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IYCBSE 2021

The International Youth Conference of Bionic Science and Engineering 2021

July 17–18, 2021 | China

PROGRAM

Welcome

Welcome to The International Youth Conference of Bionic Science and Engineering Conference 2021 (IYCBSE2021).

The IYCBSE2021 aims to bring together the world's young researchers and leading scientists to discuss the cutting-edge developments in the vigorous field of bionics. This conference will cover the basic science underpinning bionic systems as well as the applied research in a myriad of exciting areas, and stimulate discussions and exchange of ideas to better translate nature's inspiration to address grand challenges facing us.

This conference is hosted by the Youth Commission of the International Society of Bionic Engineering, City University of Hong Kong, Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences, Jilin University and Hubei University.

In light of the COVID-19 pandemic, the IYCBSE 2021 now fully goes virtual to be taken place from 17-18 July 2021 all online for the safety of all the delegates. We are fully committed to creating an excellent virtual conference - an online space to meet, network, and exchange knowledge in a safe and accessible manner.

We would like to express our sincerest gratitude to all the authors who submitted papers. Their high-quality work serves as the foundation for the success of this conference. The conference arranges presentation of accepted papers in parallel sessions with 7 plenary, 23 keynote, and 79 invited talks, plus 29 oral and 24 e-poster presentations.

In addition, the organizing committee will collectively nominate, based on the quality of paper submissions and presentations, the Best Oral Presentations and the Best Conference Poster Award, which will be awarded with E-certificates.

We gratefully acknowledge all the sponsors and benefactors for their contributions to this conference. In closing, we hope you will enjoy the technical presentations, online networking, and all the interactive features of the online platforms of the IYCBSE2021.

Conference Chair

Zuankai Wang
City University of Hong Kong

Zhihui Zhang
Jilin University

Conference Co-Chair

Zhiguang Guo
Hubei University

Zhihui Qian
Jilin University

Xuemin Du
Shenzhen Institute of Advanced Technology, CAS

Contents

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Registration Information

Including access to all live streaming talks and e-poster sessions.

Early Student/Late Student (Until June 30th)	1500/1800 RMB
Early Non-Student/Late Non-Student	2200/2800 RMB
On-line student registration (Only access to plenary talks and Session 6)	300 RMB

Refund Policy

The 2/3 of registration fee will be refunded for the student delegates, the registration fee for the non-student delegates will be not refunded.

Conference Secretariat

Dr. Qilong Zhao
Email: ql.zhao@siat.ac.cn
Phone: +86-15118817930
Address: 1068 Xueyuan Avenue, Shenzhen University Town, Shenzhen 518055, China

Mr. Ke Li
Email: Ke.li@siat.ac.cn
Phone: +86-18643064151
Address: 1068 Xueyuan Avenue, Shenzhen University Town, Shenzhen 518055, China

General Information

Conference Format

This conference will fully go virtual to be taken place from 17-18 July 2021 all online. The IYCBSE 2021 Virtual will include live streaming talks and e-poster sessions, all on an online space to enable all attendees to share, network and interact safely and easily amid the global COVID-19 pandemic.

Brief User Guideline to Online Meeting

Please download and install the software of the online conference system in advance from the website of https://zoom.us/client/latest/ZoomInstaller.exe. Entering the conference using the meeting ID and password (they will be provided prior to the conference by email). The name for entering the conference must be set as the style of "Affiliation + Name". During oral presentations, please make sure that the microphone is on, then playing the Power Point Slides and sharing the screen. After oral presentations, please shut to share the screen. We strongly encourage to test the system in the TEST sessions to be arranged prior to the formal sessions.

Presentation Specifications

Duration for each category of presentation is listed below:

- Plenary Talks are scheduled for 30 minutes (including 5 minutes Q & A) each.
- Keynote Talks are scheduled for 20 minutes (including 5 minutes Q & A) each.
- Invited Talks are scheduled for 15 minutes (including 3 minutes Q & A) each.
- Oral presentations are schedule for 10 minutes (including 2 min Q & A) each.

Language: English/Chinese

e-Poster Specifications

Poster Size: wide to high ratio of 3:4, recommended size: 90 cm (wide) x 120 cm (high)
Dimensions: minimal 300 DPI.

Morning 17 July, Saturday (Day 1)

	Main Venue (ID: 977 7442 2793)
	Opening Ceremony (08:30-09:00)
08:30-08:40	Way Kuo, *Academician of NAE, CAE and AS* *President of City University of Hong Kong* Chair: Zuankai Wang
08:40-08:45	Luquan Ren, *Academician of CAS* *Jilin University* Chair: Zuankai Wang
08:45-08:50	Hairong Zheng, *Professor* *Vice President of Shenzhen Institute of Advanced Technology, CAS* Chair: Xuemin Du
08:50-08:55	Peter Merker, *Doctor* *Chairman of China-Germany Economic and Cultural Exchange Association* Chair: Xuemin Du
08:55-09:00	Group photo Chair: Xuemin Du
	Plenary Talks (09:00-12:30)
09:00-09:30	Zhigang Suo, *Academician of NAE and NAS* *Harvard University* Chair: Zhihui Zhang
09:30-10:00	Zhenan Bao, *Academician of NAE and AAAS* *Stanford University* Chair: Zhihui Zhang
10:00-10:30	Han Ding, *Academician of CAS* *Huazhong University of Science and Technology* Chair: Zhihui Zhang
10:30-11:00	Lei Jiang, *Academician of CAS and NAE* *Technical Institute of Physics and Chemistry, CAS* Chair: Zhiguang Guo
11:00-11:30	Shuhong Yu, *Academician of CAS* *University of Science and Technology of China* Chair: Zhiguang Guo
11:30-12:00	Jian Lu, *Academician of NATF* *City University of Hong Kong* Chair: Zhiguang Guo
12:00-12:30	David Quéré, *Professor* *École Polytechnique* Chair: Zuankai Wang
12:30-13:30	Lunch break

IYCBSE 2021

Afternoon 17 July, Saturday (Day 1)

	Room I (ID: 994 2266 9485)	Room II (ID: 918 9284 7866)	Room III (ID: 926 8093 0537)	Room IV (ID: 925 7171 1971)
13:30-15:25	Session 1: Interfacial and transport phenomena - I	Session 2 Nature-inspired structural and functional materials - I	Session 3 Nature-inspired robots and flexible electronics - I	Session 6: Youth Forum of Guangdong-Hong Kong-Macao Greater Bay Area -I
15:25-15:30	Session break			
	Room I (ID: 994 2266 9485)	Room II (ID: 918 9284 7866)	Room III (ID: 926 8093 0537)	Room IV (ID: 925 7171 1971)
15:30-18:00	Session 1: Interfacial and transport phenomena - II	Session 2 Nature-inspired structural and functional materials - II	Session 5: Bionic implants, organs and systems -I	Session 4 Nature-inspired energy transport, storage, conversion and harvesting - I

18 July, Sunday (Day 2)

	Room I (ID: 994 2266 9485)	Room II (ID: 918 9284 7866)	Room III (ID: 926 8093 0537)	Room IV (ID: 925 7171 1971)
08:30-10:25	Session 1: Interfacial and transport phenomena - III	Session 2 Nature-inspired structural and functional materials - III	Session 3 Nature-inspired robots and flexible electronics - II	Session 6: Youth Forum of Guangdong-Hong Kong-Macao Greater Bay Area -III
10:25-10:30	Session break			
	Room I (ID: 994 2266 9485)	Room II (ID: 918 9284 7866)	Room III (ID: 926 8093 0537)	Room IV (ID: 925 7171 1971)
10:30-12:00	Session 1: Interfacial and transport phenomena - IV	Session 2 Nature-inspired structural and functional materials - IV	Session 5: Bionic implants, organs and systems -II	Session 6: Youth Forum of Guangdong-Hong Kong-Macao Greater Bay Area -III
12:15-13:30	Lunch break			
	Room I (ID: 994 2266 9485)	Room II (ID: 918 9284 7866)	Room III (ID: 926 8093 0537)	Room IV (ID: 925 7171 1971)
13:30-14:45	Session 4 Nature-inspired energy transport, storage, conversion and harvesting - II	Session 2 Nature-inspired structural and functional materials - V	Session 6: Youth Forum of Guangdong-Hong Kong-Macao Greater Bay Area - V	Session 6: Youth Forum of Guangdong-Hong Kong-Macao Greater Bay Area - IV
15:00-15:30	Main Venue (ID: 977 7442 2793) Award & Closing Ceremony Chair: Zuankai Wang			

IYCBSE 2021 Program Schedule

17 July, Saturday (Day 1)

08:30-09:00 Opening Ceremony

Main Venue (ID: 977 7442 2793)

08:30-08:40 Way Kuo, *City University of Hong Kong*

Chair: Zuankai Wang

08:40-08:45 Luquan Ren, *Jilin University*

Chair: Zuankai Wang

08:45-08:50 Hairong Zheng, *Shenzhen Institute of Advanced Technology, CAS*

Chair: Xuemin Du

08:50-08:55 Peter Merker, *China-Germany Economic and Cultural Exchange Association*

Chair: Xuemin Du

08:55-09:00 Group Photo

Chair: Xuemin Du

09:00-12:30 Plenary Talks

Main Venue (ID: 977 7442 2793)

09:00-09:30 Fatigue-resistant materials

Zhigang Suo, *Harvard University*

Chair: Zhihui Zhang

09:30-10:00 Skin-Inspired Organic Electronics

Zhenan Bao, *Stanford University*

Chair: Zhihui Zhang

10:00-10:30 Future of Robotics: The Tri-Co (Coexisting-Cooperative-Cognitive) Robots

Han Ding, *Huazhong University of Science and Technology*

Chair: Zhihui Zhang

10:30-11:00 Bioinspired Super-wettability System and Beyond--Quantum-confined Superfluid: Energy Conversion, Chemical Reaction and Biological Information Transfer

Lei Jiang, *Technical Institute of Physics and Chemistry, Chinese Academy of Sciences*

Chair: Zhiguang Guo

11:00-11:30 Bio-inspired functional materials: Recent Advances and Challenges

Shuhong Yu, *University of Science and Technology of China*

Chair: Zhiguang Guo

11:30-12:00 New engineering materials for biomimetic integration

Jian Lu, *City University of Hong Kong*

Chair: Zhiguang Guo

12:00-12:30 Biomimetic anti-dew materials

David Quéré, *École Polytechnique*

Chair: Zuankai Wang

13:30-15:25 Session 1: Interfacial and transport phenomena - I

Room I (ID: 994 2266 9485)

Chair: Xu Deng, Chonglei Hao, Yan Liu, Longjian Xue

13:30-13:50 KEYNOTE TALK

Bioinspired hierarchical surface for ultrafast water harvesting

Huawei Chen, *Beihang University*

13:50-14:10 KEYNOTE TALK

Green Printing Technology for Manufacturing of Functional Devices

Yanlin Song, *Institute of Chemistry, CAS*

14:10-14:25 INVITED TALK

Flow dynamics and heat transfer in droplet impact process

Zhizhao Che, *Tianjin University*

14:25-14:40 INVITED TALK

Femtosecond laser bionic fabrication

Feng Chen, *Xi'an Jiaotong University*

14:40-14:55 INVITED TALK

Moisture-enabled electricity generation (MEG) based on graphene assemblies

Huhu Cheng, *Tsinghua University*

14:55-15:10 INVITED TALK

Directional liquid dynamics of interfaces with superwettability

Zhichao Dong, *Technical Institute of Physics and Chemistry, CAS*

15:10-15:25 INVITED TALK

Artificial sodium channel based on crown-ether crystals with subnanometer pores

Jun Gao, *Qingdao Institute of Bioenergy and Bioprocess Technology, CAS*

13:30-15:25 Session 2 Nature-inspired structural and functional materials - I

Room II (ID: 918 9284 7866)

Chair: Qi Ge, Bin Wang, Daoai Wang, Xuechang Zhou

13:30-13:50 KEYNOTE TALK

Smart Patterned Surface with dynamic wrinkles

Xuesong Jiang, *Shanghai Jiao Tong University*

13:50-14:10 KEYNOTE TALK

Bio-inspired mechano-functional gels through multi-phase order-structure engineering

Mingjie Liu, *Beihang University*

14:10-14:25 INVITED TALK

Fabrication of polymer/metal composite micro/nano array structures and their applications in biological interfaces and actuators

Hongxu Chen, *Jiaxing University*

14:25-14:40	INVITED TALK	
	Droplets Manipulation on Bioinspired Multi-gradient Surfaces	
	Shile Feng, *Dalian University of Technology*	
14:40-14:55	INVITED TALK	
	Bioinspired Nanostructured Films with Controllable Wettability for Multifunctional Applications	
	Yuekun Lai, *Fuzhou University*	
14:55-15:10	INVITED TALK	
	Biomimetic Artificial Nose for Gas Detection Based on 3D Porous Laser-induced Graphene	
	Jianxiong Zhu, *Southeast University*	
15:10-15:25	INVITED TALK	
	Bioinspired surface/interface lubrication materials & devices	
	Shuanhong Ma, *Lanzhou Institute of Chemical Physics, CAS*	
13:30-15:10	**Session 3 Nature-inspired robots and flexible electronics - I**	
	Room III (ID: 926 8093 0537)	
		Chair: Chuanfei Guo, Zhiyuan Liu, Xing Ma
13:30-13:50	KEYNOTE TALK	
	Biomimetic on gecko locomotion: from researches to applications	
	Zhendong Dai, *Nanjing University of Aeronautics and Astronautics*	
13:50-14:10	KEYNOTE TALK	
	Bioinspired soft robots with new locomotion and manipulation ability	
	Guoying Gu, *Shanghai Jiaotong University*	
14:10-14:25	INVITED TALK	
	A Fast Autonomous Healing Magnetic Elastomer for Instantly Recoverable, Modularly Programmable, and Thermo-recyclable Soft Robots	
	Yin Cheng, *Shanghai Institute of Ceramics, CAS*	
14:25-14:40	INVITED TALK	
	Bio-inspired flexible pressure sensors	
	Zhuo Li, *Fudan University*	
14:40-14:55	INVITED TALK	
	A Neuromorphic Approach to Roughness Discrimination with A Bio-inspired Fingertip	
	Longhui Qin, *Southeast University*	
14:55-15:10	INVITED TALK	
	Intracellular Ion Regulation mediated Self-enhanced Cisplatin Chemotherapy by Asymmetric Nanoparticles	
	Jinjin Shi, *Zhengzhou University*	

IYCBSE 2021

13:30-15:25	**Session 6: Youth Forum of Guangdong-Hong Kong-Macao Greater Bay Area -I**	
	Room IV (ID: 925 7171 1971)	
		Chair: Steven Wang, Zhengbao Yang, Xinge Yu
13:30-13:50	KEYNOTE TALK	
	Musculoskeletal Mechanics and Mechatronics: Bionic Healthcare Engineering from Human and for Human	
	Lei Ren, *Jilin University*	
13:50-14:10	KEYNOTE TALK	
	No more laundry?	
	Liqiu Wang, *The University of Hong Kong*	
14:10-14:25	INVITED TALK	
	Versatile biomanufacturing through cell-material feedback	
	Zhuojun Dai, *Shenzhen Institute of Advanced Technology, CAS*	
14:25-14:40	INVITED TALK	
	Harnessing biointerfacial property to control cell	
	Pengyuan Wang, *Shenzhen Institute of Advanced Technology, CAS*	
14:40-14:55	INVITED TALK	
	Facile fabrication of transparent anti-reflection surface with superamphiphobic by template-assisted spraying coating	
	Yanan Li, *Sun Yat-sen University*	
14:55-15:10	INVITED TALK	
	Bio-inspired metallic microlattice metamaterials	
	Yang Lu, *City University of Hong Kong*	
15:10-15:25	INVITED TALK	
	Decellularized man-made hyaline cartilage graft for cartilage tissue engineering	
	Dongan Wang, *Chinese University of Hong Kong*	
15:30-17:55	**Session 1: Interfacial and transport phenomena - II**	
	Room I (ID: 994 2266 9485)	
		Chair: Xu Deng, Chonglei Hao, Yan Liu, Longjian Xue
15:30-15:45	INVITED TALK	
	Controllable droplet dynamics manipulated by heterogeneous surface wettability	
	Huizeng Li, *Institute of Chemistry, CAS*	
15:45-16:00	INVITED TALK	
	Liquid Plasticines as Shapable Liquid Containers for Chemical Reactions and Bioanalysis	
	Xiaoguang Li, *Northwestern Polytechnical University*	

