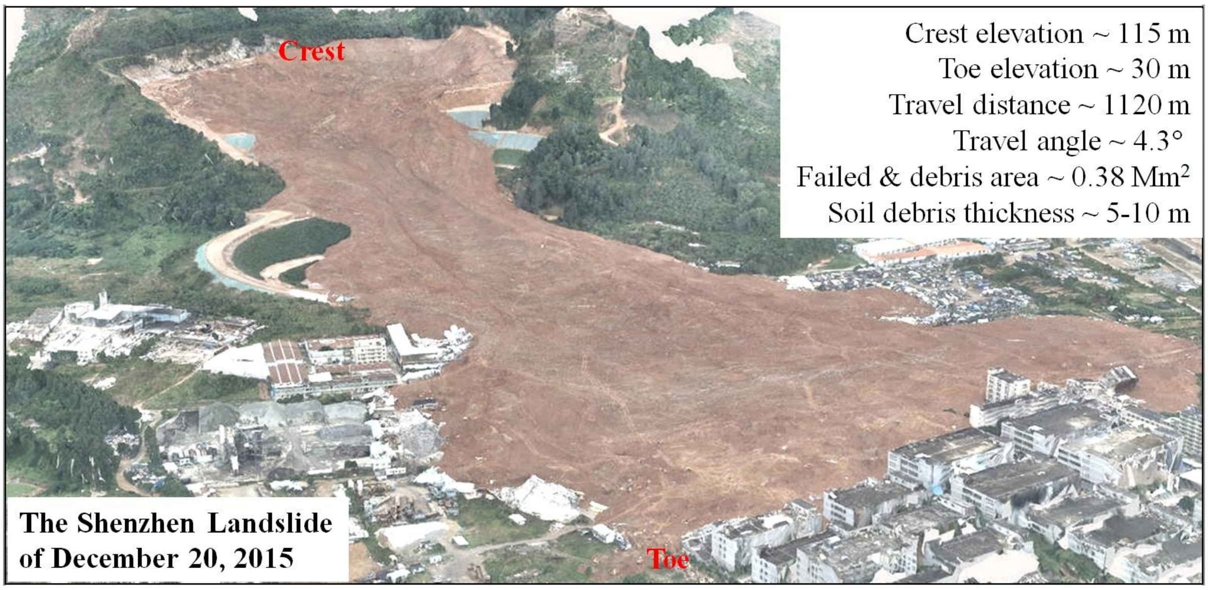

Figure 1. Site photograph for overview of Shenzhen Landslide of December 20, 2015.

Acknowledgements

The author thanks the grant (No. 41372336) from China Natural Science Foundation and friends for their supports to his independent investigation.

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Modelling soil-structural interface shear test using discrete element method

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The study in the micro-mechanical behaviour on the contact interface is significant to understand the mechanism of the interaction between the soil and the structure. It is also the foundation for the interface constitutive modelling through the micro-mechanical approach. Existing researches majorly rely on phenomenological models, which characterize the constitutive behaviour on the interface according to macroscopic observed phenomena. This kind of model, such as the zero-thickness contact model (Goodman et al., 1968) and the thin layer element model (Desai, 2013), is unable to well explain the micro-physical process on and around the interface under shearing. Since the soil is a kind of granular material, the macroscopic behaviour of the interface layer (the soil layer near the interface) can be basically attributed to the movement, rotation and breakage of soil particles. Discrete element method (DEM) is, therefore, employed to investigate the distribution and the evolution of the micro-structure in the interface layer. A soil-structural interface shear test (as shown in Figure 1) is performed, as a rolling resistance is imposed between spherical particles to reduce the particles' rotation. Three interests are held in this work: (1) the effect of the relative roughness of the interface on the shear strength; (2) the evolution of the material fabric in terms of both its anisotropy and rotation; and (3) the thickness of the interface zone.

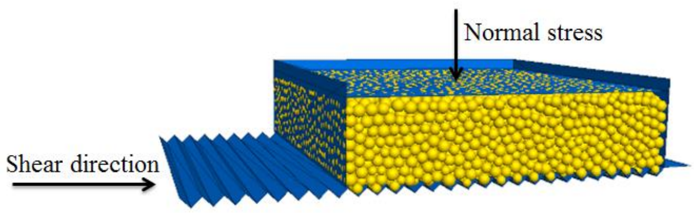

Figure 1. Soil-structural interface shear test

Acknowledgements

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On the interaction between force-chains and confining meso-structures in two-dimensional granular materials

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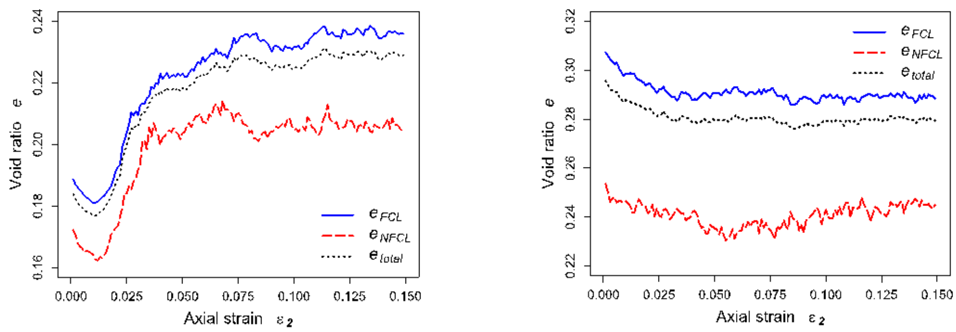
The interaction between force-chains (FCs) and meso-structures they live on governs the mechanical behavior of granular assemblies (Tordesillas, A., et al., 2011, Zhu, H., et al., forthcoming 2016). In this context, research is carried out to clarify: how the FCs influence and are influenced by the meso-structure; and how this interaction affects the macroscopic behavior of the granular material. Results show that at the meso-scale the material is structurized into two areas with totally different void ratios e (as shown in Figure 1) and meso-scale topologies. FC surrounding area is observed to be more apt to dilate than other areas. FC adjacent area can be seen as the main source of the global dilatancy. Moreover, the FC movability, a measurement closely related to the FC instability, is found to highly depend on the constitution of its surrounding mesoscopic topology.



(a) (b)

Figure 1. The void ratio e of the FC surrounding area (FCL), the complementary area (NFCL), and the total area in (a) dense and (b) loose specimens in terms of the axial strain ε_2.

Acknowlegements

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DEM analysis of initial fabric effects on undrained cyclic behaviors of sands

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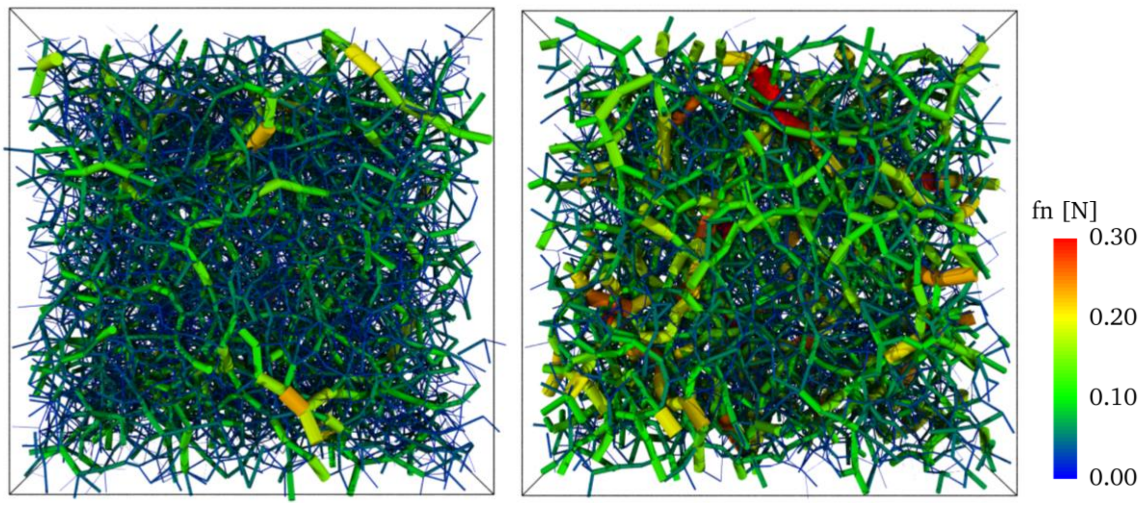
Initial fabric induced by pre-shearing has great influence on sand behaviors during undrained cyclic loading. When pre-shearing was experienced, saturated sand becomes more susceptible to liquefaction. In this study, numerical experiments by DEM are conducted to characterize the initial fabric induced by pre-shearing and investigate its influence on cyclic behaviors. Fabric of granular packing is characterized by the coordination number and a contact-normal-based fabric tensor. Under the same confining pressure and void ratio, sample prepared with pre-shearing has lower coordination number and higher degree of anisotropy. Results from numerical simulation demonstrate the significant influence of initial fabric on the liquefaction resistance, which is in good agreement with the experimental results. Liquefaction resistance decreases sharply for a sample with lower coordination number and higher anisotropy degree. From microscale, coordination number can be a good parameter to indicate the liquefaction resistance. Samples with different void ratio but the same coordination number have similar liquefaction resistance.



(a) (b)

Figure 1. (a) Force chain of sample prepared without preshearing, (b) Force chain of sample prepared with preshearing.

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A peridynamic approach for numerical modelling of sand grain crushing

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Presenter

Grain crushing is an important aspect in study of soil behaviours. The effect of grain crushing plays an important role in evolution of stress-strain relation of soil during compression (Nakata at al., 2001a). Study on grain crushing behaviour is of high interest to geotechnical researchers. Traditionally, numerical simulation of grain crushing is performed using Discrete Element Method (DEM) by composing a particle with numerous smaller spheres connected by bonds (Cheng et al., 2003). This method is conceptually simple, straightforward for implementation. However, it has some drawbacks such as difficulties in volume/mass conservation and inaccuracy in geometry. The DEM approach often simplifies the problem to a quasi-static case. It is of interest to researchers to use a dynamic approach to solve grain crushing problem. A new method, namely peridynamics, is adopted for numerical simulation of sand grain crushing problem in this study. The method is a continuum based, mesh free method first introduced by Silling (2000). It is developed and extended from molecular dynamics. Unlike classical mechanics in which the governing equation is in differential form, the peridynamics utilizes integration equation as basic equation, and this nature makes it suitable to handle discontinuities. In this study, crushing of a single sphere shaped silica sand particle by two parallel platens is modelled using state-based peridynamics (Silling et al., 2007). The results are compared with past experimental data (Nakata et al., 2001b; Zhao et al., 2015). It is found that peridynamics is able to produce reasonable results in terms of particle strength and fracture pattern. Grains with different sizes have been modelled and the results showed that the particle strength increases when the grain size decreases. This study suggests that peridynamic method can be adopted as an alternative way for numerical modelling of grain crushing problem.

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On the critical state of granular material: the role of grain shape

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Granular materials behave differently from usual solids, with many salient features such as dilatancy, anisotropy, pressure and density dependence, and nonlinear elasticity. Properly predicting the behavior of granular materials remains an area of considerable uncertainty and difficulty. The complexity originates mainly from the particulate nature of the material: that is, a granular material can exist over a range of densities at constant stress and the spectrum of states corresponds to a variety of responses ranging from flow-type failure to strain hardening. From the microscopic perspective, the overall macroscopic response of a granular material is highly dependent on the packing patterns and interactions of the constituent particles which are, further, closely related to particle characteristics such as shape and size. This paper presents several important finings on the relationship between critical states of granular materials and their grain shapes. The critical state of a granular material is defined as an ultimate state of shear failure at which the material deforms continuously under constant stress and constant volume. The relationship corresponds to the most fundamental aspect of the mechanics of granular materials.

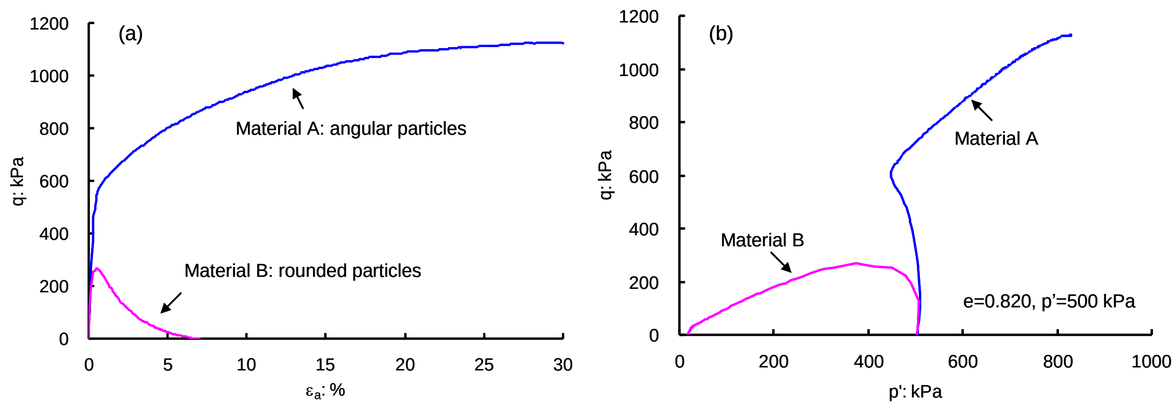

Figure 1. Shear behavior of two materials with different grain shapes under the constant-volume condition in triaxial stress space: (a) deviatoric stress versus axial strain; (b) deviatoric stress versus mean normal stress

Acknowledgements

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Bifurcation of Flapping Flexible Filament in a uniform flow using IB-LBM

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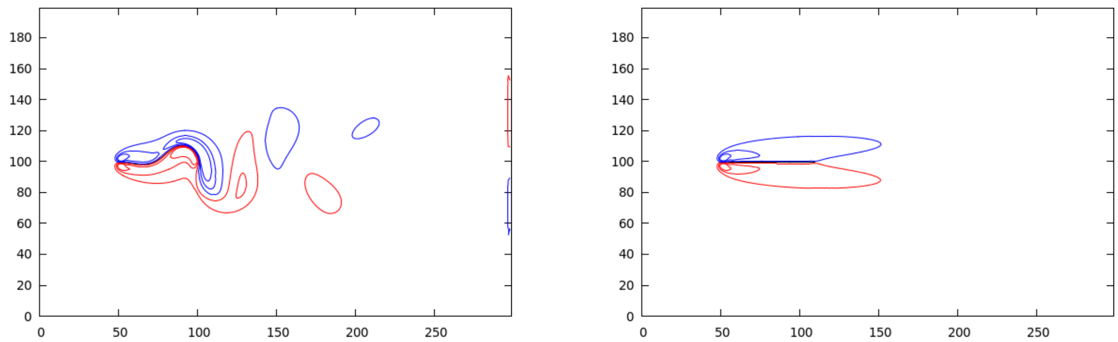
Flexible filament flapping in a flowing soap film is studied both by numerical and experimental analyse. A bifurcation to instability which is observed in experiment is investigated in this report. Numerical simulations show the bifurcation range, in which different initial states leads to either stretched-straight state or flapping state.

In this report, an in-compressible flexible filament which is described by its mass, bending rigidity is simulated using an improved IB-LBM. Numerical simulations on only stable finial state achieves comparable results with experiments and previous numerical simulations. Simulations on bifurcation to instability which is just influenced by different initial conditions show the bistable property of this system. While parameters of the system are out of this bifurcation range, either initial condition leads to only final state.



(a) (b)

Figure 1. Vorticity contours of flexible filament in uniform flow at … (a) Initial AoA = 30, (b) initial AoA = 1.

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Multiscale simulation of the mechanical behaviour of the irradiation swelling in nuclear fuel element

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Point defects such as vacancy, interstials and fission gas atoms are generated in nuclear fuels in the reactor. The diffusion and accumulation of the point defects could form microstructures such as voids and bubbles, and cause the irradiation swelling of the fuel elements. The swelling affects the evolution of the temperature and stress field in the fuel element. And the thermodynamic behaviour of the fuel element also has great influence on the swelling. In a multiscale simulation, the generation mechanism of the irradiation damage could be realized in the mesoscopic scale, while the mechanical effects could be calculated by using finite element methods.

An improved mechanistic fission gas model is developed with the main physical mechanisms in the Research and Test reactor fuels comprehensively taken into account. An analytical solution to the concerned fission gas model is solved out, and the effects of the key parameters in the theoretical model have been discussed. Besides, based on the modified Cahn-Hilliard equations, a Phase Field (PF) model with vacancy, interstitial and gas atom is developed. The evolution of the thermodynamic and dynamic process could be simulated by PF model, including the nucleation and growth of the voids and bubbles. The effects of the temperature, strength of the irradiation, etc. have been studied. This research has great significance in theory and practical value in engineering, and can lay the foundation for the thermodynamic behaviour of the test reactor fuel element in pile.