16:00-16:15	INVITED TALK	
	Efficient drop transportation on structured surfaces	
	Yahua Liu, *Dalian University of Technology*	
16:15-16:30	INVITED TALK	
	Extreme Hydrophobicity – Beyond Nature	
	Cunjing Lv, *Tsinghua University*	
16:30-16:45	INVITED TALK	
	Nature-inspired antireflection structurs and functional materials	
	Shichao Niu, *Jilin University*	
16:45-16:55	ORAL PRESENTATION	
	Earthworm-inspired Capacitive Strain Sensor based on Liquid Microfluidic with Stress-insensitivity	
	Jie Zhang, *Taiyuan University of Technology*	
16:55-17:05	ORAL PRESENTATION	
	Self-righting strategies of ladybirds Coccinella septempunctata under variable roughness	
	Jie Zhang, *Sun Yat-Sen University*	
17:05-17:15	ORAL PRESENTATION	
	Preparation of corrosion resistant coating on magnesium alloy by hydrothermal method	
	Jian Li, *Changchun University of Science and Technology*	
17:15-17:25	ORAL PRESENTATION	
	Robust scalable reversible strong adhesion by gecko-inspired composite design	
	Xiaosong Li, *Tsinghua University*	
17:25-17:35	ORAL PRESENTATION	
	Inspiration for MAV design from aerodynamic benefits of flexible deformation of insect wings	
	Liansong Peng, *Beihang University*	
17:35-17:45	ORAL PRESENTATION	
	Underwater Impact Hammer Inspired by Mantis Shrimp	
	Xinxin Li, *Tsinghua University*	
17:45-17:55	ORAL PRESENTATION	
	Research on the Mechanical Durability and Corrosion Resistance of Oil-water Separation of Stainless Steel Mesh Developed by Waterjet-assisted Laser Ablation	
	Jiaqi Wang, *Changchun University of Science and Technology*	

IYCBSE 2021

15:30-17:45	**Session 2 Nature-inspired structural and functional materials - II**
	Room II (ID: 918 9284 7866)
	Chair: Qi Ge, Bin Wang, Daoai Wang, Xuechang Zhou
15:30-15:45	INVITED TALK
	Nature-Inspired Energy Harvesting Strategy Based on Adhesive Interface and Hydrophilic Interface
	Daoai Wang, *Lanzhou Institute of Chemical Physics, CAS*
15:45-16:00	INVITED TALK
	3D Printing of bio-inspired surface with oriented structure and frictional anisotropy
	Xiaolong Wang, *Lanzhou Institute of Chemical Physics, CAS*
16:00-16:15	INVITED TALK
	Naked-eye Radiochromic Film Dosimetry via Continuously Tunable Bandgap
	Yunlong Wang, *Nanjing University of Aeronautics and Astronautics*
16:15-16:25	ORAL PRESENTATION
	A novel high toughness cementitious structural material via biomimetic design
	Hao Pan, *Southeast University*
16:25-16:35	ORAL PRESENTATION
	Multi-material additive manufacturing of a bionic layered ceramic/metal structure: Formation mechanisms, gradient interface and mechanical properties
	Rui Wang, *Nanjing University of Aeronautics and Astronautics*
16:35-16:45	ORAL PRESENTATION
	Mechanically efficient corrugated structures inspired by mantis shrimp: optimization, mechanism, and laser 3D printing
	Jiankai Yang, *Nanjing University of Aeronautics and Astronautics*
16:45-16:55	ORAL PRESENTATION
	Nature-inspired nacre-like composites combining human tooth-matching elasticity and hardness with notable damage tolerance and fatigue properties
	Guoqi Tan, *Institute of Metal Research, Chinese Academy of Sciences*
16:55-17:05	ORAL PRESENTATION
	Study on the energy absorption of sandwich plate inspired by the seagull feather rachis
	Jianfei Zhou, *Jilin University*
17:05-17:15	ORAL PRESENTATION
	Plasma electrolytic oxidation coating of magnesium alloy with corrosion resistance and durability
	Qianqian Cai, *Changchun University of Science and Technology*
17:15-17:25	ORAL PRESENTATION
	Metal-ceramic composites with biomimetic structures fabricated by freeze casting and pressure infiltration
	Meng-Qi Sun, *Jilin University*
17:25-17:35	ORAL PRESENTATION
	Fabrication of Transparent and Robust Superhydrophilic Anti-fogging Coating by Polymer and Inorganic nanoparticles Hybridization
	Weilin Deng, *Southeast University*
17:35-17:45	ORAL PRESENTATION
	How an elastic rod strengthens honey bee versatile tongue
	Jiangkun Wei, *Sun Yat-Sen University*

15:30-18:00	Session 5: Bionic implants, organs and systems -I
	Room III (ID: 926 8093 0537)

Chair: Zhou Li, Pengyuan Wang, Chao Zhong

15:30-15:50	KEYNOTE TALK
	Nitrate-functionalized biomaterials for cardiovascular regeneration
	Qiang Zhao, *Nankai University*
15:50-16:10	KEYNOTE TALK
	The Fabrication and Precision Measurement of Organs-on-a-Chip
	Zhongze Gu, *Southeast University*
16:10-16:25	INVITED TALK
	Rationally Designed Synthetic Protein Hydrogels with Predictable and Controllable Mechanical Properties
	Yi Cao, *Nanjing University*
16:25-16:40	INVITED TALK
	Soft, 3D Microsystems for Biomedicine
	Mengdi Han, *Peking University*
16:40-16:55	INVITED TALK
	Bioactive biomaterials and systems: design and biomedical applications
	Linlin Li, *Beijing Institute of Nanoenergy and Nanosystems, CAS*
16:55-17:10	INVITED TALK
	Protocells: A New Kind of Artificial Cells
	Jianbo Liu, *Hunan University*
17:10-17:25	INVITED TALK
	Research on Construction of in vitro GBM Model Based on 3D Bioprinting
	Liang Ma, *Zhejiang University*
17:25-17:35	ORAL PRESENTATION
	Independent Pattern Formation and Parallel Locomotion of Two Microrobotic Swarmsunder a Global Input
	Xingzhou Du, *The Chinese University Hong Kong*
17:30-17:40	ORAL PRESENTATION
	Modulating Neural Subtype Specification with Employing cSAPs Substrates for Neural Direct Conversion of Human Fibroblast
	Javad Harati, *Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences*
17:45-17:55	ORAL PRESENTATION
	Deciphering the role of perinuclear actin cap (pnAC) in nanocarrier trafficking and gene transfection in skeletal myoblasts on nanopillars
	Rui Zhang, *Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences*
17:55-18:05	ORAL PRESENTATION
	Mimicking Schooling Fishes to Construct a 3D Reconfigurable Microswarm for On-Demand Reaction-Rate Control
	Fengtong Ji, *The Chinese University of Hong Kong*

IYCBSE 2021

15:30-17:45	Session 4 Nature-inspired energy transport, storage, conversion and harvesting - I
	Room IV (ID: 925 7171 1971)

Chair: Xu Hou, Jun Yin, Ronggui Yang

15:30-15:50	KEYNOTE TALK
	Radiation to Outer Space: Cooling with Zero Energy Consumption
	Ronggui Yang, *Huazhong University of Science and Technology*
15:50-16:05	INVITED TALK
	Mass transport in atomic-scale confinements
	Sheng Hu, *Xiamen University*
16:05-16:20	INVITED TALK
	Study on Bio-inspired Carbon Materials in Solar-thermal Conversion
	Meng Li, *Chongqing University*
16:20-16:35	INVITED TALK
	Liquid-solid electricity generator based on bulk effect
	Xiaofeng Zhou, *East China Normal University*
16:35-16:50	INVITED TALK
	Self-assembly in Nanomaterials, Dynamic Materials, and Micro-robots
	Wendong Wang, *Shanghai Jiaotong University*
16:50-17:05	INVITED TALK
	Droplet-Based Self-Propelled Mini-Boat
	Jinlong Song, *Dalian University of Technology*
17:05-17:15	ORAL PRESENTATION
	How to make a hairy biological surface both flexible and rigid: material stiffness variation in honey bee tongue facilitates multifunctions
	Yu Sun, *Sun Yat-Sen University*
17:15-17:25	ORAL PRESENTATION
	Design and Analysis of a New Type of Twisting Pneumatic Artificial Muscle
	Wei Xiao, *Hunan University*
17:25-17:35	ORAL PRESENTATION
	Research in kinematics of jerboa hopping on sand and the jerboa-like robot model
	Hao Pang, *Jilin University*
17:35-17:45	ORAL PRESENTATION
	Fabrication of flexible ionic hydrogel battery inspired by electric eels
	Pei He, *Xi'an Jiaotong University*

18 July, Sunday (Day 2)

08:30-10:10 Session 1: Interfacial and transport phenomena - III

Room I (ID: 994 2266 9485)

Chair: Xu Deng, Chonglei Hao, Yan Liu, Longjian Xue

08:30-08:50	KEYNOTE TALK
	Probing ion-water interaction at interfaces with atomic resolution
	Ying Jiang, *Peking University*
08:50-09:10	KEYNOTE TALK
	Bioinspired dynamic wettability surfaces with micro- and nanostructures
	Yongmei Zheng, *Beihang University*
09:10-09:25	INVITED TALK
	Bionic Directional Droplet Bouncing
	Meirong Song, *Henan Agricultural University*
09:25-09:40	INVITED TALK
	Theory of Wetting and Capillary Condensation on the Nanoscale
	Fengchao Wang, *The University of Science and Technology of China*
09:40-09:55	INVITED TALK
	Bionic Optimization of Straight Cone Nozzle Structure for Reducing the Fluid Resistance
	Jiwei Wen, *Chengdu University of Technology*
09:55-10:10	INVITED TALK
	Static and Dynamic Wetting Behaviour of the Droplet on the Microstructure Surface
	Huaping Wu, *Zhejiang University of Technology*

08:30-10:25 Session 2 Nature-inspired structural and functional materials - III

Room II (ID: 918 9284 7866)

Chair: Qi Ge, Bin Wang, Daoai Wang, Xuechang Zhou

08:30-08:50	KEYNOTE TALK
	Bio-inspired materials for controlling ice formation
	Jianjun Wang, *Institute of Chemistry, CAS*
08:50-09:10	KEYNOTE TALK
	Biomimicking functionally cooperating systems for the design of mini-generator
	Feng Shi, *Beijing University of Chemical Technology*
09:10-09:25	INVITED TALK
	Femtosecond laser microfabrication towards highly functional biomimetic structures
	Dong Wu, *The University of Science and Technology of China*
09:25-09:40	INVITED TALK
	Polymers for photoinduced reversible solid-to-liquid transitions
	Si Wu, *The University of Science and Technology of China*
09:40-09:55	INVITED TALK
	Photo-steered deformation and locomotion of nanocomposite hydrogels
	ZiLiang Wu, *Zhejiang University*
09:55-10:10	INVITED TALK
	The Biomimetic Controllable Adhesion Surface Design and Preparation with High Performance
	Quan Xu, *China University of Petroleum (Beijing)*
10:10-10:25	ENTERPRISE TALK
	高精度大幅面PμSL 3D打印技术及其在仿生领域的应用
	Ying Peng, *Boston Micro Fabrication Inc.*

08:30-10:10 Session 3 Nature-inspired robots and flexible electronics - II

Room III (ID: 926 8093 0537)

Chair: Chuanfei Guo, Zhiyuan Liu, Xing Ma

08:30-08:50	KEYNOTE TALK
	Bio-Inspired Flexible Electronics for Multifunctional Aerodynamic Measurement
	Yongan Huang, *Huazhong University of Science and Technology*
08:50-09:10	KEYNOTE TALK
	Gecko-inspired adhesive structures: fabrication and application
	Jinyou Shao, *Xian Jiaotong University*
09:10-09:25	INVITED TALK
	Nature-inspired Micro-nano Structures for Soft Neural Electrodes
	Dianpeng QI, *Harbin Institute of Technology*
09:25-09:40	INVITED TALK
	Physically Transient Memristor for neuromorphic computing
	Hong Wang, *Xidian University*
09:40-09:55	INVITED TALK
	Design and implementation of flight control system for honeybee based on EEG stimulation
	Jieliang Zhao, *Beijing Institute Technology*
09:55-10:10	ENTERPRISE TALK
	界面表征技术的前沿发展
	Song Luo, *Beijing Dataphys Instruments Co. Ltd*

08:30-10:25	Session 6: Youth Forum of Guangdong-Hong Kong-Macao Greater Bay Area - II
	Room IV (ID: 925 7171 1971)
	Chair: Steven Wang, Zhengbao Yang, Xinge Yu
08:30-08:50	KEYNOTE TALK Insect Tracheal Systems Qi-Huo Wei, *Southern University of Science and Technology*
08:50-09:10	KEYNOTE TALK Development of biocompatible bulk metallic glasses Guoqiang Xie, *Harbin Institute of Technology (Shenzhen)*
09:10-09:25	INVITED TALK Crack engineering as a new route for the construction of arbitrary hierarchical architectures Kangning Ren, *Hong Kong Baptist University*
09:25-09:40	INVITED TALK Liquid-organelle-inspired engineering of all-aqueous droplets Anderson Shum, *The University of Hong Kong*
09:40-09:55	INVITED TALK Nanorobot Controlled with Collective Intelligence Jingyao Tang, *The University of Hong Kong*
09:55-10:10	INVITED TALK Biohybrid stem cell microrobots with endoluminal delivery Ben Wang, *Shenzhen University*
10:10-10:25	INVITED TALK Decellularized man-made hyaline cartilage graft for cartilage tissue engineering Dongan Wang, *Chinese University of Hong Kong*

10:30-12:00	Session 1: Interfacial and transport phenomena - IV
	Room I (ID: 994 2266 9485)
	Chair: Xu Deng, Chonglei Hao, Yan Liu, Longjian Xue
10:30-10:45	INVITED TALK Liquid transport through animal appendages:Morphological and mechanical perfection in honey bees and elephants Jianing Wu, *Sun Yat-Sen University*
10:45-11:00	INVITED TALK Clonable Droplet Array with Physical Unclonable Functions Jinbo Wu, *Shanghai University*
11:00-11:15	INVITED TALK Bioinspired structured adhesives for various surfaces Longjian Xue, *Wuhan University*
11:15-11:30	INVITED TALK Electrochemistry-Induced Improvements of Mechanical Strength, Self-healing, and Interfacial Adhesion of Hydrogels Lidong Zhang, *East China Normal University*
11:30-11:45	INVITED TALK Depinning of Multiphase Fluid Using Light and Photo-Responsive Surfactants Lei Zhao, *Dalian University of Technology*
11:45-12:00	INVITED TALK Droplet Depinning on Pored and Pillared Superhydrophobic Surfaces Youhua Jiang, *Guangdong Technion-Israel Institute of Technology*

10:30-11:35	Session 2 Nature-inspired structural and functional materials - IV
	Room II (ID: 918 9284 7866)
	Chair: Qi Ge, Bin Wang, Daoai Wang, Xuechang Zhou
10:30-10:50	KEYNOTE TALK Bioinspired wet/adhesion/lubrication interface Feng Zhou, *Lanzhou Institute of Chemical Physics, CAS*
10:50-11:05	INVITED TALK Spontaneous Fast Droplet Transport Without Mass Loss on Architectured Slippery Surfaces Xiaolong Yang, *Nanjing University of Aeronautics and Astronautics*
11:05-11:20	INVITED TALK Microscale Shape-Morphing with 3D Reconfigurable Morphology Chunhong Ye, *ShanghaiTech University*
11:20-11:35	INVITED TALK Superhydrophobic coatings for energy saving and environment protection: from materials to equipment Youfa Zhang, *Southeast University*

10:30-11:45	Session 5: Bionic implants, organs and systems -II
	Room III (ID: 926 8093 0537)
	Chair: Zhou Li, Pengyuan Wang, Chao Zhong
10:30-10:45	INVITED TALK Biomimetic construction of functional myocardial patch using natural biomaterials Honghao Hou, *School of Basic Medical Science, Southern Medical University*
10:15-11:00	INVITED TALK Bioinspired Materials and Technology for Cryopreservation Wei Rao, *Technical Institute of Physics and Chemistry, CAS*
11:00-11:15	INVITED TALK Bionic self-powered biosensors Bojing Shi, *Beihang University*
11:15-11:30	INVITED TALK Enzyme-powered Artificial Cell Models Lei Wang, *Harbin Institute of Technology*
11:30-11:45	INVITED TALK Cell mechanoresponse Qiang Wei, *Sichuan University*

10:30-12:00	Session 6: Youth Forum of Guangdong-Hong Kong-Macao Greater Bay Area -III
	Room IV (ID: 925 7171 1971)
	Chair: Steven Wang, Zhengbao Yang, Xinge Yu
10:30-10:45	INVITED TALK
	Pattern recognition techniques for sand particles
	Jeff Jianfeng Wang, *City University of Hong Kong*
10:45-11:00	INVITED TALK
	Advanced Designs for Sustainable Solar-Energy-Water Nexus
	Peng Wang, *The Hong Kong Polytechnic University*
11:00-11:15	INVITED TALK
	Mechanoluminescence of Quaternary Piezoelectric Semiconductors for Advanced Lighting and Sensing Applicationsg
	Dengfeng Peng, *Shenzhen University*
11:15-11:30	INVITED TALK
	A nature-inspired fluid mechanics approach for phase separation
	Steven Wang, *City University of Hong Kong*
11:30-11:45	INVITED TALK
	Micro/Nano-devices for Biomedical Applications
	Xi Xie, *Sun Yat-sen University*
10:10-10:25	INVITED TALK
	Interface Engineering in Multiphase Microfluidic
	Tiantian Kong, *Shenzhen University*