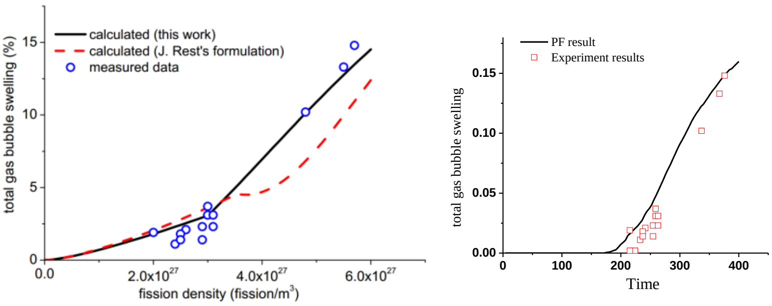

Figure 1. The evolution of the total bubble swelling.

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Wind tunnel experiments for flow and pollutant dispersion in turbulent boundary layer over urban areas

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Wind flow and pollutant transport in the atmospheric boundary layer (ABL) over urban areas are strongly affected by the dense buildings at land surface. Characterising the flow structure and pollutant plume dispersion over different urban morphology is important because it elucidates the mechanism of shear-induced turbulent pollutant transport processes. Series of wind tunnel experiments were performed in this study to investigate the flow and pollutant dispersion over two-dimensional idealised street canyons with different aspect ratios (building-height-to-street-width). Streamwise and wall-normal velocities were obtained by using hot-wire anemometry (HWA) with *X*-probe design. Simultaneously, using moisture as a passive scalar, the concentration profiles were measured after a line source emission from ground surface. Vertical profiles of mean wind, turbulence and scalar concentration were analysed in attempt to develop practical parameterizations for the flow and dispersion. Future work will be focused on the measurement of flows and scalar distribution over reduced-scale urban morphology models fabricated by 3D printing technique.

Study of Chemically Reactive Pollutant Transport over Urban Roughness in the Atmospheric Boundary Layer

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Elevated pollutant concentrations are commonly observed in urban areas, such as street canyons, threatening human health. While practical dispersion models commonly assume inert pollutants, most emissions from traffic exhaust are chemically reactive. Reactive flue gases, including nitrogen oxides (NO_x), are important pollutants that would cause a series of public health problems. There is thus a need for improved understanding of the dynamics of chemically reactive pollutants. In this study, turbulent dispersion of reactive pollutants in the atmospheric boundary layer (ABL) over hypothetical urban areas is numerically investigated using large-eddy simulation (LES). Their transport behavior in and over idealized street canyons of unity aspect ratio in isothermal conditions is examined. In pseudo-steady state, fully developed turbulent flows, nitric oxide (NO) is emitted from the ground surface in the first street canyon into the urban ABL doped with background ozone (O_3). By looking into the pollutant concentrations and dispersion characteristics over the urban canopy layer, it is realized that, apart from pollutant removal, ABL turbulence plays an important role in the mixing of chemicals, which substantially affects the reaction rates of chemical kinetics. Six different scenarios with different background O_3 concentration (1 ppb, 10 ppb, 50 ppb, 100 ppb, 500 ppb and 1,000 ppb) are studied. To contrast the effect of chemistry and dispersion, the time scales of reaction and diffusion of pollutants are compared by switching on and off the NO_x-O_3 chemistry component in the LES. The plume characteristics and time scales in different cases will be discussed.

Study of Dynamic Stall Behaviours of a Straight-Bladed Vertical Axis Wind Turbine by Large Eddy Simulations

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The operation of a straight-bladed vertical axis wind turbine (VAWT) is characterized by dynamic stall behaviours to varying extents. As the VAWT rotates, the angle of attack (AOA, α) changes rapidly over a broad range in each revolution. This induces the strong vortex shedding from blades, and hence significant drops of lift forces. This phenomenon is called the dynamic stall which deeply affects the aerodynamic performance of the VAWT. In this work, a full-scale three-dimensional large eddy simulation (LES) model was constructed to examine the dynamic stall behaviours of a straight-bladed VAWT. The LES model was validated by the wind tunnel test data. The LES model offers fascinating insights into and improves the understanding of the dynamic stall behaviours.

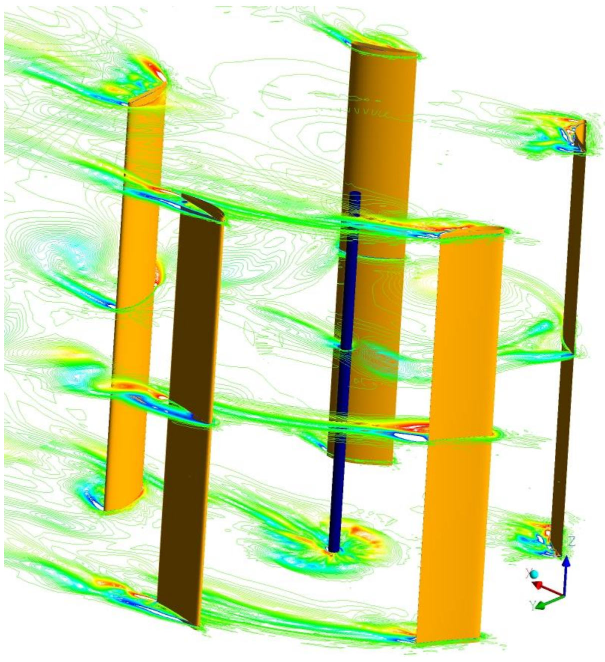

Figure 1. Flow fields in the vicinity of the VAWT.

Acknowledgements

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Numerical and Experimental Investigation on the Support Interference of Civil Transport Aircraft in Low Speed Pressurized Wind Tunnel

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Abstract: The support interference test of a civil transport aircraft model in a low speed wind tunnel is modelled by numerical wind tunnel technique. As the aircraft model is reversely mounted by a dorsal support, the aerodynamic forces are calculated with and without the fake abdominal support. Since this calculation is based on the real support interference wind tunnel test with the consideration of wall interference, the aerodynamic forces and derived interference agree well with the test results. Calculated pressure distribution and forces indicate the blockage effect from abdominal support and the separation effect in the support's wake region are the main reason why C_L and C_D with abdominal support are greater than those without the support. The increment of C_L and C_D mainly occurs on wing and fuselage. The positive pressure field ahead of the abdominal support and the negative pressure field behind the support both lead to that C_m increases mainly on fuselage and horizontal tail. This study provides fundamental for the subsequent study on the support interference for civil transport aircraft in low speed wind tunnel.

Key words: support interference; civil transport aircraft; numerical wind tunnel; low speed wind tunnel

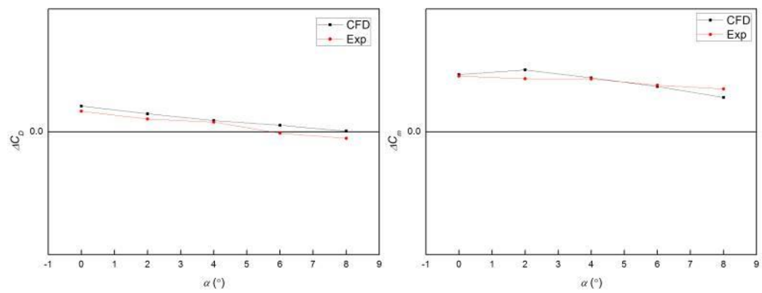

Figure 1. support interference of calculated and test results

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Numerical Study of Reynolds Number Effect on Supercritical Wing Aerodynamic Load

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The base aerodynamic data for the load simulation comes from wind tunnel data. The Reynolds number in wind tunnel is largely less than the one of full-scale flight because of the wind tunnel condition limitation.

The supercritical airfoils are applied in the current aircraft wing design. A significant research effort has been emphasized on its improvement. The superior performance enables its widely application to some civil aircrafts, such as A320, A330, A380, B777, and B787 and so on. Supercritical airfoils are characterized by their flatted upper surface (suction side surface), highly cambered aft section, and greater leading edge radius compared with conventional airfoil shapes. Flows about supercritical airfoil are shown to be particularly sensitive to viscosity. The shock location and strength and the interfere of shock and boundary layer are directly affected by the difference of Reynolds number resulting in the variety of load distribution and aerodynamics coefficient, ultimately the load distribution between wing and empennage vary greatly.

The load distribution difference is from the absence of study for Reynolds number effect in the C-141 design resulting in the aircraft’s newly design. The reason for this newly design is the great difference between wind tunnel Reynolds number and full-scale flight Reynolds number.

The aerodynamics connection between wind tunnel Reynolds number and true flying Reynolds number is studied by CFD avoiding load simulation error from wind tunnel data, and then acquire load distribution and aerodynamics coefficient in full-scale flight.

平尾偏度对民机纵向力矩特性影响的研究

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民用飞机纵向力矩特性关系到民用飞机的失速试飞评估。本文通过风洞试验研究不同的平尾偏度对纵向力矩特性的影响。结果表明，当飞机在后重心配平时相应平尾正偏度，纵向力矩上仰幅度增加，纵向力矩特性变差。相反，当飞机在前重心配平相应平尾负偏度，纵向力矩特上仰幅度减小直至不上仰，纵向力矩特性改善。通过长丝线试验及理论分析表明，平尾偏转会改变当地洗流方向，而当地攻角的变化反过来又会改变平尾对力矩的贡献。当平尾负偏度时，平尾在其上游产生下洗，该下洗流和机翼在平尾处的洗流综合作用推迟了机翼尾流达到平尾区的攻角，从而改善了飞机的失速特性。

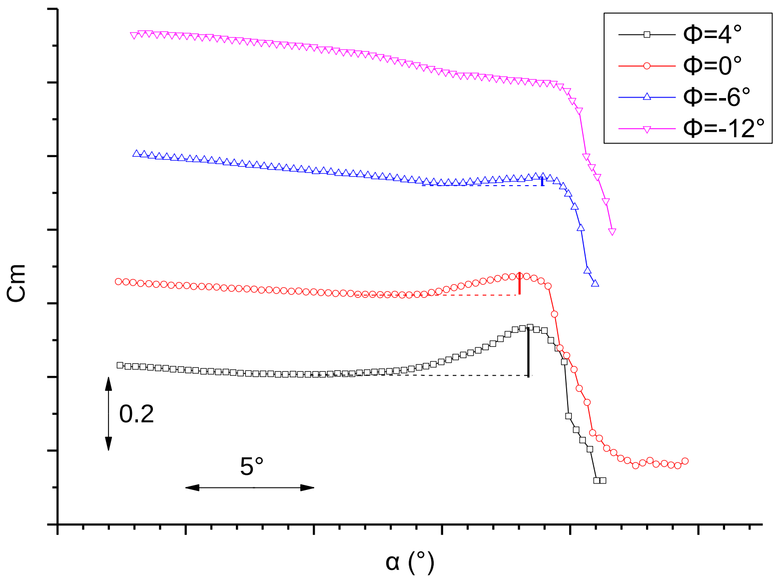

图 1. 平尾偏度对纵向力矩特性的影响.

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半模垫板高度模拟对失速特性的影响研究

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半模通常采用附面层垫板使得模型远离风洞壁面来减小洞壁对模型的干扰。本文研究了在 4.5m 量级风洞中不同垫板高度对失速特性的影响。结果表明，随着垫板高度的增加，线性段升力系数增加，垫板高度在 80mm（h/δ=0.57, δ为试验段核心区边界层名义厚度）时失速攻角与全模较为接近，失速提前约 1°；垫板高度在 60mm（h/δ=0.43)时失速提前较早，失速提前近 3°。垫板高度的增加使得机身远离壁面的影响，但同时垫板突出边界层的高度增加，这使得垫板对机身及内翼的不利干扰增加，而内翼对升力贡献最大，这种不利影响使得内翼分离提前，失速较早。

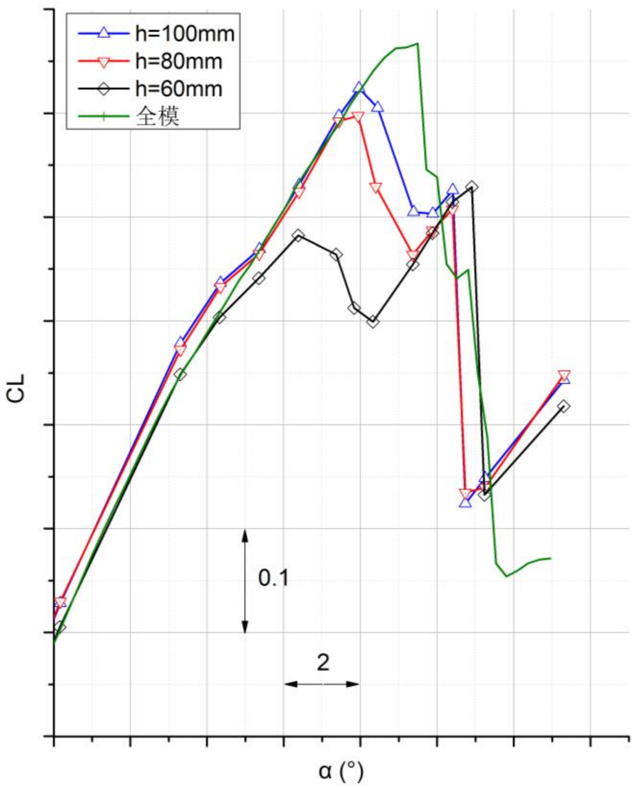

图 1. 不同垫板高度对失速的影响

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Molecular Dynamics Simulation of Passive Fluidic Diode for Simple Fluids

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Through molecular dynamics simulations, we numerically demonstrate a nested nanochannel structure to work as a fluidic diode, which accepts water flows in the forward direction and blocks flows in the backward direction in a wide range of pressure drops. The flow rectification effects are caused by direction dependent activation pressures due to different flow mechanisms in the forward and backward directions. In the forward direction, the activation pressure is small, which is determined by the infiltration pressure of the inner channel. In the backward direction, the activation pressure is quite large due to the capillary effects when flows are released from the inner to outer channel. The pressure drop range for the fluidic diode can be flexibly adjusted for practical applications by modifying the channel size or surface wettability. The fluidic diode offers a novel way for flow control in integrated micro- and nanofluidic devices.

A Simple Relation for Nanodroplet Diffusion on Supported Graphene

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The dynamics of droplets on surfaces is of great importance in various areas, including the thermal management of micro-electronic devices, fabrication of self-cleaning surfaces, nanomaterial synthesis, and the design of miniaturized chemical reactors. Even though some recent studies report that nanodroplets can diffuse fast on vibrating surfaces such as graphene[1] and carbon nanotube[2], the mechanism of nanodroplets diffusion remains elusive, even on smooth flat surfaces. In this work, we study how nanodroplets diffuse on supported graphene surface through molecular dynamics (MD) simulations and theoretical analysis. The atomic simulations show that the dependence of nanodroplet diffusion coefficient on temperature undergoes a linear to nonlinear transition as the surface wettability is weaken. This is due to the coupling of surface energy and temperature and the phenomenon is specific for nanodroplet diffusion. Meanwhile, a simple relation for nanodroplet diffusion is developed by using contact angle and contact radius of the droplet, which works well for different surfaces wettabilities with different droplet sizes. The relation is verified by MD simulations.

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Electric Field Enhancement of 3D Nano-spikes Devices for Energy Efficient Biological Manipulations

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Energy efficient biological manipulations i.e., electroporation (EP), cell lysis (CL) is highly desirable in portable lab-on-a-chip, micro total analysis systems, and smartphone based systems due to power limitations. We employed highly periodic 3D nano-spikes (NSPs) for electric field enhancement due to their high aspect-ratio (λ). The enhance electric field E_{nsp} was defined by enhancement factor α which depend onλ. 3D nano-spikes were fabricated with controllable dimensions i.e., length L_{ns}, base radius R_{ns} by using scalable and cost-effective electrochemical anodization and etching processes (Fig. 1). Numerical simulations were performed for electric field distribution at NSPs using a commercial finite element method (FEM) package (COMSOL Multiphysics 4.2, COMSOL Ltd., USA). The NSP electrode was separated from counter electrode by distance d and cell suspension medium was considered between electrodes with relative permittivity and conductivity of 77.4 ± 5% and 1.7 S/m ± 10%, respectively. The boundary condition was fixed potential which was applied between electrodes. Simulation results indicate that applied electric field E_a was enhanced especially near the tip of NSPs and α can be determined by E_{ns}/E_a (Fig. 1). α was estimated in the range of ~5.9 to 8.9 for NSPs with λ of 2 to 3 respectively (Fig. 1). Efficient EP and CL were conducted on 3D nano-spike devices at energy (0.5-2 mJ/mL) which is 2 to 3 order of magnitude lower than traditional systems [1,2].