13:30-14:30	Session 4 Nature-inspired energy transport, storage, conversion and harvesting - II
	Room I (ID: 994 2266 9485)
	Chair: Xu Hou, Jun Yin, Ronggui Yang
13:30-13:45	INVITED TALK
	Optical Wood with Switchable Transmittance of Solar Irradiation for Thermal Management
	Hongbo Xu, *Harbin Institute of Technology*
14:00-14:15	INVITED TALK
	Nonlinear vibration energy harvesters: Design, analysis and experiment
	Shengxi Zhou, *Northwestern Polytechnical University*
14:15-14:30	INVITED TALK
	Biomorphic ceramics embedded molten salts for ultrafast thermal and solar energy
	Xianglei Liu, *Nanjing University of Aeronautics and Astronautics*

13:30-14:30	Session 2 Nature-inspired structural and functional materials - V
	Room II (ID: 918 9284 7866)
	Chair: Qi Ge, Bin Wang, Daoai Wang, Xuechang Zhou
13:30-13:45	INVITED TALK
	Bioinspired Nanostructures with Long-term Mechano-Bactericidal effectiveness
	Jie Zhao, *Jilin University*
13:45-14:00	INVITED TALK
	A Floquet-Based Bar-Spring Model for Load-Bearing Biological and Bioinspired Composites
	Zuoqi Zhang, *Wuhan University*
14:00-14:15	INVITED TALK
	Laser powder bed fusion of bio-inspired honeycomb structures: effect of twist angle on compressive behaviors
	Kaijie Lin, *Nanjing University of Aeronautics and Astronautics*
14:15-14:30	INVITED TALK
	Bioinspired natural energy collection and biomass resource utilization strategy
	Zhuangzhi Sun, *Northeast Forestry University*

13:30-14:45	Session 6: Youth Forum of Guangdong-Hong Kong-Macao Greater Bay Area - IV
	Room III (ID: 926 8093 0537)
	Chair: Steven Wang, Xinge Yu
13:30-13:45	INVITED TALK
	Mechanics underlying the structure-property relations unveiled from natural biomaterials
	Haimin Yao, *The Hong Kong Polytechnic University*
13:45-14:00	INVITED TALK
	Soft actuators in skin-integrated electronics for VR/AR
	Xinge Yu, *City University of Hong Kong*
14:00-14:15	INVITED TALK
	Liquid-Solid Hybrid Soft Packaging Materials
	Yanhao Yu, *Southern University of Science and Technology*
14:15-14:30	INVITED TALK
	Bio-inspired Magnetic Microrobots: From Individual to Swarm
	Li Zhang, *Chinese University of Hong Kong*
14:30-14:45	INVITED TALK
	When biomimetics meets microfluidics
	Pingan Zhu, *City University Hong Kong*

13:30-14:30	Session 6: Youth Forum of Guangdong-Hong Kong-Macao Greater Bay Area - V
	Room IV (ID: 925 7171 1971)
	Chair: Zhengbao Yang
13:30-13:45	INVITED TALK
	IceMicroneedles for intradermal delivery of vaccines
	Chenjie Xu, *City University of Hong Kong*
13:45-14:00	INVITED TALK
	Achieving adjustable elasticity with non-affine to affine transition
	Lei Xu, *Chinese University of Hong Kong*
14:00-14:15	INVITED TALK
	Triboelectric Nanogenerator towards Low-Frequency Hydrodynamic Energy Harvesting
	Xiya Yang, *Jinan University*
14:15-14:30	INVITED TALK
	Vibration Energy Harvesting and Flexible Piezoelectric Devices
	Zhengbao Yang, *City University of Hong Kong*
14:30-14:45	INVITED TALK
	Introduction to The International Society of Bionic Engineering
	To be determined, *The International Society of Bionic Engineering*

Plenary Speakers

Prof. Zhigang Suo
Harvard University
Email: suo@seas.harvard.edu

Fatigue-resistant materials

Abstract
Many materials suffer from a disease: fatigue. Symptoms include excessive hysteresis and growth of cracks under cyclic stretch. They are unfit for applications such as artificial heart valves and soft robots. Recently, we have developed materials called elastic dissipaters. They have high toughness and low hysteresis. They are fatigue-resistant. This talk describes the fundamental mechanics, along with several implementations in practical materials.

Biography

Zhigang Suo is the Allen E. and Marilyn M. Puckett Professor of Mechanics and Materials at Harvard University. He grew up on the campus of Xian Jiaotong University, and graduated from its kindergarten, elementary school, middle school, high school, and college. He wrote his undergraduate thesis on coupled boundary and finite elements, under Professor Xing Ji, at Xian Jiaotong University, in 1985. He wrote his PhD thesis on interfacial fracture mechanics, under Professor John W. Hutchinson, at Harvard University, in 1989. Suo joined the faculty of the University of California at Santa Barbara in 1989, Princeton University in 1997, and Harvard University in 2003. His research centers on the mechanical behavior of materials.

Prof. Zhenan Bao
K.K. Lee Professor and Department Chair in the Department of Chemical Engineering
Courtesy Professor in the Department of Chemistry and Department of Materials Science and Engineering
Stanford University
Director of Stanford Wearable Electronics Initiative (eWEAR)
Email: zbao@stanford.edu
Website: http://baogroup.stanford.edu

Skin-Inspired Organic Electronics

Abstract
Skin is the body's largest organ, and is responsible for the transduction of a vast amount of information. This conformable, stretchable, self-healable and biodegradable material simultaneously collects signals from external stimuli that translate into information such as pressure, pain, and temperature. The development of electronic materials, inspired by the complexity of this organ is a tremendous, unrealized materials challenge. However, the advent of organic-based electronic materials may offer a potential solution to this longstanding problem. Over the past decade, we have developed materials design concepts to add skin-like functions to organic electronic materials without compromising their electronic properties. These new materials and new devices enabled arrange of new applications in medical devices, robotics and wearable electronics. In this talk, I will discuss several projects related to engineering conductive materials and developing fabrication methods to allow electronics with effective electrical interfaces with biological systems, through tuning their electrical as well as mechanical properties. The end result is a soft electrical interface that has both low interfacial impedance as well as match mechanical properties with biological tissue.

Biography

Zhenan Bao is Department Chair and K.K. Lee Professor of Chemical Engineering, and by courtesy, a Professor of Chemistry and a Professor of Material Science and Engineering at Stanford University. Bao founded the Stanford Wearable Electronics Initiate (eWEAR) in 2016 and serves as the faculty director.
Prior to joining Stanford in 2004, she was a Distinguished Member of Technical Staff in Bell Labs, Lucent Technologies from 1995-2004. She received her Ph.D in Chemistry from the University of Chicago in 1995. She has over 650 refereed publications and over 100 US patents with a Google Scholar H-Index >175.
Bao is a member of the National Academy of Engineering, the American Academy of Arts and Sciences, and the National Academy of Inventors. She is a Fellow of MRS, ACS, AAAS, SPIE, ACS PMSE and ACS POLY.
Bao was selected as Nature's Ten people who mattered in 2015 as a “Master of Materials” for her work on artificial electronic skin. She was awarded MRS Mid-Career Award 2021, the inaugural ACS Central Science Disruptor and Innovator Prize in 2020, the Gibbs Medal by the Chicago session of ACS in 2020, the Wilhelm Exner Medal by Austrian Federal Minister of Science 2018, ACS Award on Applied Polymer Science 2017, the L'Oréal-UNESCO For Women in Science Award in the Physical Sciences 2017, the AICHE Andreas Acrivos Award for Professional Progress in Chemical Engineering in 2014, ACS Carl Marvel Creative Polymer Chemistry Award in 2013, ACS Cope Scholar Award in 2011, the Royal Society of Chemistry Beilby Medal and Prize in 2009, the IUPAC Creativity in Applied Polymer Science Prize in 2008.
Bao is a co-founder and on the Board of Directors for C3 Nano and PyrAmes, both are silicon-valley venture funded start-ups. She serves as an advising Partner for Fusion Venture Capital.

Prof. Han Ding

Huazhong University of Science and Technology, China

Future of Robotics: The Tri-Co (Coexisting-Cooperative-Cognitive) Robots

Abstract

Tri-Co Robots (Coexisting-Cooperative-Cognitive Robots) are those that can naturally interact and collaborate with the environment, including humans as well as other robots, and adapt to new situations. Coexistence will allow robots to ubiquitously and safely work alongside humans, considerably increasing our efficiency and quality of life. Cooperation will enable robots to collaborate and coordinate effectively with other agents through communication and interplay. Cognition will provide robots the resources to gather information, perceive and predict behaviors, and respond accordingly. This will all be achieved through state-of-the-art machine learning, control and planning algorithms. Key characteristics of Tri-Co Robots are: plastic and dexterity, multi-modal perception, and working autonomously and collaboratively. In particular, the development of rigid-flexible-soft robots and efficient solution methods are essential to achieve adaptation to environmental uncertainty and compliant interactions with humans and other robots.

This talk will introduce the current research activities of robotics in China, especially the Tri-Robot Research Plan of NSFC (National Natural Science Foundation of China). It will discuss the primary scientific challenges and key scientific problems of the plan, mainly focusing on mechanism, perception and control. The talk will also forecast China's expected breakthroughs and goals in Tri-Co robot research. Finally, the talk will present recent research results of our group and discuss current and future challenges.

Biography

Han Ding received his Ph.D. degree in Mechatronics from Huazhong University of Science & Technology in 1989. Supported by the Alexander von Humboldt Foundation, he worked at University of Stuttgart, Germany in 1993. He obtained the National Distinguished Youth Scientific Fund in 1997 and was awarded the “Cheung Kong” Chair Professor at Shanghai Jiao Tong University in 2001. He was elected a member of Chinese Academy of Sciences in 2013.

Prof. Ding has long dedicated himself to research in the field of robotics and digital manufacturing, and has successfully combined both technologies. He published three academic books and more than 300 journal papers, and licensed more than 100 patents in China.

Prof. Ding is currently the chairman of Academic Committee of HUST and the director of the National Innovation Institute of Digital Design and Manufacturing. He is also a scientific committee member of the NSFC Tri-Co Robot major research program.

Prof. Lei Jiang

Technical Institute of Physics and Chemistry, Chinese Academy of Sciences, Beijing 100190, P.R. China

Bioinspired Super-wettability System and Beyond --Quantum-confined Superfluid: Energy Conversion, Chemical Reaction and Biological Information Transfer

Abstract

Biological ionic/molecular channels embedded in plasma membranes play important roles in a wide spectrum of physiological processes such as energy conversion, bioinformation transformation and biochemical reaction etc. On the basis of biological channels, signals can be transmitted from the nerves to brain in the process of vision, smell, audition and tactility. Those crucial functions highly depend on their selective protein-based gatekeepers that allow extremely rapid transit (107 ions per channel in one second). This ultrafast mass transfer stems from the special features of the biological channels, e.g., small size, unique structure and surface charge distribution, which lead to peculiar properties, inducing ultrafast ion and molecule transmission in the form of single strand. From the viewpoint of classical thermodynamics, mass transport across nanometer-scale channel with chemical selectivity should be very slow. In the living system, however, the fast transit of ions and molecules is precisely the state of ultrafast fluid caused by a quantized flow. Biological ion channels show that ultrafast ions and molecules transmission are in a quantum way of single molecular or ionic chain with a certain number of molecules or ions, and we define it as “quantum-confined superfluid” (QSF). The biomimetic systems also exhibit QSF phenomena, such as ultrafast ions transport in artificial ion channels, and ultrahigh water flux in artificial water channels. The introduction of QSF into the fields of energy, chemistry and biology would have significant impact. As a challenge to the traditional theory, the concept of QSF will open up a new field of quantum ionics and promote the development and application of energy conversion materials. The development of QSF reactions will expand the application of nanochannels (even sub nanochannels), promote the development of interfacial catalytic chemistry theory, and open up a new way for the future development of chemistry, chemical engineering and synthetic biology. The introduction of quantum ionics into the field of bioinformatics will provide new technical means for the study of neural signals, overturn the understanding of neural signal transmission in neuroscience and brain science, and expand the development of biophysics, bioinformatics and biomedicine.

Biography

Lei Jiang is a Professor at the Technical Institute of Physics and Chemistry, Chinese Academy of Sciences (TIPC) and Beihang University. He is an academician of the Chinese Academy of Sciences, Academy of Sciences for the Developing World, and National Academy of Engineering, USA. He received his Bachelor's and Master's degrees from Jilin University, and PhD from the University of Tokyo. He worked as a post-doctoral fellow with Prof. Akira Fujishima and then as a senior researcher in the Kanagawa Academy of Sciences and Technology. In 1999, he joined Institute of Chemistry, Chinese Academy of Sciences. In 2015, he and his group moved to TIPC. His scientific interests focus on bio-inspired, smart, multi-scale interfacial materials with superwettability. Prof. Lei Jiang has discovered and established the basic principle of the interfacial material systems with superwettability and extended them to successful innovative applications. His work has been followed by more than 1,400 research institutions in 94 countries around the world. He is the most original and influential scientist in the field of material science in China. Due to his contribution to the development of superwettability, he won the “TWAS Prize in Chemistry” in 2011, the Advanced Science and Technology Award of “THE HO LEUNG HO LEE FUNDATION” in 2013 and the “Outstanding Achievement Award” of the Chinese Academy of Sciences in 2014. In 2016, he won the “UNESCO Medals” for contributions to the development of nanoscience and nanotechnologies, and the “Nikkei Asia Prize”. In 2017, he won the “Humboldt Research Award” in Germany. In 2018, he was awarded the “Qiu Shi Outstanding Scientist Award” and “Nano Research Award”. In 2020, he won the “ACS Nano Lectureship Award”.

Prof. Shuhong Yu

Department of Chemistry, University of Science and Technology of China, Division of Nanomaterials and Chemistry, Hefei National Laboratory for Physical Sciences at the Microscale, China, Hefei 230026
Email: shyu@ustc.edu.cn

Bio-inspired functional materials: Recent Advances and Challenges

Abstract

There is a rich and long history of gaining inspiration from nature for the design of practical materials and systems. Biominerals are well-known composites of inorganic and organic materials in the form of fascinating shapes and high ordered structures, which exist in Nature, for example, pearl, oyster shells, corals, ivory, sea urchin spines, cuttlefish bone, limpet teeth, magnetic crystals in bacteria, and human bones, created by living organisms. During the past few decades, it has been one of the hottest research subjects in materials chemistry and its cutting-edge fields to explore new bio-inspired strategies for generation of materials with controlled morphologies, unique structural specialty, and complexity. This lecture will present our recent advances on bio-inspired synthesis of a family of inorganic or inorganic-organic micro-/nano- structural materials and their macroscopic scale assemblies, including bio-inspired molecule induced synthesis of micro-/nano-inorganic materials, bio-inspired interfacial assembly of macroscopic assemblies and functionalization. Especially, we will report our recent effort on how to realize the production of bulk materials, such as synthetic nacre and artificial woods, spanning all the length scales, either by predesigned matrix-directed mineralization process or a bottom-up self-assembly process. These bio-inspired materials are emerging as a new material system, showing enormous application potentials in diverse fields.

Biography

Shu-Hong Yu completed PhD in inorganic chemistry in 1998 from University of Science and Technology of China. From 1999 to 2001, he worked in Tokyo Institute of Technology as a Postdoctoral Fellow, and was awarded the AvH Fellowship (2001-2002) in the Max Planck Institute of Colloids and Interfaces, Germany. He was appointed as a full professor in 2002 and the Cheung Kong Professorship in 2006. He was elected as Academician of Chinese Academy of Sciences in 2019. He serves as the Director of the Division of Nanomaterials and Chemistry, Hefei National Laboratory for Physical Sciences at Microscale. He is the Editor-in-Chief of Materials Chemistry Frontiers, and was a senior editor for Langmuir from 2017 to 2020, and an associate editor for Sci. China Mater. and EnergyChem, and on the editorial board or advisory board of journals Accounts of Chemical Research, Advanced Materials, Nano Letters, Chemistry of Materials, Materials Horizons, Matter, Trends in Chemistry, Research, Nano Research, and ChemNanoMat. His research interests include bio-inspired synthesis of inorganic nanostructures, self-assembly of nanoscale building blocks, nanocomposites, their related properties and applications. His research work has been cited more than 61,600 citations (H index 137), named as a Highly Cited Researcher from 2014 to 2020.

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Prof. Jian Lu

Centre for Advanced Structural Materials (CASM), Department of Mechanical Engineering Greater Bay Division, Shenyang National Laboratory for Material Science, City University of Hong Kong
Email: jianlu@cityu.edu.hk

New engineering materials for biomimetic integration

Abstract

The development of highly efficient and advanced mechanical systems, new energy generation and storage systems are the key research directions to safeguard the sustainable development of mankind. To develop advanced biomimetic and/or unmanned systems, the creation of new materials and associated manufacturing systems such as additive manufacturing is very important. This presentation will feature recent development of structural nanomaterials including the supra-nanostructured materials with multiphase embedded structure. The feasibility of applying new engineering nanomaterials on various advanced systems, such as solar energy and ocean thermal energy conversion will be discussed. We will present the morphing underwater vehicle system by integrating the bi-stable nanostructured metallic materials. The realization of new engineering nanomaterials with morphing features for reducing the air resistance of automotive vehicle and enhancing aerodynamic performance of aerospace structures can be anticipated. We will report our research on the 4D printing of complex shape devices with multiples stimulus (pre-stressed, water, alcohol, light and aggregates) and the extended applications. The additive manufacturing offers numerous new paradigms and routes to biomimetic design and develop new meta-materials with supra-nature physical performances. The concepts and perspectives will be presented and analyzed.