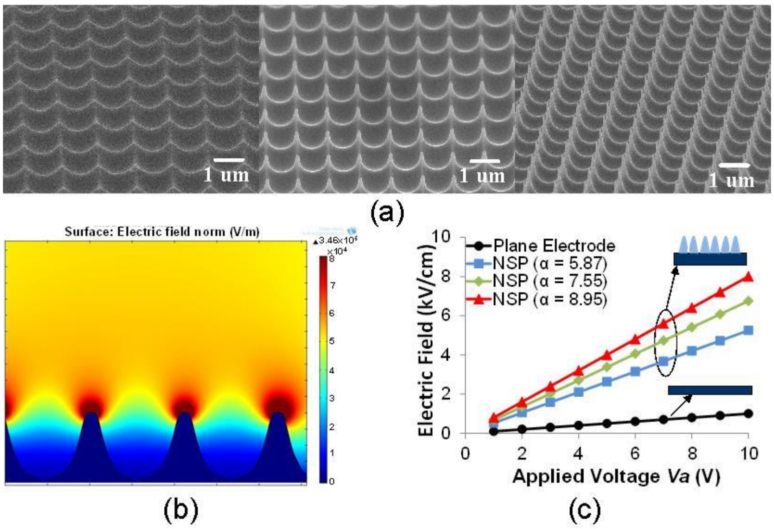

Figure 1. (a) SEM micrograph of 3D nano-spikes (NSPs) with different lengths, (b) numerical simulation of electric field distribution due to nano-spikes using COMSOL at applied voltage V_a = 4V, and (c) electric field as function of applied voltages for nano-spikes with different α and plane electrode without nano-spikes.

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A Simplified Model for the Column-Supported Embankment System

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Column–supported embankment is usually constructed on weak foundation in order to reduce total settlement and accelerate construction process. In this study, a simplified model is carried out to study the load transfer mechanism for this kind of embankment. To evaluate the differential settlement between the column and the surrounding soil, a shape function is used to simulate the deformation of the column-reinforced foundation. As the differential settlement would stimulate the movement of embankment fill, an inner cylinder above the column and a hollow cylinder above the surrounding soil are assumed to model the embankment fill. Soil volume continuity and stress continuity are considered between the embankment fill and column reinforced soft foundation. The feasibility of the proposed method is verified by comparing the results with a two-dimensional finite element model. Some factors influencing the behaviour of column-supported embankment are investigated. When the modulus ratio between the column (E_c) and surrounding soil (E_s) becomes larger, the stress ratio between the column (σ_c) and surrounding soil (σ_s) will increase (Figure 1). Similar tendency is found with an increasing ratio between the column spacing (d_o) and diameter (d_i). By capturing the main features of the column-supported embankment, the proposed model provides reliable predictions which can be recommended to engineers.

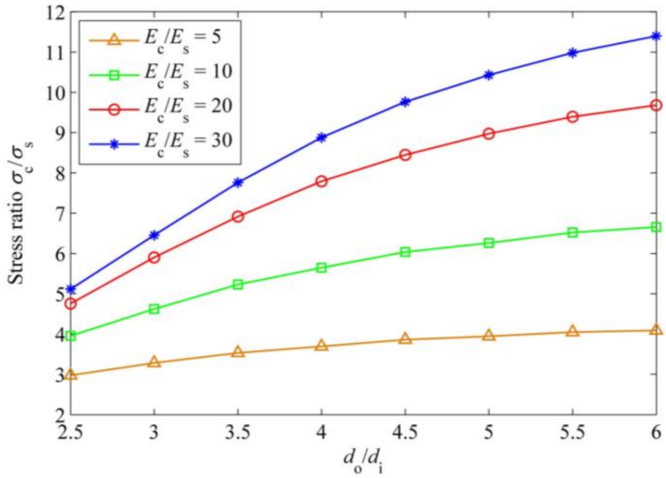

Figure 1. Stress ratio, σ_c/σ_s, versus the ratio of d_o/d_i with different modulus ratio, E_c/E_s.

Acknowledgements

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Liquefaction and Extensive Viscous Flow in Metallic Glass at Room Temperature

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The common notion suggests that the plastic deformation of bulk metallic glass (BMG) at room temperature is localized in narrow shear bands, which eventually results in a catastrophic failure. In contrast, we found that the extensive viscous flow can occur with shear bands, which suggests Zr-base BMG can liquefy during the nanoindentation tests at room temperature. The apparent moduli noticeably decrease with the amount of plastic deformation. Then, a physical model is constructed to describe this liquefaction process. Modulus mapping images and atomic force microscopy (AFM) topographic images also provide the evidence that shear banding is suppressed and insufficient to accommodate the applied plastic strain, due to a tensile stress field under the indentation. Therefore, extensive viscous flow simultaneously take places as another plastic deformation mechanism in confined stain condition. Promisingly, the liquefaction of BMG at room temperature provides possibilities for low temperature forming and promotes the application prospects of BMG.

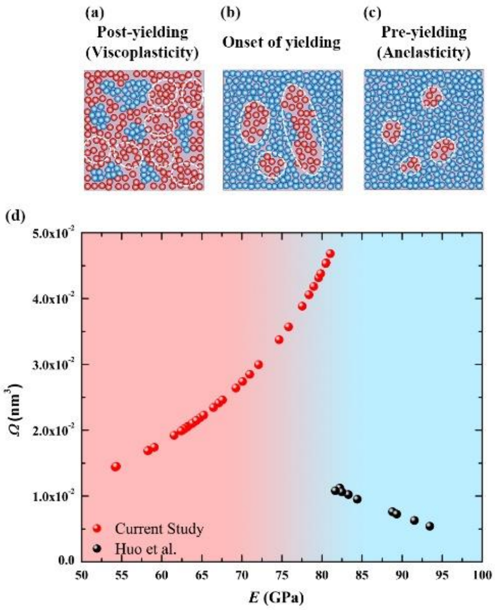

Figure 1. Schematic illustration of the structural evolution. The red or blue pellets represent the atoms in liquid or solid-like region. (a) Post-yielding; (b) Onset of yielding; (c) Pre-yielding; (d) Change of activation volume

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MEASURING THE VISCOELASTIC AND ADHESION PROPERTIES OF NEURITE BY FORCED PEELING

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The neuron-extracellular matrix (ECM) and neuron-neuron adhesion have been widely reported to be essential for processes like neurite outgrowth and the formation of synapses. However, measuring the interactions between neurons and their micro-environment has always been challenging. In this study, a novel method based on AFM peeling test on well-developed neurite was proposed to investigate the viscoelastic and adhesion properties of neural cells. To extract quantities of key interest from experimental data, a computational model was developed where the neurite is treated as a standard linear viscoelastic solid while a cohesive law between the cell and the substrate is introduced to represent their attractive interactions. These descriptions were then implemented in the quasi-static implicit finite element method. Our simulations suggested that the instantaneous and long-time moduli of neurite should be around 7.5 kpa and 2.8 kpa, respectively, with a characteristic time ~2s. In addition, the adhesion energy of the neurite-ECM interface is estimated to be of the order of 0.07 mJ/m^2. The validity of these results were further tested and verified by a series of relaxation tests conducted after peeling the neurite with different rates.