Biography

Prof. Jian LU is Chair Professor of Mechanical Engineering, former Vice-President (Research &Technology) and Dean of graduate studies at the City University of Hong Kong. He was elected as academician of the National Academy of Technologies of France in 2011. He serves as Director of the Center for Advanced Structural Materials of City University of Hong Kong and Head of the Greater Bay Division of Shenyang National Laboratory for Material Science. He serves as the President of the Hong Kong Material Research Society (HK-MRS) and served as the President of Hong Kong Society of the Theoretical and Applied Mechanics (HKSTAM). He commenced his undergraduate education in 1978 at Peking University where he was selected for a national scholarship for overseas study in 1979. He obtained the Dip. Ing., Master (DEA) degree and Doctoral degree from University of Technology of Compiegne France in 1984 and 1986 respectively. Professor LU's primary research interest is advanced engineering materials and its integration in mechanical and biomedical systems using the combination of experimental mechanics and mechanical simulation. He has also branched out into several other areas of interest including surface science and engineering, biomechanics, residual stresses, and mechanics of nanomaterials. He has published more than 400 SCI journal papers including papers in Nature (cover story), Science, Nature Materials, Nature Communications, Science Advances, Advanced Materials, Materials Today, Advanced Functional Materials, PRL, Acta Materialia, and Journal of the Mechanics and Physics of Solids. He received the French Knight of the National Order of Merit and French Knight of the National Order of Légion d'Honneur in 2006 & 2017 respectively. He received the Guanghua Engineering Science and Technology Award from the Chinese National Academy of Engineering in 2018.

Prof. David Quéré

ESPCI-Paris and École Polytechnique, France
Email: david.quere@espci.fr

Biomimetic anti-dew materials

Abstract

We discuss the antifogging abilities of materials decorated by hydrophobic micro- and nano-cones, such as observed on the legs of water striders or on the wings of cicadas. It is found that such designs generate unprecedented capacities to evacuate the dew as it forms.

Biography

David Quéré graduated with an M.Sc. from ESPCI-Paris and a Ph.D. from Université Pierre et Marie Curie, Paris. He continued with a CNRS position, which successively lead him to the Physics Labs at Collège de France (until 2006) and to the Laboratoire de Physique et Mécanique des Milieux Hétérogènes at ESPCI (since). In 2006, he also became a Professor at École Polytechnique (Departments of Physics and Mechanics). He is engaged in experimental research in Soft Matter Physics and Fluid Mechanics, with a strong interest in interfacial hydrodynamics (drops, films, bubbles, coating, wicking) as well as in aerodynamics, morphogenesis and biomimetics, all topics on which he coworked with about 35 PhD students. He is or was a scientific advisor at Saint-Gobain (Paris), Procter & Gamble (Cincinnati) and Nikon/Essilor (Tokyo), a coeditor at Europhysics Letters and an associate editor at Physical Review Fluids.

IYCBSE 2021

Session 1: Interfacial and transport phenomena

17 July, Saturday (Day 1)

13:30-15:25	**Session 1: Interfacial and transport phenomena - I**
	Room I (ID: 994 2266 9485)
	Chair: Xu Deng, Chonglei Hao, Yan Liu, Longjian Xue
13:30-13:50	KEYNOTE TALK
	Bioinspired hierarchical surface for ultrafast water harvesting
	Huawei Chen, *Beihang University*
13:50-14:10	KEYNOTE TALK
	Green Printing Technology for Manufacturing of Functional Devices
	Yanlin Song, *Institute of Chemistry, CAS*
14:10-14:25	INVITED TALK
	Flow dynamics and heat transfer in droplet impact process
	Zhizhao Che, *Tianjin University*
14:25-14:40	INVITED TALK
	Femtosecond laser bionic fabrication
	Feng Chen, *Xi'an Jiaotong University*
14:40-14:55	INVITED TALK
	Moisture-enabled electricity generation (MEG) based on graphene assemblies
	Huhu Cheng, *Tsinghua University*
14:55-15:10	INVITED TALK
	Directional liquid dynamics of interfaces with superwettability
	Zhichao Dong, *Technical Institute of Physics and Chemistry, CAS*
15:10-15:25	INVITED TALK
	Artificial sodium channel based on crown-ether crystals with subnanometer pores
	Jun Gao, *Qingdao Institute of Bioenergy and Bioprocess Technology, CAS*
15:30-17:55	**Session 1: Interfacial and transport phenomena - II**
	Room I (ID: 994 2266 9485)
	Chair: Xu Deng, Chonglei Hao, Yan Liu, Longjian Xue
15:30-15:45	INVITED TALK
	Controllable droplet dynamics manipulated by heterogeneous surface wettability
	Huizeng Li, *Institute of Chemistry, CAS*
15:45-16:00	INVITED TALK
	Liquid Plasticines as Shapable Liquid Containers for Chemical Reactions and Bioanalysis
	Xiaoguang Li, *Northwestern Polytechnical University*

16:00-16:15 INVITED TALK

Efficient drop transportation on structured surfaces

Yahua Liu, *Dalian University of Technology*

16:15-16:30 INVITED TALK

Extreme Hydrophobicity – Beyond Nature

Cunjing Lv, *Tsinghua University*

16:30-16:45 INVITED TALK

Nature-inspired antireflection structurs and functional materials

Shichao Niu, *Jilin University*

16:45-16:55 ORAL PRESENTATION

Earthworm-inspired Capacitive Strain Sensor based on Liquid Microfluidic with Stress-insensitivity

Jie Zhang, *Taiyuan University of Technology*

16:55-17:05 ORAL PRESENTATION

Self-righting strategies of ladybirds Coccinella septempunctata under variable roughness

Jie Zhang, *Sun Yat-Sen University*

17:05-17:15 ORAL PRESENTATION

Preparation of corrosion resistant coating on magnesium alloy by hydrothermal method

Jian Li, *Changchun University of Science and Technology*

17:15-17:25 ORAL PRESENTATION

Robust scalable reversible strong adhesion by gecko-inspired composite design

Xiaosong Li, *Tsinghua University*

17:25-17:35 ORAL PRESENTATION

Inspiration for MAV design from aerodynamic benefits of flexible deformation of insect wings

Liansong Peng, *Beihang University*

17:35-17:45 ORAL PRESENTATION

Underwater Impact Hammer Inspired by Mantis Shrimp

Xinxin Li, *Tsinghua University*

17:45-17:55 ORAL PRESENTATION

Research on the Mechanical Durability and Corrosion Resistance of Oil-water Separation of Stainless Steel Mesh Developed by Waterjet-assisted Laser Ablation

Jiaqi Wang, *Changchun University of Science and Technology*

IYCBSE 2021

18 July, Sunday (Day 2)

08:30-10:10 Session 1: Interfacial and transport phenomena - III

Room I (ID: 994 2266 9485)

Chair: Xu Deng, Chonglei Hao, Yan Liu, Longjian Xue

08:30-08:50 KEYNOTE TALK

Probing ion-water interaction at interfaces with atomic resolution

Ying Jiang, *Peking University*

08:50-09:10 KEYNOTE TALK

Bioinspired dynamic wettability surfaces with micro- and nanostructures

Yongmei Zheng, *Beihang University*

09:10-09:25 INVITED TALK

Bionic Directional Droplet Bouncing

Meirong Song, *Henan Agricultural University*

09:25-09:40 INVITED TALK

Theory of Wetting and Capillary Condensation on the Nanoscale

Fengchao Wang, *The University of Science and Technology of China*

09:40-09:55 INVITED TALK

Bionic Optimization of Straight Cone Nozzle Structure for Reducing the Fluid Resistance

Jiwei Wen, *Chengdu University of Technology*

09:55-10:10 INVITED TALK

Static and Dynamic Wetting Behaviour of the Droplet on the Microstructure Surface

Huaping Wu, *Zhejiang University of Technology*

10:30-12:00 Session 1: Interfacial and transport phenomena - IV

Room I (ID: 994 2266 9485)

Chair: Xu Deng, Chonglei Hao, Yan Liu, Longjian Xue

10:30-10:45 INVITED TALK

Liquid transport through animal appendages:Morphological and mechanical perfection in honey bees and elephants

Jianing Wu, *Sun Yat-Sen University*

10:45-11:00 INVITED TALK

Clonable Droplet Array with Physical Unclonable Functions

Jinbo Wu, *Shanghai University*

11:00-11:15 INVITED TALK

Bioinspired structured adhesives for various surfaces

Longjian Xue, *Wuhan University*

11:15-11:30 INVITED TALK

Electrochemistry-Induced Improvements of Mechanical Strength, Self-healing, and Interfacial Adhesion of Hydrogels

Lidong Zhang, *East China Normal University*

11:30-11:45 INVITED TALK

Depinning of Multiphase Fluid Using Light and Photo-Responsive Surfactants

Lei Zhao, *Dalian University of Technology*

11:45-12:00 INVITED TALK

Droplet Depinning on Pored and Pillared Superhydrophobic Surfaces

Youhua Jiang, *Guangdong Technion-Israel Institute of Technology*

Keynote Speakers

Huawei Chen
School of Mechanical Engineering and Automation, Beihang University
Email: chenhw75@buaa.edu.cn

Bioinspired Hierarchical Surface for Ultrafast Water Harvesting

Abstract

Fog harvest through bionic strategies to solve water shortage have drawn great attention. Recently, an ultrafast fog harvest and transport mode is found on Sarracenia trichome, which is mainly attributed to the super-slippery capillary force induced by unique hierarchical micro-channel. However, the underlying effect of hierarchical micro-channel induced ultrafast transport on fog harvest and the multi-scale structural coupling effect on ultrafast fog harvest are still great challenges. Herein, through one-step thermo-plastic stretching approach on glass fiber bundle under the constraint of inner gear pattern, bionic Sarracenia trichome (BST) with on-demand regular hierarchical micro-channel is successfully manufactured, whose major channels are confined by inner gear pattern and junior micro-channels are automatically assembled by glass fiber monofilaments. The BST achieves excellent gravity-ignoring fog harvest properties, realizing thousand times faster fog harvest and transport velocity than cactus spine and spider silk. Moreover, the BST and Janus Membrane (JM) coupling effect was discovered and coupling principle was proposed to enhance the harvest performance. Finally, a high-efficient multi-scale fog collector is developed, in which gradient high-pressure field is purposely formed to improve fog harvest performance over three times than single-scale structure. This easy-manufacturing, low-cost fog collector provides new potential idea to harvest fog water for producing and living.

Biography

Dr. Chen Huawei, Professor/Deputy Dean of School of Mechanical Engineering and Automation, Beihang University. Dr. Chen's research is focused on the bio-inspired functional surface, micro/nano fabrication, micro/nano fluidics, and its applications in aerospace and precision. He is the Leading Talent of Ten Thousand Plan, Outstanding Young Scientist Foundation of National Nature Science Foundation of China, a JSPE Fellow etc. Dr. Chen has authored more than 100 journal papers in Nature, Nature Materials, Advanced Materials, Advanced Science, Small, Angew. Chemie, ACS Applied Materials & Interface etc.

IYCBSE 2021

Ying Jiang
International Center for Quantum Materials, School of Physics, Peking University, Beijing, China
Email: yjiang@pku.edu.cn

Probing ion-water interaction at interfaces with atomic resolution

Abstract

Ion hydration and transport at interfaces are relevant to a wide range of applied fields and natural processes. Interfacial effects are particularly profound in confined geometries such as nanometre-sized channels, where the mechanisms of ion transport in bulk solutions may not apply. To correlate atomic structure with the transport properties of hydrated ions, both the interfacial inhomogeneity and the complex competing interactions among ions, water and surfaces require detailed molecular-level characterization. Using a noncontact atomic force microscopy (AFM) system, we were able to image the individual ion hydrates at surfaces with atomic resolution. We found that the alkali ion with specific hydration numbers diffuses orders of magnitude more quickly than other ion hydrates, arising from the degree of symmetry match between the hydrates and the surface lattice. In addition, we found that the alkali ions can come into close contact with each other through the dehydration and water rearrangement process, which is driven by the effective ionic attraction due to the interplay between the water-ion and water-water interactions. These results not only help us to understand the nature of biological ion channels, but may also provide general design principles for artificial ion channels towards high permeation rate and selectivity.

Biography

Dr. Jiang is a Boya Distinguished Professor of Peking University. He received his PhD from Institute of Physics, Chinese Academy of Sciences (CAS) in 2008. After working as a Postdoctoral Associate in University of California, Irvine (2008-2010), he joined International Center for Quantum Materials, Peking University as a tenure-track assistant professor, and was promoted to a full professor in 2018. Jiang's research fields are condensed matter physics and chemical physics. His research achievement covers from the innovative development of scanning probe microscopy/spectroscopy to the application of those techniques to probe atomic-scale properties of single molecules and low-dimensional materials. He has published over 60 peer-reviewed papers, including 2 in Science, 5 in Nature, and 10 in Nature Journals. His research works were selected as Top-ten Science Advances in China (2016, 2018). Selected awards include Distinguished Young Scholars of NSFC (2017), Tan Kah Kee Young Scientist Award (2018), Fellow of American Physical Society (2019), Nishina Asia Award (2020), AAA Robert T. Poe Prize (2020). Jiang serves on the Editorial Boards or Editorial Advisory Boards of Journal of Chemical Physics, Advanced Quantum Technologies, Chemical Physics, Chinese Physics Letters, etc.

Yanlin Song

Key Laboratory of Green Printing, Institute of Chemistry, Chinese Academy of Sciences
Email: ylsong@iccas.ac.cn

Green Printing Technology for Manufacturing of Functional Devices

Abstract

Based on the droplet drying process on the surfaces of different wettabilities, controllable nanoparticles assembling and stereo structures patterning could be achieved. [1] Through controlling the droplet spinning motion and movement of the vapor-solid-liquid three phase contact lines [2], the basic units (dot, line, plane and stereo structures) via the printing technology can be precisely controlled. Significantly, we achieved the silver nanoparticles assembled conductive patterns with single nanoparticle resolution.[3] Our further work on assembling metal nanomaterials or graphene via printing process, patterned various linear or curved 1D/2D structures on diverse substrates.[4] The desirable conductive patterns contribute the remarkable application on sensitive electronical skin[4a], transparent touch screen[4b,c], multi-layer circuits[4d], ultra-integrated complex circuits[4e] and soft actuators[4f]. Moreover, stereo structures can be prepared through manipulating the solid-solid interface, which contributes to a versatile additive manufacture procedure. [5] This achievement on printed electronics and additive manufacture are benefited from the fundamental researches on interfacial wettability manipulation, morphology control of drying droplets, as well as functional nanomaterial fabrication, which constructs the theoretical and technical system of Green Printing Technology.

Biography

Yanlin Song is a professor in the Institute of Chemistry, Chinese Academy of Sciences (ICCAS). He received his Ph.D. degree from the Department of Chemistry at Peking University in 1996. Then he conducted research as a postdoctoral follow at Tsinghua University from 1996 to 1998. He has been working at ICCAS since 1998. His research interests include nano-materials and green-printing technology, printed electrics and photonics, fabrication and applications of nanostructured devices. He has published more than 400 papers with 19000 citations, 2 books and 12 chapters, and has been granted more than 120 patents from China, USA, European Union, Japan and Korea, etc.

Yongmei Zheng

Beihang University
Email: zhengym@buaa.edu.cn

Bioinspired dynamic wettability surfaces with micro- and nanostructures

Abstract

Biological surfaces provide endless inspiration for design and fabrication of smart materials. It has recently been revealed to have become a hot research area in materials and science world [1-2]. Inspired by the roles of micro- and nanostructures in biological materials and surfaces, such as spider silk, etc., a series of bioinspired functional surfaces with micro- and nanostrucutres can be fabricated to reveal the water harvesting properties. Otherwise, biological surfaces such as plant leaves and butterfly wings with gradient structure features display the effect of water repellency. Smart bioinspired micro- and nanostructured surfaces can be achieved to control the dynamic wettability, e.g., droplet transport or manipulation on surfaces with gradient features such as wettable difference in directions, etc. In addition, the water repellency at low temperature can be investigated on the superhydrophobic micro- and nanostructured surfaces for development of anti-icing/icephobic abilities. These as-designed micro- and nanostructured surfaces will offer insights into design of novel materials for promising applications such as water harvesting, anti-icing, etc..

Biography

Yongmei Zheng, PhD, is a professor at School of Chemistry, Beihang University. Research interests are focused on bioinspired surfaces with gradient micro- and nanostructures to control dynamic wettability, and develop the surfaces with characteristics of water repellency, anti-icing, or fog-harvesting, tiny droplet transport, and so on. Publications are more than 100 SCI papers included in Nature, Adv. Mater., etc., with 14 Cover stories, and 2 books in Pan Stanford Publishing and Elsevier, respectively. Her work was highlight as scientist on News of Royal Society of Chemistry, ChemistryWorld in 2014. She is a member of Chinese Composite Materials Society (CSCM), American Chemistry Society (ACS), International Society of Bionic Engineering (ISBE), and International Association of Advanced Materials (IAAM). She wins an ISBE outstanding contribution award in 2016 by ISBE.