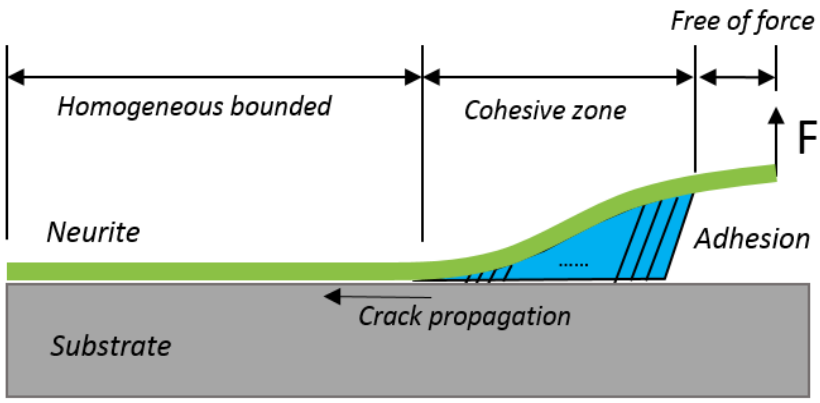

Figure 1. Forced peeling of the neurite

Acknowledgements

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Effects of Flowing Red Blood Cells on Adhesion of a Rolling Circulating Tumor Cell in Microvessels

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Circulating tumor cells (CTCs) adhesion to microvessels largely depends on the hydrodynamic conditions (Haier and Nicolson), one of correlating significant factors is the blood viscosity. Since blood is a non-Newtonian fluid and its viscosity increases with hematocrit significantly at low shear rates. Limited information has been reported on the interaction between CTCs and red blood cells (RBCs), but some similarities with the interactions of leukocytes and RBCs can be found. Existing experimental and numerical studies have shown that leukocyte margination and adhesion are pronounced within an intermediate hematocrit range values of Ht ≈0.1-0.3 (Abbitt and Nash; Fedosov and Gompper) and the margination of tumor cell depends on its deformability (King et al.) and its relative size to the vessel (Takeishi et al.).

In this study, the effects of tumor cell deformability, hematocrit, and red blood cells aggregation as well as the vessel size on adhesion of a rolling circulating tumor cell in a capillary were numerically investigated using dissipative particle dynamics. The membrane of cells was represented by a spring-based network connected by elastic springs to characterize its deformation. Red blood cell aggregation was modelled by a Morse potential function based on depletion-mediated assumption represented by Liu et al. Adhesion of cells to vessel wall surface is mediated by the interactions between receptors and ligands which are the adhesion sites distributed on a cell and a surface, respectively. The probabilistic model developed by Hammer and Apte was employed to describe cell attachment, rolling and adhesion.

The results demonstrated that at lower hematocrit (Ht=0.1, 0.2), the rolling tumor cell might be pulled off the vessel by the intercellular interactions, as shown in Figure 1(a). This is due to the particulate nature of blood, the tumor cell has a lower collision frequency with red blood cells. However, at Ht=0.3, the tendency of RBCs migrating towards the vessel center inhibits detachment of CTC from the vessel wall (Figure 1(b)). Instead, the CTC maintains to roll along the wall, resulting in a larger number of receptor-ligand bonds formed on the cell surface compared with the cases of Ht =0.1 and Ht =0.2, as shown in Figure 1(c). In addition, it seems that at the low flow rate, increasing the tumor cell deformability does not apparently affect its adhesion and rolling velocity. But, decreasing the Young's modulus by 10 times enable the CTC deform significantly, leading to a large fluctuation in the number of bonds. At same hematocrit, the CTC has a higher rolling velocity in a smaller vessel due to the Fahraeus-Lindqvist. Moreover, enhanced red blood cell aggregation has been found to cause margination of leukocyte and further initiate attachment to the vessel (Abbitt and Nash; Pearson and Lipowsky; Nash et al.), which is expected for the circulating tumor cells. By comparing the flows of a rolling CTC in the blood stream with and without red blood cell aggregation, the findings showed that the rolling velocity of tumor cell decreases largely in the case with red cell aggregation.

(a) (b) (c)

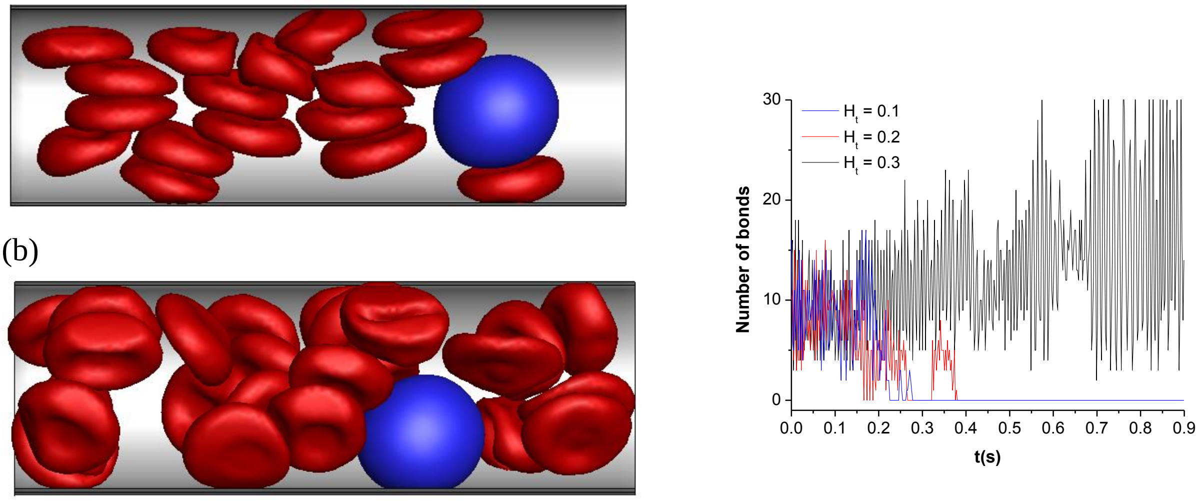

Figure 1. Simulation snapshots of RBCs (red) and a circulating tumor cell (blue) at $H_t = 0.2$ (a) and $H_t = 0.3$(b); and the variation of number of receptor-ligand bonds formed on the surface of CTC at different hematocrits (c) in a vessel with diameter of 15μm.

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Personalized Micro-Elasto-Filtration (pMEF) Chips for Detecting Circulating Tumor Cells in Cancer Patients

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Personalized Micro-Elasto-Filtration (pMEF) chips for detecting circulating tumor cells (CTCs) in cancer patients is presented. Unlike the conventional size-based filtration methods, the difference of cell elasticity (also known as stiffness or deformability) between CTCs and normal blood cells is also effectively utilized in pMEF chips. An optimal value of Capillary number (*Ca*), which is the ratio between the viscous force and the cell's cortical tension σ, has been identified around 0.038 to enhance the capture efficiency of CTCs and depletion of leucocytes, in which $Ca = \mu V / \sigma$, where μ is the viscosity of the cell suspension, V is the flow velocity. Thus when applying microfiltration chips to detect CTCs in cancer patients, it is important to choose the optimal *Ca*. However, there exist large variations of blood viscosity among cancer patients. The blood viscosity of a patient may also be influenced by both cancer development and treatment. If we apply the same flow velocity to all cancer patients, the actual value of *Ca* will significantly deviate from the optimal value and result in a reduction of 20% or higher in the capture efficiency. Thus we propose pMEF chips based on the blood viscosity of individual cancer patient, in which a personalized filtration flow rate is determined by the measured blood viscosity and the optimal *Ca*. In a clinical testing in Sun Yat-sen University Cancer Center, Guangzhou, pMEF chips detected more than 1 CTC in 2 mL of blood sample from 9 out of 12 cancer patients, while FDA approved CellSearch® assay only detected CTCs from 4 in 11 cancer patients, as shown in Figure. 1.

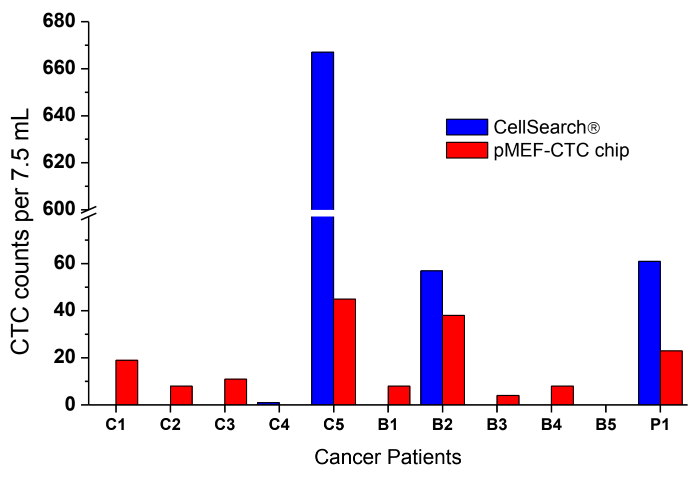

Figure 1. Comparison of CTC counts in pMEF-CTC chips (normalized to 7.5 mL of blood) and CellSearch® assay for 11 cancer patients.

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Numerical study of the correlation between skin blood flow oscillation and radial pulse at wrist

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There is evidence that microcirculation may mirror the vascular function of other parts of the body and the microvascular abnormalities may initiate the pathogenesis sequence in some diseases [1]. Moreover, the traditional Chinese physicians could decide the diagnosis entirely based on the radial pulse palpation at wrist. We argue that what the Chinese physicians palpated is actually the status of microcirculation. Thus, the thorough understanding of interaction between vasomotion related and cardiac activity related pressure waves would enable us to develop novel diagnostic technique. Therefore, the experimental and numerical studies are carried out to understand the interaction between vasomotion and cardiac rhythm in radial artery at wrist, which is an attractive fluid-structure interaction research topic in itself.

A numerical study is conducted using CFD solver ANSYS Workbench and CFX. The fluid-structure interaction is solved using FSI technique. The different pressure pulses and flow rates are studied. In the study, the high frequency pressure pulse follows the blood flow representing the pulse from heart beating, and the low frequency pressure pulse travels back from downstream to upstream representing the vasomotion. The resulted pulse pattern from the upstream and downstream is shown in Figure 1, which is consistent with the measured pulse pattern at wrist Figure 2.

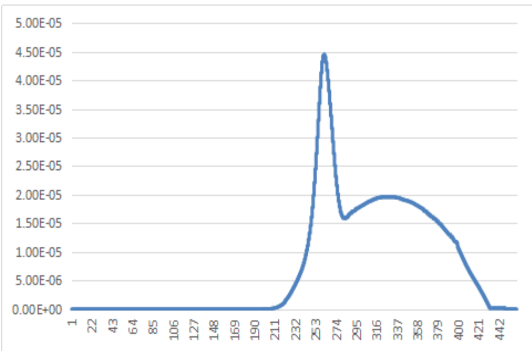

Figure1. Total mesh displacement at moniter1

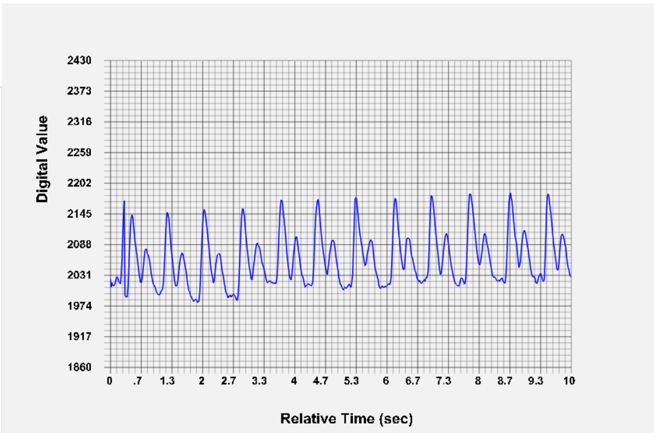

Figure2. Measured pulse pattern at wrist

Acknowledgement

Supports given by the Research Grants Council of the Government of the HKSAR under grant No.PolyU 5202/13E and the Hong Kong Polytechnic University under grant No. G-YL41 are gratefully acknowledged .

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Modeling Cellular Blebbing with Boundary Integral Method

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Although cell blebbing has been widely observed in important processes like cell locomotion, cytokinesis and apoptosis, how such phenomenon actually take places remains unclear. Here we simulate the blebbing process by tracking the movement of the cell membrane in a viscous medium with a boundary integral method. A cohesive law is also introduced to capture the gradual detachment between the lipid bilayer and the cortex during the growth of the bleb. We will show how factors such as the cortex tension, bending rigidity and area expansion modulus of the membrane influence the size, shape and growing speed of blebs. Comparison between simulation results and various experimental findings, obtained by us or reported in the literature, will also be presented.

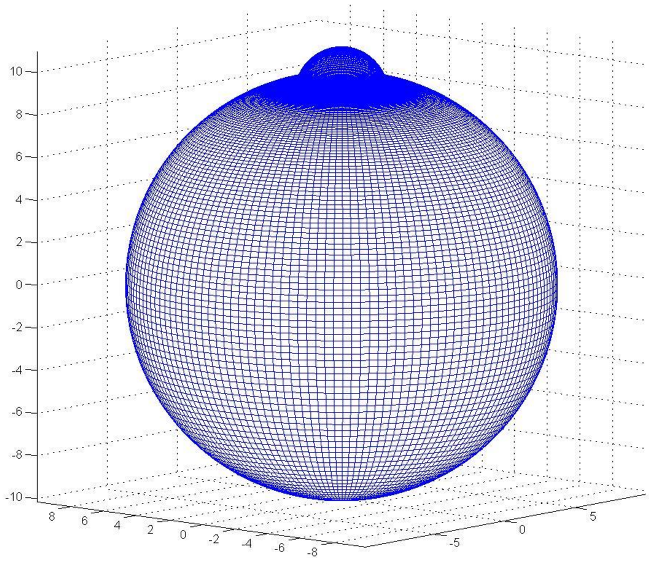

Figure 1. The 3D simulation result of cell blebbing.

Acknowledgements

The work was supported by grants from the Research Grants Council (Project No. HKU 17205114 and HKU 714713E) of the Hong Kong Special Administration Region as well as a seed fund (Project No. 201311159128) from The University of Hong Kong.

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Numerical studies on the elastomechanical characteristics of human erythrocyte membrane

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With the rapid increase in the number of deaths worldwide due to blood related diseases such as malaria, sickle cell anaemia, Zika fever and so on, the importance of better understanding of human erythrocyte membrane properties and behaviour cannot be overemphasized since the development and progression of these infectious diseases is closely related to the state of the membrane. In this paper, the elastic and mechanical properties of human erythrocyte or red blood cell (RBC) membrane as well as its large deformation behaviour are studied using an atomistic-continuum hyperelastic constitutive relationship that directly incorporates the microstructure of the spectrin network.

The coarse-grained Helmholtz free energy model is used to derive the strain energy density function, after which energy in the representative microstructure is minimized using the Newton's method and the elastomechanical properties of the membrane are computed. Furthermore, the large deformation behaviour of the human erythrocyte membrane was investigated using a three-dimensional (3D) improved moving least-square (IMLS) Ritz meshfree method by simulating the optical tweezer experiment. The results obtained from this study provide new insights about the RBC membrane's elastomechanical properties and large deformation behaviour.

Acknowledgements

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Spectral Analysis for Vasomotion under the Skin Blood Flow Oscillation and radial pulse at wrist

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The vasomotion under the skin mirrors the human health situation, and the frequency range of vasomotion is 0.0095-0.02, 0.02-0.06, 0.06-0.15, 0.15-0.4 and 0.4-1.6 Hz, which is influenced by the endothelial, neurogenic, myogenic, breathing, and cardiac activity, respectively (1). Moreover, the traditional Chinese physicians could decide the diagnosis entirely based on the radial pulse palpation at wrist. We argue that what the Chinese physicians palpated is actually the status of microcirculation. This study carried out LDA measurement to investigate the spectral coherence between radial pulse and vasomotion at acupoint or non-acupoint. In order to obtain these low frequency data, each experiment would be sustained around 20 mins. The time series of flowmotion is analyzed using wavelet analysis, coherence analysis and FFT (as shown in Figure 1). The results suggested that the vasomotion in microcirculation is interrelated with the wrist pulse.