Invited Speakers

Zhizhao Che

State Key Laboratory of Engines, Tianjin University, Tianjin 300072, China
Email: chezhizhao@tju.edu.cn

Flow dynamics and heat transfer in droplet impact process

Abstract

The impact of droplets on solid and liquid surfaces is ubiquitous in nature and play an important role in industrial engineerings, such as energy, chemical, environmental, and aerospace engineering. Under the interactions of different forces and the coupling effect among various influencing factors, small droplets can undergo dramatic deformation and exhibit complex dynamics behaviors, and leave many scientific questions for researchers to answer. In this talk, several droplet impact phenomena are discussed, including droplet impact on high-temperature surfaces, droplet impact in high environmental pressure, impact of high-viscosity droplets, and impact of volatile droplets. During the droplet impact on high-temperature surfaces, the bottom interface of the droplet, rather than remaining stable, may oscillate rapidly during the rebounding stage of the droplet in the Leidenfrost state. During the impact of droplets in high environmental pressure, the surrounding gas can lead to the splashing of the crown in a thread rupture mode and the threshold impact speed of the splash decreases with increasing the environmental pressure. During the impact of high-viscosity droplets, a surface-climbing jet occurs besides the widely known Worthington jet, forming a two-jet phenomenon. In the study of the impact of volatile droplets, we propose a method to measure the vapor concentration field based on the modified background oriented Schlieren. The complex structure of the vapor cloud during the impact process is revealed and is the result of the interplay among fluid inertia, fluid evaporation, vapor diffusion, vapor convection, and droplet shape evolution.

Feng Chen

Xi'an Jiaotong University, Xi'an, 710049, P. R. China
Email: chenfeng@mail.xjtu.edu.cn

Femtosecond laser bionic fabrication

Abstract

Biological micro/nano-structures all comprise the goals for the next-generation smart artificial materials and devices. Recently, femtosecond (fs) laser has becoming a powerful tool to fabricate complex three-dimensional microstructures and devices. Various femtosecond-laser-based processes have been used for machining high-precise microstructures and devices with arbitrary shapes and the unique properties. In this talk, we introduce the recent progress in fs-laser bioinspired fabrication of micro-/nano-structures and devices, includes artificial compound eye, 3D microstructures inside transparent materials, bioinspired wetting surfaces. The unique ability of fs-laser bioinspired fabrication opens up a new avenue for fabricating a variety of smart μ-feature functional structures & surfaces and their potential and applications for high value manufacturing purposes.

Huhu Cheng

Department of Chemistry, Tsinghua University, Beijing 100084, PR China
Email: huhucheng@tsinghua.edu.cn

Moisture-enabled electricity generation (MEG) based on graphene assemblies

Abstract

The transformation of energy in clean and renewable sources into mechanical or electric power is highly important for reducing environmental pollutions and satisfying the growing electricity demands in our daily life. As a widely existed power source, the energy embedded in moisture diffusion is huge and ubiquitous in atmosphere. However, the utilization of this unexplored energy source is a big challenge. With systematical regulation on graphene assemblies and so on, we have developed novel moisture-triggered actuators and moist-electric generator (MEG), which can make the device move or produce electric power when gaseous or vaporous water molecules diffuse from air to functional materials, transforming the energy in moisture into useful mechanical energy and electricity directly. The voltage of MEG unit has achieved to with a high value of ~1.5 V. Exceptionally high voltage (e.g., 20 V with 17 units) can be easily reached by simply scaling up MEG units in series, enough to drive many commercial electronic devices. Our effort on this new type of energy conversion device provides a new insight for design and development of functional materials and MEG, which will highly promote the efficient conversion of potential energy in environmental atmosphere to electricity towards practical applications.

Zhichao Dong

Affiliation: CAS Key Laboratory of Bio-inspired Materials and Interface Sciences,
Technical Institute of Physics and Chemistry, Chinese Academy of Sciences,
Email: dongzhichao@iccas.ac.cn

Directional liquid dynamics of interfaces with superwettability

Abstract

Natural creatures use their surface structures to control directional liquid dynamics for survival. Learning from nature, artificial superwetting materials have triggered technological revolutions in many disciplines. To improve controllability, researchers have attempted to use external fields, such as thermal, light, magnetic, and electric fields, to assist or achieve controllable liquid dynamics. Emerging directional liquid transport applications have prosperously advanced in recent years but still present some challenges. This talk discusses and summarizes the field of directional liquid dynamics on natural creatures and artificial surfaces with superwettabilities and ventures to propose several potential strategies to construct directional liquid transport systems for open microfluidic chip, 3D printing, water harvest, separation, which are useful for driving liquid transport or motility.

Jun Gao

Qingdao Institute of Bioenergy and Bioprocess Technology, Chinese Academy of Sciences, Qingdao, 266101 China
Email: jun.gao@qibebt.ac.cn

Artificial sodium channel based on crown-ether crystals with subnanometer pores

Abstract

Biological sodium channels ferry sodium ions across the lipid membrane while rejecting similar-sized potassium ions and other metal ions. Realizing such ion selectivity in an artificial solid-state nanochannel will enable new separation technologies but remains highly challenging. In this work, we for the first time report a biomimetic artificial sodium channel with high selectivity, built on newly synthesized porous crown-ether crystals which consist of densely packed and parallelly aligned 0.26-nm-wide pores. These extremely narrow pores are expected to exhibit strong steric hindrance to both bare K^+ (0.27 nm) and hydrated multivalent ions (>0.4 nm). As a result, the Na^+ selectivity of the artificial sodium channel reached 15 against K^+, which is comparable to the biological counterpart, 523 against Ca^{2+}, which is nearly two orders of magnitude higher than the biological one, and 1128 against Mg^{2+}. This work may contribute to the understanding of the structure-performance relationship of ion selective nanopores.

Huizeng Li

Key Laboratory of Green Printing, Institute of Chemistry, Chinese Academy of Sciences
Zhongguancun North First Street 2,100190 Beijing, PR China
Email: lihz@iccas.ac.cn

Controllable droplet dynamics manipulated by heterogeneous surface wettability

Abstract

All organisms interact physically as solids with their gaseous and liquid environment. Defined as boundary layers, surfaces are a significant player in biomimetic interactions. Thus, it is no surprise that organisms evolved a stunning diversity of most complex and usually multifunctional structured surface architectures. Droplet impacting and bouncing off solid surface plays a vital role in various biological/physiological processes and engineering applications. However, due to a lack of accurate control of force transmission, the maneuver of the droplet movement and energy conversion is rather primitive. Taking advantage of the heterogeneous surface wettability design, we achieved precise control of the droplet dynamic behaviors.

Using low-adhesive stripes on high-adhesive surfaces, the droplet can be instantaneously split into a controlled number of subdrops and deposited into desired locations with desired morphology. We demonstrated that the mass exchange during the droplet splitting process can be prohibited, thus offering an avenue for multi-detection using only one drop of sample. Further, we realized droplet rotationally rebounding after impacting on superhydrophobic surfaces with superhydrophilic spirals. Through pattern optimization, the droplet rotational speed reached more than 7300 revolutions per minute. During this process, the translational motion of the impacting droplet can be converted into rotation, which seemingly violates “Newton's Law of Impact”. We further proposed the general principle for droplet dynamics control using heterogeneous wettability surfaces, considering the rotational symmetry and mirror symmetry of the wettability patterns. The findings deepen the understanding of the interactions between droplet and heterogeneous wettability surfaces, and show potential for advanced detection and energy collection.

Xiaoguang Li

School of Physical Science and Technology, Northwestern Polytechnical University, Xi'an, China
Email: lixiaoguang@nwpu.edu.cn

Liquid Plasticines as Shapable Liquid Containers for Chemical Reactions and Bioanalysis

Abstract

Here we report a self-supporting liquid container with solid-like plasticity, which is achieved by coating a liquid droplet/pancake with hydrophobic particles and subjecting the interfacial particles to jamming. We have proposed “liquid plasticine” to name it and this term has been gradually adopted by other researchers. Liquid plasticines can be readily cut or joined without liquid flowing away. The inner stuff can be extracted by easy insertion of a pipettor into a liquid plasticine. In addition, a liquid plasticine with a complex shape features very large specific surface area compared with a common droplet, resulting in high efficiency when gas is involved in liquid plasticine applications. When a cylindrical liquid plasticine is used as a gas sensor, it not only detects the existence of target gas but also reveals the gas diffusion speed and frontier concentration. We have also applied liquid plasticines in protein analysis. In this application, a “工” shaped liquid plasticine is produced to realize separation of different kinds of proteins with the aid of isoelectric focusing technique. The separated proteins can be in-situ analyzed and easily extracted for further analysis. The channel structure, designable shape, and other superior intrinsic properties endow liquid plasticines with great application potential in chemistry, material, and biomedicine areas.

Yahua Liu

School of Mechanical Engineering, Dalian University of Technology Dalian, China
Email: yahualiu@dlut.edu.cn

Efficient drop transportation on structured surfaces

Abstract

Regulating drop transportation on structured surfaces is essential to various potential applications, such as self-cleaning, water-harvesting, cooling and heat and mass transfer. However, this kind of research is still in the rough. For instance, there exists a theoretical contact time limit which is imposed by the classical hydrodynamics and the directional droplet motion is still hard to be controlled especially at high temperature. In this talk, I will briefly discuss our recent efforts to these puzzles. [1-4] Several droplet bouncing mechanisms were put forward to reduce the contact between impinging droplets and the underlying solid surfaces and the corresponding textured superhydrophobic surfaces have been sculptured to realize this goal. We believe the research which can achieve enhanced droplet transportation will stimulate new applications.

Cunjing Lv

Department of Engineering Mechanics, Tsinghua University, 100084, Beijing China
Email: cunjinglv@tsinghua.edu.cn

Extreme Hydrophobicity – Beyond Nature

Abstract

Superrepellency is a favorable nonwetting scenario (Cassie wetting state) featuring a dramatic reduction of the solid/liquid contact area. However, when subjected to external disturbances, water may readily penetrate the surface textures, transforming into a Wenzel wetting state, and it has been assumed that the reverse transition cannot happen spontaneously after the external disturbance has been removed. The robustness of superhydrophobicity challenges practical applications of water- repellent materials. Recently, we devoted to developing strategies to promote the robustness of superhydrophobicity from the source. We found the existence of a "monostable" region in the phase space of surface chemistry and roughness, where transitions from Cassie to Wenzel states become spontaneously reversible. Moreover, we also created a microskeleton-nanofiller (MSNF) film which could highly increase the ability to resist abrasion and maintain the superhydrophobicity. Moreover, we will show spectacular properties of wetting dynamics resulting from the monostability and superhydrophobicity, such as a deep self-cleaning effect and lubricant film-induced contact time reduction on moving superhydrophobicity surfaces. These results would guide further design and engineering of robust superrepellent materials.

Shichao Niu

Key Laboratory of Bionic Engineering, Ministry of Education, Jilin University, 130022, People's Republic of China.
5988 Renmin Street, Changchun,130022, China
Email: niushichao@jlu.edu.cn

Nature-inspired antireflection structurs and functional materials

Abstract

Nature creatures can always provide perfect strategies for excellent antireflection (AR), which is valuable for photovoltaic industry, optical devices, and flexible displays. Cicada wings, covered with arranged nanostructure, were widely studied owing to their highly transparency and low reflection. However, limited by technologies, its exquisite surface structures and multifunctional features were not inherited and applied by most artificial materials adequately. Here, the excellent optical properties of cicada wing were investigated in details experimentally and theoretically. Besides, a flexible self-cleaning broadband antireflective film inspired by the cicada wing has been successfully fabricated by a well-designed biological template method and sol-gel process. The cicada wing (Megapomponia intermedia) was selected as the original template directly, and a SiO_2 negative replica was obtained by a sol-gel process. Then, chemical corrosion was used to remove the original template, remaining the pure negative replica. Subsequently, the PMMA positive replica could be rebuilt after another sol-gel process. Compared with flat PMMA film, the average reflectivity of structural PMMA film over the visible region was reduced from 10% to 2%. Besides, the bio-inspired film with a thickness of 0.18mm exhibited satisfactory comprehensive performances with low reflectance ($\leqslant$2%) in most of visible region, as well as superhydrophobic property (CA=152°, SA=3°) and perfect flexibility. On the other hand, a novel large-scale flexible AR film is inspired by the cicada wings and successfully fabricated with a recycled template. The adjustable structures on porous template make it possible to optimize the design of AR structure parameters towards the practical demand. It breaks the limitation of the biological organism size, accomplishing the replication of AR nanostructure units in a large scale. Interestingly, Even the film is covered by the enlarged dome cone arrays, it still maintains almost perfect AR property, achieving excellent scale-insensitivity AR performance. This work numerically and experimentally investigates its scale-insensitivity AR performances in detail. Compared with subwavelength nano cones, the enlarged cones change the original optical behaviors, and the proportion of transmitted light is reduced while scattering and absorption increases. Based on this, this bio-inspired scale-insensitivity AR arrays could be used in flexible display, photothermic conversion, solar cell, and so on.

Meirong Song

College of Science, Henan Agricultural University/Henan international joint laboratory of laser technology in agricultural sciences, Zhengzhou, 450000, China
Email: smr770505@iccas.ac.cn

Bionic Directional Droplet Bouncing

Abstract

Starting from the dynamic physical phenomenon of droplets hitting solids in nature, we try to discover new phenomena of directional droplet bouncing, summarize their characteristics, reveal the underlying mechanism about the interaction of gas, liquid, and solid. These studies can be potentially applied into material and information transportation, electricity generation and other fields.

Fengchao Wang

Department of Modern Mechanics, University of Science and Technology of China, Hefei, Anhui, China
Email: wangfc@ustc.edu.cn

Theory of Wetting and Capillary Condensation on the Nanoscale

Abstract

Wetting and capillary phenomena on the macroscale are ubiquitous and have been well understood. However, the relevant physics and mechanics on the nano-scale still remain mysterious. In this talk, I would like to discuss the exploration of capillarity from a nanoscopic perspective, including wetting, evaporation and condensation. At the solid/liquid interface, the liquid exhibits a pronounced layered structure that extends over several intermolecular distances from the solid surface. Our recent studies have shown that such molecular detail could provide some new understanding on century-old classical theory in this field, such as Young's equation and Kelvin equation.

Jiwei Wen

College of Environment and Civil Engineering, State Key Laboratory of Geohazard Prevention and Geoenvironment Protection, Chengdu University of Technology, Chengdu City, Sichuan Province, China 610059
Email: wenjiwei2014@cdut.edu.cn

Bionic Optimization of Straight Cone Nozzle Structure for Reducing the Fluid Resistance

Abstract

High-pressure water jet technology (H-PWJT) is a clean and effective approach to break, cut or clean solid materials. H-PWJT has been widely utilized resulting in remarkable social and economic benefits in several engineering and technical disciplines and may be combined with other technologies to develop new ones, such as high-pressure jet grouting, high-pressure jet mining, hydraulic jet fracturing, etc. Nozzle is a fundamental component in the implementation of H-PWJT, its hydraulic performance determines the efficiency and quality of H-PWJT directly. Since the early years of human society development, mankind has been influenced by the observation, study, and imitation of the natural world and its creatures, resulting in the development of several tools and devices. The influence of natural occurrences has resulted in the overall advancement of technology ranging from the simple to the complex. Learning and simulating biology is one of the most relevant innovative ways to develop new technologies. Increasingly, scientists and engineers are actively seeking new design ideas and principles from the biological world, resulting in numerous innovations to face current challenges. Engineering Bionics (EB) is best described as the intersection between bionics and engineering technology. EB seeks to solve technical problems in the field of engineering by providing new ideas, theories and methods for engineering and technical innovation. Moreover, it can promote the birth of various bionic technologies and products which are characterized by

their high efficiency, low energy consumption, and powerful function. The fluid resistance reduction technology of bionic non-smooth surface is applied to the structural design of the straight cone nozzle (SCN) successfully. The circular groove is selected as the bionic unit. The selection results in the investigation and developed of a bionic straight cone nozzle (BSCN) with the optimum hydraulic performance. Moreover, the separated nozzle machining method is successfully implemented. A comprehensive approach that implements the orthogonal experiment, high-pressure water jets' impact forces testing, and range analysis results in the optimization of the BSCN's structure. The optimal structural parameters of the BSCN as follows: the outlet diameter is 4 mm, length-to-diameter ratio is 2.5, contraction angle is 60°, the circular groove width is 3 mm, the circular groove depth is 2 mm and the circular groove number is 2. In addition, the circular grooves are uniformly arranged on the surface of the SCN's internal chamber resulting in reducing the fluid resistance effectively. Under the same experimental conditions, the impact forces of high-pressure water jets produced by the BSCNs are greater in comparison to the impact forces of high-pressure water jets produced by the ordinary SCNs. The average rate of fluid resistance reduction of BSCNs is up to 2.33 %. Furthermore, the results of CFD numerical simulation show that the circular grooves at the contraction and the outlet sections can also reduce the high-pressure water flow resistance effectively. In the meantime, the opposite rotating vortexes in the circular grooves is the main reason for the reduction in fluid resistance of the BSCN.

Huaping Wu

College of Mechanical Engineering, Zhejiang University of Technology, Hangzhou 310023, China
Email: wuhuaping@gmail.com

Static and Dynamic Wetting Behaviour of the Droplet on the Microstructure Surface

Abstract

Mimicry of the surface microstructure and wetting characteristics via artificial patterned surfaces exhibits broad applications in bionic engineering. Here, we report static and dynamic wetting behaviours of the droplet based on the superhydrophobic surfaces with hierarchical structures. Combined with thermodynamic theory and energy principle, the theoretical models of static wettability stability, underwater wettability, and anti-wettability of flexible hierarchical microstructure surface are established. The sidewall microstructure design and mechanical strain control criteria of wetting characteristics of solid-liquid interface are clarified, which provides guidance for the design of superhydrophobic bionic hierarchical architecture. Additional efforts on dynamic wetting states of the droplet on the tailorede surface have demonstrated to extend the wettability mechanism. The flexible superhydrophobic cone array substrate and superhydrophobic curved surface structure have been proposed as an effective route to promote the complete rebound of droplets. Furthermore, the influence of vibration frequency, amplitude, and impact phase on droplets rebound on the surface of vibratory superhydrophobic cone array are investigated by constructing an active vibration platform with loudspeakers and a power amplifier. The vibration control of circular cone microstructure array surface effectively regulates the contact time of pancake bouncing of the droplets, thereby allowing the droplets to achieve rapid rebound. The theoretical approach and experimental results provide a unique strategy for developing static and dynamic wetting behaviour of the droplet on the bionic microstructure surface, which delivers promising opportunities in self-cleaning, anti-icing, and waterproofing.

Jianing Wu

School of Aeronautics and Astronautics, Sun Yat-Sen University, Shenzhen, China

Email: wujn27@mail.sysu.edu.cn

Liquid transport through animal appendages: Morphological and mechanical perf

Abstract

Drinking is a fundamental technique for animals ranging from flies to whales. Million years of evolution drives animals to develop a variety of specialized organs and specific techniques to drink, which not only overcomes environmental constraints but augments the survival rate of animals. We combine experimental and theoretical investigation on two animal models, namely the western bee and African elephant, to understand enigmas embedded in the feeding behavior, including the high efficiency in liquid uptake and the potentially optimal strategies for saving energy. This work may enlighten extensive methodologies to evaluate feeding behavior of animals, and open up a new way to design liquid transport facilities.

Jinbo Wu

Shanghai University, Shanghai, China

Email: jinbowu@t.shu.edu.cn

Clonable Droplet Array with Physical Unclonable Functions

Abstract

Based on the lyophilic surface patterning and discontinuous dewetting technology, we can generate droplet array by liquid strip sliding in high throughput manner. These surface droplets are confined by the lyophilic patterning shape and possess clonable information. Combining evaporative self-assembling for thin film deposition, we further coupled the clonable information with Physical Unclonable Functions (PUFs). The level of hardware or information security can be increased by applying PUFs, which have a high complexity and unique nonreplicability and are based on random physical patterns generated by nature, to anti-counterfeiting and encryption technologies. The preparation of PUFs should be as simple and convenient as possible, while maintaining the high complexity and stability of PUFs to ensure high reliability in use. By adjusting the temperature and lyophilic region for evaporation-induced self-assembly, we fabricated perovskite nano-crystal film anti-counterfeiting labels with clonable micro-shape and unclonable micro-texture. The film patterns showed high tunability from shape to inner part and from the microscale to the macroscale, high-throughput preparation could be achieved at low cost, and each thin film had a unique texture. At the same time, we established a set of matching recognition algorithms. The data could be refined and classified by changing the shape of the film, and the refining classification could accelerate the recognition speed. It only took a few seconds to complete the authentication. The user only needs a portable microscope with UV light and a smart phone to complete the verification, so no expensive equipment or professional training is needed. Combined the low cost (2.1×10-4 USD), convenient and fast authentication (12.17s) and large encoding capacity (2.1×10623), our anti-counterfeiting technology shows

outstanding overall performance. In addition, an all-inorganic perovskite single-crystal array with a controllable morphology and a random size was prepared by a one-step recrystallization method in the droplet array to generate all-photonic cryptographic primitives. The nondeterministic size of the perovskite nanorods mainly arises from crystal growth in an indeterminate direction, producing a high entropy for the system. Therefore, the prepared perovskite nanorod array with random sizes can be transformed into a quaternary cryptographic key array following encoding rules based on the lasing-mode number. Superior lasing stability was observed for the all-inorganic perovskite under continuous excitation, demonstrating the high reliability of this application.

Longjian Xue

Department of Materials Engineering, Wuhan University, South Donghu Road 8, Wuhan 430072, China

Email: xuelongjian@whu.edu.cn

Bioinspired structured adhesives for various surfaces

Abstract

Many animals, like geckos and insects, can stand and crawl on almost all kinds of solid surfaces in natural environment. On one hand, the micro- & nano-structures on the toe pad of these animals allow them to form effective contacts on various surfaces, generating strong adhesion forces. On the other hand, they can also detach from the adhered surface easily. Inspired by these adhesive microstructures, we have obtained a series of bioinspired micro- & nano-pillar arrays with strong adhesions, even surpass the gecko's feet. Using materials responsible to stimuli, like light, electricity, temperature and humidity, a variety of intelligent structured adhesives with controllable adhesions are obtained. Making use of shape memory resin, we obtained a micropillar array with strong adhesion on various rough surfaces, and the adhesion can be switched by light and temperature. Moreover, the incorporation of nanopits, which are inspired by tree frog foot, onto the tip of micropillars endows them with strong adhesion on wet surfaces. Furthermore, we introduced the bioinspired asymmetric micropillar array into a soft robot, allowing it to move on smooth / rough, dry / wet, up / down slope surfaces at high / low temperatures.

Lidong Zhang

Department of Chemistry and Molecular Engineering, East China Normal University, Shanghai, 200241, People's Republic of China

E-mail: ldzhang@chem.ecnu.edu.cn

Electrochemistry-Induced Improvements of Mechanical Strength, Self-healing, and Interfacial Adhesion of Hydrogels

Abstract

Hydrogels have demonstrated great potential in biomedical and engineering areas. To improve its physical performances, development of efficient physical/chemical protocols is essential. This work reports an electrochemistry functionalization strategy that is capable of enabling the functional improvements of hydrogel in the mechanical strength, interfacial adhesion, healing capability, and modular sensitivity. We demonstrate the electrochemistry functionalization on a hydrogel model of polyacrylamide (PAAm)@κ-carrageenan. The electrochemistry reaction generates metal ions (Fe^{3+}) that migrates and coordinates with the sulfate groups of κ-carrageenan resulting in the prominent function improvements. In comparison with untreated PAAm@κ-carrageenan hydrogel, it can improve the mechanical strength by 7.37 times, and can increase the interfacial adhesion energy of the hydrogel on a glass surface from zero to 1400 J m–2, stronger than the bonding strength of tendons (adhesion energy: ~ 800 J m–2). Two pieces of hydrogel strips integrate into an intact structure by the electrochemistry functionalization, where the healing efficiency reaches 100% in comparison to the untreated hydrogel, which allows convenient suturing of hydrogel upon being broken as a bionic skin. The most significant development is that it enables functional patterning on hydrogel by the electrode assembly, which provides the hydrogel modular sensitivity to external pressure, analogous to the sensing systems of human skin. Therefore, it can be a general protocol for rapid generation of multifunctional hydrogels for biomedical and engineering developments. .

Lei Zhao

School of Mechanical Engineering, Dalian University of Technology, Dalian, Liaoning, 116024, China
Department of Mechanical Engineering, University of California at Santa Barbara, Santa Barbara,California 93106-5070, USA
Department of Chemistry, University of California at Santa Barbara, Santa Barbara,California 93106-5070, USA
Email: leizhao@dlut.edu.cn

Depinning of Multiphase Fluid Using Light and Photo-Responsive Surfactants

Abstract

The development of non-invasive and robust strategies for manipulation of droplets and bubbles is crucial in various applications such as boiling and condensation, electrocatalysis and microfluidics. In the present study, we develop a viable bubble/droplet manipulation strategy using photo-responsive surfactants. We designed and synthesized a photo-responsive surfactant capable of achieving fast, reversible, and significant interfacial changes of different solvents. In this work, we demonstrate the removal of droplets and bubbles pinned on a solid substrate using photo-responsive surfactants and low intensity lights. This is achieved by creating a net force on the bubble or droplet due to the Marangoni effect induced by the non-uniform distribution of these photo-responsive surfactants. Since light is used to activate the Marangoni effect, we term it as the photo-Marangoni effect. In particular, we demonstrate that a pinned toluene droplet can depart from the solid substrate in 0.38 second. For pinned air bubbles, the maximum departure volume can be reduced by 20%. A numerical model is developed to understand the dominating factors contributing to the bubble and droplet departure. This study can advance the fundamental understandings on bubble and droplet dynamics and the physical insights gained can be broadly applied to various applications, such as drug delivery, boiling heat transfer and electro-catalysis.

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Youhua Jiang

Guangdong Technion-Israel Institute of Technology
Email: youhua.jiang@gtiit.edu.cn

Droplet Depinning on Pored and Pillared Superhydrophobic Surfaces

Abstract

Droplet pinning on solid substrates are important to many transport phenomena topics relating to bionics, including the lotus leaves-inspired surfaces with low liquid adhesion, springtail skin-inspired surfaces with high underwater durability, rice leaves-inspired surfaces with directional liquid transport, etc. Therefore, it is critical to understand how surface structures affect the droplet pinning. Here, we showed that the effective contact line length, i.e., the length of three-phase contact line that contributes to droplet pinning, vary depending on the morphology and size of microstructures. Specifically, the pore structures have little effect on droplet pinning. By contrast, the entire pillar tip perimeter contributes to the contact line pinning for sparsely packed pillar structures and decreases to the pillar tip diameter as the pillars are packed denser. This new finding suggests that the microscopic solid-liquid interaction varies depending on the morphology and packing density of solid structures, which largely opposes to prior notions.

Session 2: Nature-inspired structural and functional materials

17 July, Saturday (Day 1)

13:30-15:25	Session 2 Nature-inspired structural and functional materials - I
	Room II (ID: 918 9284 7866)

Chair: Qi Ge, Bin Wang, Daoai Wang, Xuechang Zhou

13:30-13:50	KEYNOTE TALK
	Smart Patterned Surface with dynamic wrinkles
	Xuesong Jiang, *Shanghai Jiao Tong University*
13:50-14:10	KEYNOTE TALK
	Bio-inspired mechano-functional gels through multi-phase order-structure engineering
	Mingjie Liu, *Beihang University*
14:10-14:25	INVITED TALK
	Fabrication of polymer/metal composite micro/nano array structures and their applications in biological interfaces and actuators
	Hongxu Chen, *Jiaxing University*
14:25-14:40	INVITED TALK
	Droplets Manipulation on Bioinspired Multi-gradient Surfaces
	Shile Feng, *Dalian University of Technology*
14:40-14:55	INVITED TALK
	Bioinspired Nanostructured Films with Controllable Wettability for Multifunctional Applications
	Yuekun Lai, *Fuzhou University*
14:55-15:10	INVITED TALK
	Biomimetic Artificial Nose for Gas Detection Based on 3D Porous Laser-induced Graphene
	Jianxiong Zhu, *Southeast University*
15:10-15:25	INVITED TALK
	Bioinspired surface/interface lubrication materials & devices
	Shuanhong Ma, *Lanzhou Institute of Chemical Physics, CAS*

15:30-17:45	Session 2 Nature-inspired structural and functional materials - II
	Room II (ID: 918 9284 7866)

Chair: Qi Ge, Bin Wang, Daoai Wang, Xuechang Zhou

15:30-15:45	INVITED TALK
	Nature-Inspired Energy Harvesting Strategy Based on Adhesive Interface and Hydrophilic Interface
	Daoai Wang, *Lanzhou Institute of Chemical Physics, CAS*
15:45-16:00	INVITED TALK
	3D Printing of bio-inspired surface with oriented structure and frictional anisotropy
	Xiaolong Wang, *Lanzhou Institute of Chemical Physics, CAS*

16:00-16:15	INVITED TALK
	Naked-eye Radiochromic Film Dosimetry via Continuously Tunable Bandgap
	Yunlong Wang, *Nanjing University of Aeronautics and Astronautics*
16:15-16:25	ORAL PRESENTATION
	A novel high toughness cementitious structural material via biomimetic design
	Hao Pan, *Southeast University*
16:25-16:35	ORAL PRESENTATION
	Multi-material additive manufacturing of a bionic layered ceramic/metal structure: Formation mechanisms, gradient interface and mechanical properties
	Rui Wang, *Nanjing University of Aeronautics and Astronautics*
16:35-16:45	ORAL PRESENTATION
	Mechanically efficient corrugated structures inspired by mantis shrimp: optimization, mechanism, and laser 3D printing
	Jiankai Yang, *Nanjing University of Aeronautics and Astronautics*
16:45-16:55	ORAL PRESENTATION
	Nature-inspired nacre-like composites combining human tooth-matching elasticity and hardness with notable damage tolerance and fatigue properties
	Guoqi Tan, *Institute of Metal Research, Chinese Academy of Sciences*
16:55-17:05	ORAL PRESENTATION
	Study on the energy absorption of sandwich plate inspired by the seagull feather rachis
	Jianfei Zhou, *Jilin University*
17:05-17:15	ORAL PRESENTATION
	Plasma electrolytic oxidation coating of magnesium alloy with corrosion resistance and durability
	Qianqian Cai, *Changchun University of Science and Technology*
17:15-17:25	ORAL PRESENTATION
	Metal-ceramic composites with biomimetic structures fabricated by freeze casting and pressure infiltration
	Meng-Qi Sun, *Jilin University*
17:25-17:35	ORAL PRESENTATION
	Fabrication of Transparent and Robust Superhydrophilic Anti-fogging Coating by Polymer and Inorganic nanoparticles Hybridization
	Weilin Deng, *Southeast University*
17:35-17:45	ORAL PRESENTATION
	How an elastic rod strengthens honey bee versatile tongue
	Jiangkun Wei, *Sun Yat-Sen University*

18 July, Sunday (Day 2)

08:30-10:25	**Session 2 Nature-inspired structural and functional materials - III**
	Room II (ID: 918 9284 7866)
	Chair: Qi Ge, Bin Wang, Daoai Wang, Xuechang Zhou
08:30-08:50	KEYNOTE TALK
	Bio-inspired materials for controlling ice formation
	Jianjun Wang, *Institute of Chemistry, CAS*
08:50-09:10	KEYNOTE TALK
	Biomimicking functionally cooperating systems for the design of mini-generator
	Feng Shi, *Beijing University of Chemical Technology*
09:10-09:25	INVITED TALK
	Femtosecond laser microfabrication towards highly functional biomimetic structures
	Dong Wu, *The University of Science and Technology of China*
09:25-09:40	INVITED TALK
	Polymers for photoinduced reversible solid-to-liquid transitions
	Si Wu, *The University of Science and Technology of China*
09:40-09:55	INVITED TALK
	Photo-steered deformation and locomotion of nanocomposite hydrogels
	ZiLiang Wu, *Zhejiang University*
09:55-10:10	INVITED TALK
	The Biomimetic Controllable Adhesion Surface Design and Preparation with High Performance
	Quan Xu, *China University of Petroleum (Beijing)*
10:10-10:25	ENTERPRISE TALK
	高精度大幅面PμSL 3D打印技术及其在仿生领域的应用
	Ying Peng, *Boston Micro Fabrication Inc.*
10:30-11:35	**Session 2 Nature-inspired structural and functional materials - IV**
	Room II (ID: 918 9284 7866)
	Chair: Qi Ge, Bin Wang, Daoai Wang, Xuechang Zhou
10:30-10:50	KEYNOTE TALK
	Bioinspired wet/adhesion/lubrication interface
	Feng Zhou, *Lanzhou Institute of Chemical Physics, CAS*

10:50-11:05	INVITED TALK
	Spontaneous Fast Droplet Transport Without Mass Loss on Architectured Slippery Surfaces
	Xiaolong Yang, *Nanjing University of Aeronautics and Astronautics*
11:05-11:20	INVITED TALK
	Microscale Shape-Morphing with 3D Reconfigurable Morphology
	Chunhong Ye, *ShanghaiTech University*
11:20-11:35	INVITED TALK
	Superhydrophobic coatings for energy saving and environment protection: from materials to equipment
	Youfa Zhang, *Southeast University*
13:30-14:30	**Session 2 Nature-inspired structural and functional materials - V**
	Room II (ID: 918 9284 7866)
	Chair: Qi Ge, Bin Wang, Daoai Wang, Xuechang Zhou
13:30-13:45	INVITED TALK
	Bioinspired Nanostructures with Long-term Mechano-Bactericidal effectiveness
	Jie Zhao, *Jilin University*
13:45-14:00	INVITED TALK
	A Floquet-Based Bar-Spring Model for Load-Bearing Biological and Bioinspired Composites
	Zuoqi Zhang, *Wuhan University*
14:00-14:15	INVITED TALK
	Laser powder bed fusion of bio-inspired honeycomb structures: effect of twist angle on compressive behaviors
	Kaijie Lin, *Nanjing University of Aeronautics and Astronautics*
14:15-14:30	INVITED TALK
	Bioinspired natural energy collection and biomass resource utilization strategy
	Zhuangzhi Sun, *Northeast Forestry University*

Keynote Speakers

Xuesong Jiang
School of Chemistry & Chemical Engineering, Shanghai Jiao Tong University, Shanghai 200240, People's Republic of China.
E-mail: ponygle@sjtu.edu.cn

Smart Patterned Surface with dynamic wrinkles

Abstract

The responsive micro/nanoscale patterns on the surface whose morphology can be tuned dynamically by environmental stimulus can possibly enable the on-demand control of the surface properties, and provide an important alternative to realize the smart surface. Recently, we developed a facile and effective strategy for the fabrication of a reversible pattern with a morphology that can be dynamically erased and tuned in-situ by light, pH and temperature through introducing the dynamic chemistry into wrinkling systems. Taking dynamic photo-dimerization of anthracene as example, the key point for this strategy is that the modulus of the top layer can be tuned by the reversible cross-linking via photo-dimerization. The reversible nature of the photo-dimerization of anthracene enables the dynamic change of the pattern morphology from the smooth state to the wrinkle pattern, allowing for accurate control of the adhesion, wettability and optical properties of the resulting surface. This one-step and robust approach for the fabrication of complex tunable wrinkle patterns provides the possibility that surface properties can be controlled on demand.