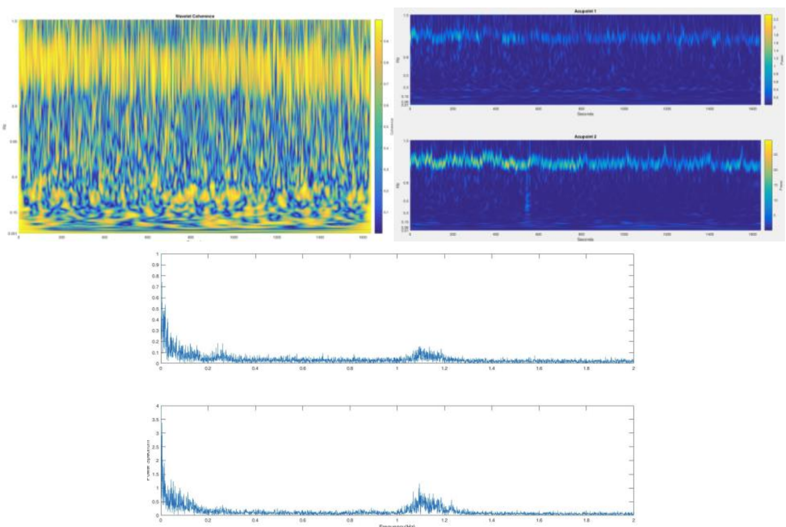

Figure 1. Three Method(coherence, wavelet and FFT analysis)

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Ambient Test and Numerical Modeling of a Metal Roofing System

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Abstract

The standing seam metal roofing system has over years proven to be an excellent combination of economic, aesthetics and high performance structural system. Therefore, it is widely applied in public facilities (e.g., airport terminal and ferry station). Most recent metal roofing related research works focus on analyzing the static or quasi-static behavior of the system. To accumulate valuable knowledge about the dynamic characteristics of the system, an in-door test panel was built and a series of ambient vibration tests were conducted. The vibration data were analyzed using a fast Bayesian FFT method. The first two identified modes are shown in Figure 1. To quantifying the stiffness contributions to the dynamic properties from various components of the metal roofing system, a numerical model of the steel frame supported metal roofing system was built. Seam-clip-purlin joint and seam joints are two most important components of a standing seam metal roof system and they are modeled as equivalent springs The ambient test and modeling results in this research can provide the industry a better understanding of the dynamic behavior of metal roofing system and will also contribute in the improvement in the design and construction of this type of structures in the future.

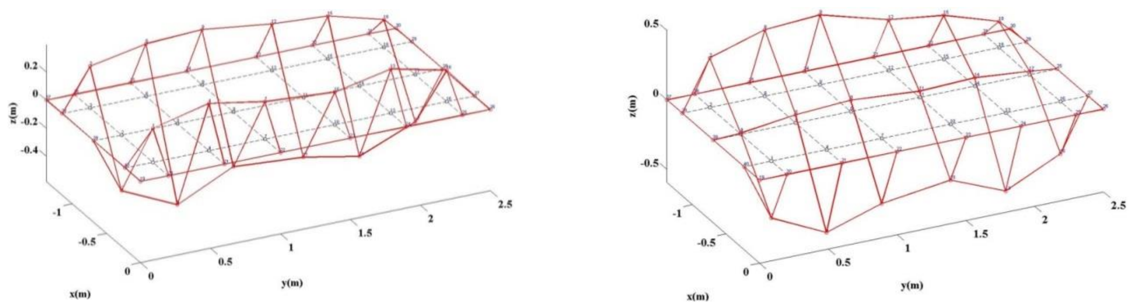

Figure 1: (Left) Identified first mode (19.42Hz, 0.67%), (Right) Identified second mode (22.30Hz, 0.52%).

Acknowledgements

The work described in this paper was fully supported by a grant from the Research Grants Council of the Hong Kong Special Administrative Region, China [Project No. CityU 114712 (9041770)].

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Behaviour Of Normal And Lightweight Reinforced Concrete Tensile Members Subjected To Sustained Loading

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A very limited number of studies have been devoted to the investigation of tension stiffening for the case of long-term loading (*Bacinskas et al. 2012*). Furthermore, long-term tension stiffening of lightweight RC members has not been investigated on the whole. Current study compares the decay of long-term degradation of tensile stiffening in normal and lightweight RC ties. Experimental tests were made in the Laboratory of Reinforced Concrete and Masonry Structures at Vilnius Gediminas Technical University, Lithuania. Eight geometrically similar RC tensile members have been tested under sustained loading with load duration of 100 days. Four RC members were cast using normal concrete and four with lightweight concrete. Ties were 1500 mm long with 100×100 mm nominal cross-section. Each member was reinforced with a single 12 mm diameter steel bar. Four test frames based on a double lever system were designed to sustain the applied load for these long-term experiments. The test rigs applied load using a weight and double lever system achieved a 16:1 load ratio – each 5 kg weight applied a force of 0.8 kN to the test specimen (*Gudonis et al. 2012*). Applying 0.001 mm mechanical gauges, reinforcement strains were measured along the 1520 mm gauge length. Deformation response of ties was assessed using the force and strain measurements. The experiments reveal that the early-age degradation of the tension-stiffening effect under sustained loading may reach 40-80% of the observed value (*Gudonis et al. 2012*) at the end of loading for normal concrete and 70-90% for lightweight concrete, respectively. The predicted decay of long-term tension stiffening has occurred instantly after the load sustaining. Such reduction might be considered as a supreme value since further deformation increment (due to concrete creep and shrinkage effects) was found insignificant. It has been shown that the influence of shrinkage effect prior to external loading is much more significant for lightweight RC members in comparison to ordinary RC ties.

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Mechanical properties of CoCrCuFeNi high-entropy alloy micro/nanopillars

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Here we report our group's recent studies on the mechanical behavior and deformation mechanisms of high entropy alloys (HEAs) at micro and nanoscales. High entropy alloys (HEAs) are among the most promising new materials with unmatched mechanical properties, such as high strength and hardness, outstanding wear resistance, exceptional high-temperature strength, good structural stability, good irradiation resistance, good corrosion and oxidation resistance. The microstructural features and micromechanical behavior of face centre cubic CoCrCuFeNi high-entropy alloy (HEA) were characterized and tested by in situ method using high-resolution scanning electron microscopy and micro/nano-compression tests. The face centre cubic high-entropy alloy CoCrCuFeNi is evolving multi-component intermetallic systems, wherein multiple principal elements tend to form single solid-solution-like phases with a strong tendency to solid solution strengthening. Single-crystalline HEA micro/nanopillars in the same orientations were produced by ion beam lithography and compressed using a flat-punch tip in a nanoindenter. By *in situ* SEM nanoindenter compression tests of micro-fabricated pillar samples (diameter ranging from 400nm to 2500nm), we found that the mechanical strengths of face center cubic CoCrCuFeNi high-entropy alloy micro- and nano-structures are less sensitive to their respective diameters, unlike those reported metals and alloys. The correlation between normalized strengths, length scales and temperatures for face centre cubic-structured pillars is illustrated, and the relevance of a size-effect slope as well as the additivity of strengthening mechanisms is critically discussed.

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Digital Micromirror Device (DMD)-Based *in situ* Nano-Fatigue Characterizations of 1-D Nanostructures

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Fatigue behavior of nanomaterials could ultimately limit their applications in variable nano-devices and flexible nanoelectronics. However, very few existing nanoscale mechanical testing instruments were designed for dedicated fatigue experiments, especially for the challenging high cyclic loading. In this work, a novel high-cycle tensile test micromachine, based on the digital micromirror device (DMD), has been developed for the tensile fatigue study on various one-dimensional (1D) nanostructures, such as metallic and semiconductor nanowires. Due to the small footprint of the DMD chip itself and its cable-remote controlling mechanisms, it can be further used for the desired *in situ* testing under high-resolution optical or electron microscopes (e.g., SEM), which allows real-time monitoring of the fatigue testing status and construction of useful structure-property relationships for the nanomaterials. Because of the commercial availability of the DMD and millions of micromirrors available on a single chip, this platform could offer a low-cost and high-throughput nanomechanical solution for the research of high-cycle fatigue behavior of 1D nanostructures.

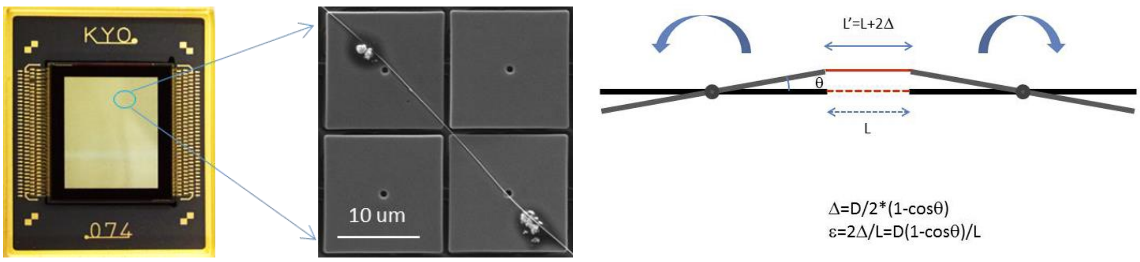

Figure 1. A silver nanowire clamped on the micormirrors of DMD for high-cycle tensile testing

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