Biography

Prof. Xuesong Jiang was born in 1977 in China, and earned his Bachelor degree from East China University of Science and Technology (ECUST) in 1999 and Ph.D. Degree from Shanghai Jiao Tong University (SJTU) in 2005, respectively. From 2009 to 2010, he worked as Postdoctoral in Georg-August-Universitat Gottingen, supported by the Alexander von Humboldt fellowship. Now, he is a professor in polymer department of Shanghai Jiao Tong University (SJTU), and is leading a research group of functional polymers for surface. He got some awards such as Hitachi-Chemical Outstanding Researcher of Oversea, and Outstanding Young Scientist Foundation of NSFC. His research is focused on surface pattern, especially nano and micro wrinkles, and their applications, and developed methods to realize dynamic and 2D ordered wrinkles.

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Mingjie Liu
Beihang University, Xueyuan Road #37, Haidian District, Beijing, China
Email: liumj@buaa.edu.cn

Bio-inspired mechano-functional gels through multi-phase order-structure engineering

Abstract

Adaptive gel materials can greatly change shape and volume in response to diverse stimuli, and thus have attracted considerable attention due to their promising applications in soft robots, flexible electronics and sensors. In biological soft tissues, the dynamic coexistence of opposing components (for example, hydrophilic and oleophilic molecules, organic and inorganic species) is crucial to provide biological materials with complementary functionalities (for example, elasticity, freezing tolerance and adaptivity). Taking inspiration from nature, we developed a series of high mechanical performance soft active materials, so-called organohydrogels, based on multiphase synergistic strategy. Traditional techniques such as post-polymerization modification, interpenetrating network and controlled micro-phase separation are combined with binary complementary concept to design and fabricate new organohydrogels with diverse topology of heteronetworks. Meanwhile, the synergistic effect of heteronetworks provided the organohydrogels with unprecedented mechanical functions such as freeze-tolerance, programmed high-strain shape memory and shaking insulation. Their applications in anti-biofouling, thin-film fabrication, flexible electronics and actuators are also explored.

Biography

Prof. Mingjie Liu is currently a full-time professor at Beihang University. He received his B.S. degree in applied chemistry (2005) from Beijing University of Chemical Technology. In 2005, he joined Prof. Lei Jiang's group and received his Ph.D. degree from the National Center for Nanoscience and Technology, Chinese Academy of Sciences (2010). He then worked as a postdoc in Prof. Takuzo Aida's group in Riken in Japan from 2010 to 2015. In 2015, he joined Beihang University and became a full professor. He has published 70+ papers in prestigious journals such as Nature, Nat. Rev. Mater, Nat. Mater. Nat. commun., Angew. Chem. Int. Ed.and Adv. Mater. His scientific interests focus on bio-inspired design of adaptive gel materials through multi-phase order-structure engineering and explore their applications in anti-biofouling coatings, thin-film fabrication, flexible electronics and soft robotics. He was awarded the National Science Fund for Distinguished Young Scholars (2017) and the Changjiang Scholars Program of China (2018).

Jianjun Wang

Institute of Chemistry, Chinese Academy of Science
Email: wangj220@iccas.ac.cn

Bio-inspired materials for controlling ice formation

Abstract

Understanding and controlling ice formation are of great importance in both fundamental research and practical applications. However, our understanding of ice formation is far from satisfactory. Nature has unique ways in regulating ice formation, for example, antifreeze proteins (AFPs) protect organisms from freezing damage by regulating ice formation via controlling the arrangement of hydroxyl groups. In this talk, I will first discuss our investigation into the fundamentals ice formation, e.g., ice nucleation and ice growth. Based on our understanding, we have synthesized a series of materials for regulating ice formation for various practical applications such as cryopreservation of cells as well as anti-icing coating with ultra-low ice adhesion.

Biography

Jianjun Wang obtained his Ph.D degree at Max-Planck Institute for Polymer Research and University of Mainz (Germany) in 2006. After the postdoctoral research, he became a project leader at Max-Planck Institute for Polymer Research in 2007. Since 2010, he has been a professor at the Institute of Chemistry, Chinese Academic of Sciences. His current research is focused on the molecular level understanding of ice formation and its applications such as cryopreservation of cells, organs and tissues. Dr. Wang is currently an Advisory Board member for Advanced Materials Interfaces.

Feng Shi

College of Materials Science and Engineering, Beijing University of Chemical Technology
Beisanhuan East Road 15, Beijing, 100029
Email: shi@mail.buct.edu.cn

Biomimicking functionally cooperating systems for the design of mini-generator

Abstract

The concept of 'functionally cooperating system', which integrates a few smart materials to function sequentially for a given task, has inspired design of mini-generators, especially on the aspects of harvesting weak energy from the environment. Previously, we have designed a functionally cooperating mini-generator by mimicking the functions of the swim bladder of bony fish for pressure-responsive vertical motions, which further facilitated the electricity generation in external magnetic field based on the Faraday's law. Such bio-mimicking mini-generators have been extended to other application scenes, such as blood-pressure responsive motions by connecting to a sheep's artery and electricity generation, converting sunlight energy into electric energy with a black diving-surfacing device, integrating the device with the fermentation line generating bubbles for motions and electricity. The basic principle of such mini-generators is the density fluctuation of the device under stimuli for reciprocating motions, which has inspired new designs of smart devices based on vertical motions. Recently, we have interpreted the motion mechanism of the common phenomenon of tea leaf dancing during the tea brewing process, especially for needle-like tea leave (e. g. the 'Jun Shan Yin Zhen' tea). The hierarchical porous structures of tea leaves contribute to containing air and the hydrophilic nature of tea leaf surfaces block the interior air, leading to a natural moving device in response to external pressure change. Inspired by the above features of tea leaves, we have designed a smart device consisting of a superhydrophilic surface and an empty chamber filled with a certain a mount of air. This device underwent reciprocating vertical motions in warm water (70 ℃) in an open glass container. The reasons for the motions are the vertical temperature gradient and the density fluctuation of the device in response to changes of external pressure. When exposing the device in a magnetic field, we have obtained a mini-generator converting weak thermal energy into electric energy. The tea-leaf-inspired functionally cooperating system holds promise to provide solutions to harvesting low-grade heat energy that is hard to be used into useful electric energy.

Biography

Feng Shi is a professor and doctoral supervisor at Beijing University of Chemical Technology. He received his bachelor's and master's degrees from Jilin University in 2001 and 2004, respectively. In 2007, he received his Ph.D. from Tsinghua University under the tutelage of Professor Xi Zhang. Since 2008, he started working as a full professor of Beijing University of Chemical Technology. His research interest is focused on macroscopic supramolecular assembly and its applications towards fabrication of supramolecular materials. Until now, he has totally 97 published papers, 5 issued patents and 1 book chapter, among which 68 are corresponding-authored papers published on journals regarding material science such as Adv. Mater., Adv. Funct. Mater., Angew. Chem. Int. Ed. etc. The total citation of all publications is more than 5000. Based on the above works, he has been awarded and supported with the National Science Fund for Distinguished Young Scholars (2019), Beijing Natural Science for Distinguished Young Scholars (2018), Cheung Kong Scholars Program Young Scholar (2016), National Science Fund for Excellent Young Scholars (2015) etc.

Kunyan Sui

State Key Laboratory of Bio-fibers and Eco-textiles, Shandong Collaborative Innovation Center of Marine Bio-based Fibers and Ecological Textiles, College of Materials Science and Engineering, Institute of Marine Biobased Materials, Qingdao University, Qingdao 266071, China.
Email: sky@qdu.edu.cn (K.S.)

Dual-Gradient Enabled Ultrafast Biomimetic Snapping of Hydrogel Material

Abstract

The design of materials that can mimic the complex yet fast actuation phenomena in nature is important but challenging. Herein, we present a new paradigm for designing responsive hydrogel sheets that can exhibit ultrafast inverse snapping deformation. Dual-gradient structures of hydrogel sheets enable the accumulation of elastic energy in hydrogels by converting prestored energy andrapidreverse snapping (<1 s)toreleasethe energy. By controlling the magnitude and location of energy prestored within the hydrogels, the snapping of hydrogel sheets can be programmed to achieve different structures and actuation behaviors. We have developed theoretical model to elucidate the crucial role of dual gradients and predict the snapping motion of various hydrogel materials. This new design principle provides guidance for fabricating actuation materials with applications in tissue engineering, soft robotics, and active medical implants.

Biography

Kunyan Sui is currently a Professor in the State Key Laboratory of Bio-Fibers and Eco-Textiles at Qingdao University. She is also the dean of College of Materials Science and Engineering. She received her Ph.D. degree in Materials Science and Engineering from Donghua University in 2003. Currently her research interests include smart hydrogel actuator, wearable ion-based devices, and smart marine polymer fibers, and some research results have been published in the journals of Science Advances, Advanced Functional Materials, Materials Horizons, Chemistry of Materials, etc. She was the recipient of a number of awards, including Qilu Female Inventors in Shandong Province Award, Excellent Scientific Research Achievement Awards of Shandong Provincial Education Department, etc.

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Feng Zhou

State Key Laboratory of Solid Lubrication, Lanzhou Institute of Chemical Physics, CAS
18 Middle Tianshui Road, Lanzhou 730000, China
Email: zhouf@licp.cas.cn

Bioinspired wet/adhesion/lubrication interface

Abstract

Wet-adhesion and wet-lubrication are two typical cases in nature. In the past 10 years, we have done a lot of research work on relative topics. I will introduce some recent progress of our research team in surface/interface wet/adhesion/lubrication. (1) Wet lubrication. Tissues, organs and cartilage etc are constituent of soft matters that usually provide extremely low friction. For example, natural articular cartilage has ultralow friction even at high squeezing pressure. Biomimicking cartilage with soft materials has been and remains a grand challenge in the fields of materials science and engineering. Inspired by the unique structural features of the articular cartilage, as well as by its remarkable lubrication mechanisms dictated by the properties of the superficial layers, we have developed a series of cartilage-mimicking layered lubrication material by robustly entangling thick hydrophilic polyelectrolyte brushes into the subsurface of high strength hydrogels. The topmost soft polymer layer provides effective aqueous lubrication, whereas the bottom high sytrength hydrogel layer used as a substrate delivers the load-bearing capacity. Their synergy is capable of attaining low friction coeffcients under heavily loaded conditions in water environment, a performance incredibly close to that of natural articular cartilage. These findings are theoretically explained and compounded by multiscale simulations, opens innovative technology routes for developing cartilage-mimicking ultralow friction soft materials. (2) Wet adhesion. Nowadays, robust underwater adhesives products are highly demanded both in industrial and biomedical fields. Meanwhile, study of the underwater adhesion mechanism of natural organisms under fluid environment is necessary, which provides inspiration for engineering adhesive materials that can be used in wet environment. Despite extensive efforts to mimic the fascinating adhesion capability or robust interface bonding in these years, the development of reversible adhesives underwater has long been lagging. In order to address this challenge, we have developed a series of intelligently responsive wet-adhesion materials by employing some advanced strategies, such as hydration regulation, structural design and mechanical deformation. The switchable wet adhesion can be theoretically explained by dynamic evolution of interface contact mehanism. These novel concepts and materials can be used for developing functional accessories, medical devices or soft robotics.

Biography

Dr. Feng Zhou is a Full Professor in Lanzhou Institute of Chemical Physics, Chinese Academy of Sciences, China, and head of the State Key Laboratory of Solid Lubrication. He gained his PhD in 2004 and spent three years (2005–2008) in the Department of Chemistry, University of Cambridge as a Research Associate. He has published more than 400 journal papers, which have received more than 20 000 citations and have a high-index of 80. His research interests include bioinspired tribology, biomimic surfaces/interfaces of soft matter, drag-reduction, anti-biofouling, and boundary lubrication. He has gained a number of awards including the ''Outstanding Youth Award'' of the International Society of Bionic Engineering, 2013, and National Award for Natural Sciences (Second Class), 2015. He serves as an Editorial Board Member of Tribology International, Friction, Journal Fiber Bioengineering and Informatics, Coatings etc.

Invited Speakers

Hongxu Chen

Jiaxing University
No. 56, South Yuexiu Road, Jiaxing City, Zhejiang Province, China.
Email: hx.chen@zjxu.edu.cn

Fabrication of polymer/metal composite micro/nano array structures and their applications in biological interfaces and actuators

Abstract

The chameleon change color when the environment changes, the gecko's feet have super adhesion ability, and the surface of lotus leaf is hydrophobic. All of these are due to their micro/nano structures. So the biomimetic micro/nano structures have attracted much attention due to their broad applications in self-cleaning, microelectronic devices, information storage, plasma optics, biomedical interfaces, micro/nanofluidic and sensors. Our research is about the fabrication and application of biomimetic micro/nano structures based on the colloidal lithography. The colloidal lithography is a technique for fabricating ordered micro/nano structures using 2D or 3D colloidal crystal as template or mask. This method is simple, low cost and suitable for large area preparation. Then the metal nanoparticles or metal layer were combined with the polymer micro/nano structure by adsorpotion or deposition. The composite micro/nano structures can be used as barcode nanorods, coaxial gold nanorings. And the integrated micro/nanomotors, constituted by gold hollow microcone array, can realize controllable motions under near-infrared light illumination. Furthermore, a microcone-array-based living biointerface that matches the cellular feature sizes of neurons is developed. The rose-petal-like microcone structures not only ensure excellent cytocompatibility with neurons but also facilitate the formation of complex and interconnected neuronal networks. Our work has potential applications in self-assembly, micro/nano robotics and biomedicine fields.

Shile Feng

Key Laboratory for Precision & Non-Traditional Machining Technology of Ministry of Education, Dalian University of Technology, Dalian 116024 (P. R. China)

Droplets Manipulation on Bioinspired Multi-gradient Surfaces

Abstract

Water droplets, despite their simplicity, manifest a wide spectrum of forms and dynamics at various scales in our daily life as exemplified by the raindrops, morning dew on solid surfaces, fogs on the mirror, as well as in various industrial settings. In many cases, the formation, collection, transport and manipulation of droplets constitute the basic paradigm of numerous biological systems and industrial processes. Along this vein, natural or synthetic bio-inspired materials can be rendered to achieve droplets manipulation, which is arising from special physical structures and surface energy promoting capillary or elastic forces at the drop scale. Especially, the gradients of these surface performances play crucial roles in droplets manipulation. Following this basic principle, we have designed functional surfaces with surface energy gradient, physical structure gradient or multi-gradients to create adequate driving force to lead to the preferential droplet manipulation without the need of external energy. Such manipulation can offer promising applications for efficient mass and momentum transfer as well as energy conversion in micro fluidics, water harvesting, heat exchange system, etc..

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Yuekun Lai

National Engineering Research Center of Chemical Fertilizer Catalyst (NERC - CFC), College of Chemical Engineering, Fuzhou University, Fuzhou 350116
Email: yklai@fzu.edu.cn

Bioinspired Nanostructured Films with Controllable Wettability for Multifunctional Applications

Abstract

Bioinspired surfaces with special wettability and adhesion have attracted great interest in both fundamental research and industry applications. Various kinds of special wetting surfaces have been constructed by adjusting the chemical composition under the assitance of photocatalytic reaction. Here, recent progress of the artificial superhydrophobic surfaces with high contrast in solid/liquid wettability and adhesion has been reported, with a focus on the bioinspired construction and applications of one - dimensional (1D) TiO2 - based surfaces (TBNs). In addition, the significant applications related to photocatalytic engineering super - wetting/antiwetting TBNs with controllable wettability adhesion for multifunctional applications are summarized, e.g., self - cleaning, anti - fogging/icing, microfluidic manipulation, fog/water collection, oil/water separation, anti - bioadhesion, and micro - templates for patterning. Finally, the current challenges and future prospects of this renascent and rapidly developing field, especially with regard to 1D TBNs with special wettability and adhesion, are proposed and discussed.

Jianxiong Zhu

School of Mechanical Engineering, Southeast University, Nanjing, China
Email: mezhujx@seu.edu.cn

Biomimetic Artificial Nose for Gas Detection Based on 3D Porous Laser-induced Graphene

Abstract

Inspired by three dimensional nano structure in olfaction system of dog, a biomimetic artificial nose based on 3D porous laser-induced graphene (LIG) decorated with palladium (Pd) nanoparticles (NPs) has been developed for room temperature (RT) hydrogen (H2) detection. 3D porous biomimetic turbinate-like network of graphene was synthesized by simply irradiating an infrared laser beam onto a polyimide (PI) substrate, which could further be transferred onto another flexible substrate such as polyethylene terephthalate (PET) to broaden its application. The sensing mechanism is based on the catalytic effect of the Pd NPs on the crystal defect of biomimetic LIG turbinate-like microstructure, which allows facile adsorption and desorption of the nonpolar H2 molecules. The sensor demonstrated an approximately linear sensing response to H2 concentration. Compared to chemical vapor deposited (CVD) graphene-based gas sensors, the biomimetic turbinate-like microstructure LIG-gas sensor showed ~1 times higher sensing performance with much simpler and lower cost fabrication. Furthermore, to expand the potential applications of the biomimetic sensor, we could modulate the resistance of the biomimetic LIG sensor by varying laser sweeping gaps, and also demonstrated a well transferred LIG layer onto transparent substrates. Moreover, the LIG sensor showed good mechanical flexibility and robustness for potential wearable and flexible device applications.

Shuanhong Ma

State Key Laboratory of Solid Lubrication, Lanzhou Institute of Chemical Physics (LICP) Chinese Academy of Science (CAS)
18 Middle Tianshui Road, Lanzhou 730000, China
Email: mashuanhong@licp.cas.cn

Bioinspired surface/interface lubrication materials & devices

Abstract

Biolubrication is widespread in nature and the sliding interface is in a low friction state. The extraordinary lubrication mechanisms from biological system can provide us inspiration for developing functional artificial lubrication materials and products. Herein, my presentation mainly focuses on hydrogel-based lubrication materials. Firstly, I will introduce some new methods to prepare functional hydrogels materials and coatings. Secondly, I will introduce a series of bio-inspired layered hydrogels materials with low-friction, loading-bearing and anti-wear properties. These as-prepared materials imitate the basic hydration and energy dissipation mechanism of natural articular cartilage system (NACS) under harsh mechanical conditions, so they exhibit good engineering application potential. Recently, one kind of layered composite materials with combination of polymer brushes and high strength hydrogel was prepared, for which can show stably low COF (~0.02) under 8 MPa contact pressure, and almost without any surface wear after 50000 test cycles. Next, I will show how to use our new methods and ideas to prepare some functionally bio-inspired hydrogels materials, such as adhesive hydrogels and structural tubular hydrogels, and explore their basic application in biomedical field. Then, I will simply introduce how to develop some functional soft-actuation devices based on the responsive structural hydrogels.

Daoai Wang

State Key Laboratory of Solid Lubrication, Lanzhou Institute of Chemical Physics, Chinese Academy of Sciences
18 Middle Tianshui Road, Lanzhou 730000, China
Email: wangda@licp.cas.cn

Nature-Inspired Energy Harvesting Strategy Based on Adhesive Interface and Hydrophilic Interface

Abstract

Many peculiar interface properties in nature provide a lot of inspiration for the storage, regulation and collection of electrostatic energy. We hope to incorporate some interesting interface behaviors or properties into future mechanical energy harvesting, and develop new interface energy harvesting technologies and materials to improve energy conversion efficiency. The progress made in the harvesting of mechanical energy based on the adhesion interface and the hydrophilic interface is reported here.

First of all, adhesion is a basic interface behavior/phenomenon of interfaces in nature. Inspired by the adhesion-peeling behavior that abounds in nature and life, we systematically studied the mechanism of adhesion-peeling electrification and the factors affecting the peeling electrification. Based on this work, two effective strategies for energy harvesting by peeling and electrification at the adhesion interface are proposed. The peeling and electrification of the adhesion interface will have huge application potential in the fields of interface monitoring and the Internet of Things in the future. Secondly, moisture in environment can severely decrease the output of the solid-solid triboelectric nanogenerators (TENGs) which usually hinders their further practical applications. Inspired by the various hydrophilic interfaces in nature, we have developed hydrophilic surfaces containing abundant hydroxyl groups based on starch and polyvinyl alcohol, respectively, to achieve a high output of electrical energy in a high humidity environment. It is an important supplement of TENG family and highly expand application scopes for energy harvesting and self-powered sensors in high humidity environment, especially in cloudy, foggy days or under water and sweat conditions.

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Xiaolong Wang

Lanzhou Institute of Chemical Physics, Chinese Academy of Sciences, Lanzhou 730000, China
Email: wangxl@licp.cas.cn

3D Printing of bio-inspired surface with oriented structure and frictional anisotropy

Abstract

Anisotropic friction is widespread in biological surfaces/interfaces which covered with micro- and nanostructures oriented to supporting layer,1 which is crucially responsible for the purpose of locomotion or transporting items in nature, which is therefore attracting extensive attention.2 Recently, our group systematically revealed the scientific mechanisms behind several typical anisotropic friction cases in nature, for examples, the wheat awn and the Filefish skin. It was found that both the orientation of the structure and the supporting layer are critical for its frictional anisotropy of the surfaces. Subsequently, inspired surfaces with structures oriented to supporting layer were fabricated with the emerging 3D printing, which all exhibited frictional anisotropy as expected.3 Importantly, combined with the stimuli-responsive materials, surfaces with tunable frictional anisotropy were also realized readily. These biomimetic surfaces were demonstrated to be promising for directional driving and transportation devices and so on. In order to understand the directional migration mechanism of artificial wheat awn device from the scientific level, we cooperated with the researchers of Imperial College and developed the ratchet model to systematically analyze the scientific mechanism behind our experimental results from the perspective of interface contact mechanics and tribology.

Yunlong Wang

Department of Materials Science and Technology, Nanjing University of Aeronautics and Astronautics Nanjing 211106, P. R. China;
E-mails: wylong@nuaa.edu.cn

Naked-eye Radiochromic Film Dosimetry via Continuously Tunable Bandgap

Abstract

Radiochromic film dosimetry, a passive device for measuring the accumulated dose in that the internal power supply is unnecessary, becomes increasingly attractive in a widespread use. However, most of these films have limitations such as the inevitable errors in accurate dose determination by color saturation, the cumbersome process typically using a densitometer and high sensitivity to environmental factors (e.g., light and temperature), presenting major challenges and critical demands. Herein, the present study developed a

brand-new concept radiochromic dosimetry using photonic crystal film, which has the spectral capabilities of quantitation of the absorbed dose of Γ-rays up to 225 kGy. We showed these polymeric inverse opal materials, undergo continuous and linear Bragg wavelength-shift with the dose due to the periodic porosity degradation, while remain exceptional stable for more than two months under daylight illuminating and 2 days under temperature as high as 70°C. Moreover, readout techniques through naked-eye and cell phones are described based on the color stripe calibration and hue value obtained through digital camera. We propose the scalable and reliable photonic crystal dosimeter are promising in many emerging fields such as accelerator facilities and space explorations.

Dong Wu

University of Science and Technology of China
Email: dongwu@ustc.edu.cn

Femtosecond laser microfabrication towards highly functional biomimetic structures

Abstract

Inspired by many unique structures in natural species, functional biomimetic structures have drawn extensive attention in potential applications including microfluids and biomedicine. Conventional fabrication methods, such as lathe machining and chemical synthesis, are effective to fabricate biomimetic structures with simple configurations. However, it is still challenging for such approaches in fabricating complex 3D microstructures. As an alternative, femtosecond laser microfabrication has been proved to be a powerful 3D microfabrication technique with high precision and contamination-free in obtaining diverse complex microstructures. Herein we report several typical advanced functional biomimetic structures relying on femtosecond laser microfabrication technology: (1) Super-wetting (superhydrophobic/superhydrophilic) 2D-3D structures (e.g., tapered micro holes or hierarchical microgrooves) were fabricated to significantly speed up the self-propelled transport of tiny bubbles and droplets; (2) Lubricant-infused surfaces were proposed for the repellency of diverse foreign fluids; (3) Stimuli-responsive surfaces (e.g., magnetic or optimal/thermal field) were developed for active control of their structural configurations. Our works have been further demonstrated in potential applications upon highly functional biomimetic structures, such as microfluid manipulation, oil-water separation, and reconfigurable architectures.

Si Wu

University of Science and Technology of China, Hefei 230026, China
Email: siwu@ustc.edu.cn

Polymers for photoinduced reversible solid-to-liquid transitions

Abstract

I will present that light can switch the Tg of azobenzene-containing polymers (azopolymers) and induce reversible solid-to-liquid transitions of the polymers.[1-3] The azobenzene groups in the polymers exhibit reversible cis-trans photoisomerization. Trans azopolymers are solids with Tg above room temperature, while cis azopolymers are liquids with Tg below room temperature. Because of the photoinduced solid-to-liquid transitions of these polymers, light can reduce the surface roughness of azopolymer films, repeatedly heal cracks in azopolymers, and control the adhesion of azopolymers for transfer printing. The photoswitching of Tg provides a new strategy for designing healable polymers with high Tg and allow for control over the mechanical properties of polymers with high spatiotemporal resolution.

Ziliang Wu

Department of Polymer Science and Engineering, Zhejiang University,
Hangzhou 310027, China
Email: wuziliang@zju.edu.cn

Photo-steered deformation and locomotion of nanocomposite hydrogels

Abstract

Inspired by the natural activated systems, realization of programmed deformations and locomotion in artificial materials has recently attracted great interest due to their promising applications in biomedical devices, soft robotics, and flexible electronics. Photo-responsive hydrogels are recognized as one ideal material to construct soft actuators and robots owing to their drastic volume change induced by contactless light irradiation with high spatial and temporal resolutions. The challenge is how to construct composite hydrogel with gradient structure and dynamically activate the specific regions of the gel toward programmed deformation and locomotion. We present here a photolithographic method to fabricate patterned composite hydrogel sheets with heterogeneous structures by embedding the photo-responsive hydrogel in a preformed nonresponsive hydrogel. Under photo irradiation, the swelling/contraction mismatch results in the built-up of internal stress and thus programmed deformations of the composite hydrogel. Furthermore, a moving light beam is imposed on the composite hydrogel to spatiotemporally actuate the gel that shows sophisticated motions, including crawling, walking, and turning. Experimental and simulation results reveal that multigait locomotion is realized by the mutual coordination of shape-morphing and dynamic friction of the gel against a substrate under the spatiotemporal light stimulation. The programmed deformations of motions of photo-responsive hydrogels should be instructive for the development of soft robotics with advanced technologies and versatile applications.

Quan Xu

State Key Laboratory of Heavy Oil Processing, Beijing Key Laboratory of Biogas Upgrading Utilization, China University of Petroleum (Beijing), Beijing, China
Email: xuquan@cup.edu.cn

The Biomimetic Controllable Adhesion Surface Design and Preparation with High Performance

Abstract

In previous study, inspired by the self-cleaning properties of gecko spatulae, we proposed the dry self-cleaning mechanism based on a dynamic effect and fabricate artificial micromanipulators for microparticles transport and assembly. Mimicking the tough and wet adhesion structure of mussel thread, we proposed a wet gradient design principle and fabricated biomimatic surface with self-healing, light responsive properties, which can be used for remote force measurement. Based on the self-sensing, self-responsive,

and fast-driven principles seen in living organisms, a biomimetic design is proposed to achieve smart adhesion surfaces by integrating gradient structural distribution with intelligent/smart nanomaterials. This smart surface will break the existing technical berries, such as single-action, slow response time and large size, enabling large driving force, active controllability by photonic, electronic, or magnetic stimuli, as well as quick and easy switch between attachment and detachment.

Xiaolong Yang

College of Mechanical and Electrical Engineering, Nanjing University of Aeronautics and Astronautics, Nanjing 210016, PR China
Email: xlyang@nuaa.edu.cn

Spontaneous Fast Droplet Transport Without Mass Loss on Architectured Slippery Surfaces

Abstract

Spontaneous droplet transport without mass loss has great potential applications in the fields of energy and biotechnology, but it remains challenging due to the difficulty in obtaining sufficient driving force for the transport while suppressing droplet mass loss. Learning from slippery peristome of Nepenthes alata and wedge topology of shore bird beak that can spontaneously feed water against the gravity, a combined system consisting of two face-to-face slippery liquid-infused porous surfaces (SLIPS) with variable beak-like opening and spacing was proposed to constrain the droplet in-between and initiate fast droplet transport over a long distance of 75 mm with a maximum speed of 12.2 mm·s-1 without mass loss by taking the advantage of Laplace pressure gradient induced by the asymmetric shape of constrained droplet. In addition, in-situ sophisticated droplet manipulations such as droplet mixing are readily feasible when applying flexible 304 stainless foil as the substrate of SLIPS. It is believed that the extended research can provide new reference for the precise and fast droplet motion control intended on energy harvest and lab-on-a-chip devices.

Chunhong Ye

School of Physical Science and Technology, ShanghaiTech University, Shanghai, 201210, China
Email: yechh@shanghaitech.edu.cn

Microscale Shape-Morphing with 3D Reconfigurable Morphology

Abstract

Micro-scale origami with programmable, reversible, and fast autonomous 3D shape transformation was successfully fabricated from responsive polymers. Distinct 3D morphologies including microscopic rings, tubules and helical tubules can be readily formed by rational designing of the individual two dimension sheets shape. Both experimental observations and computational modeling indicated that the selective swelling within the bimorph micro-sheets generated strong interfacial stress between layers and out-of-planar forces, triggering autonomous self-rolling into various 3D constructs. Furthermore, based on this principle, 3D reconfigurable micro-helices with chirality conversion was obtained from one micro-sheet with unique “hard” stripe/“soft” groove topography. Based the simulation and theoretical analysis, we ascribe this 3D-to-3D shape transformation to the selective activation of in-planar or/and out-of-planar mismatched stress within

micro-sheets controlled by stripe/groove geometry. And more complex 3D reconfiguration behavior has been demonstrated utilizing the stripe/groove topography, such as “windmill”-to-“T cross”, “cylinder”-to-“scroll” and dynamic blossoming of biomimetic orchid. In contrast to conventional micro-origami with 2D-to-3D shape-morphing, we not only demonstrated programmable 3D morphologies from different 2D patterns, but also obtained 3D-to-3D shape transformation from one sample. We expect that the micro-structures with reconfigurable 3D morphology will present a great potential for applications in bioengineering, such as minimally invasive operation and cell manipulation with all soft materials based micro-robotics.

Youfa Zhang

Jiangsu Key Laboratory of Advanced Metallic Materials, School of Materials Science and Engineering, Southeast University
Email: yfzhang@seu.edu.cn

Superhydrophobic coatings for energy saving and environment protection: from materials to equipment

Abstract

In the past ten years, our group focused on the fundamentals such as design, fabrication and performance control of superhydrophobic coatings. We deeply studied the influence of nanoparticle microstructure, active polymer bonding and functional polymer hybridization on wetting behavior and their stability. Based on the design strategy and the mechanism of mechanical and environmental stability, we developed a variety of superhydrophobic coatings for different applications. Collaborating with some famous companies, such as Sinopec and Huawei, the coatings or their equipment have been commercially used for oil-water separation, anti-fingerprint, anti-oil, etc. At present, we make great efforts on the coating application in air conditioning, aircraft, air purification so as to improve the energy-saving and environmental protection performance.

Jie Zhao

Key Laboratory of Bionic Engineering, Ministry of Education, Jilin University
No. 5988 Renmin Street, Changchun, China 130022
Email: jiezhao@jlu.edu.cn

Bioinspired Nanostructures with Long-term Mechano-Bactericidal effectiveness

Abstract

Medical device-associated infections, caused by bacterial adhesion and contaminations, remain a leading threat to public healthcare, due to continuous emergence of drug-resistant pathogens. Antibiotics, as a power tool to combat pathogenic bacterial infection, suffer their inability to kill drug-resistant bacteria. Bioinspired nanostructured surfaces, with mechano-bactericidal surfaces hold dominant potentials in killing bacteria without causing antimicrobial resistance, however, accumulation of dead bacteria and debris would greatly compromise the antimicrobial activity. In our group, a series of bioinspired mechano-bactericidal surfaces, possessing with both bacterial repelling and bacterial-releasing performances have been designed and developed. Notably, all those antibacterial behaviors are derived from purely physical mechanisms. Those bioinspired surfaces have the great advantages in maintaining high-efficiency and long-term effectiveness in antimicrobial activities, while avoiding the potential risk in causing antimicrobial resistances.

Zuoqi Zhang

School of Civil Engineering, Wuhan University
Email: zhang_zuoqi@whu.edu.cn

A Floquet-Based Bar-Spring Model for Load-Bearing Biological and Bioinspired Composites

Abstract

There are a variety of staggered alignments of reinforcements in load-bearing biological materials. These staggered microstructures well integrate the hard and soft constituent materials, and provide the biological composites not only excellent supporting functions (resisting static loading) but also brilliant protecting functions (attenuating dynamic impact). Therefore, the relationship between staggered structure and mechanical property within load-bearing biological and bioinspired materials has been attracting more and more research attention. Based on Floquet theory, we developed a new generic bar-spring model which can be utilized to evaluate the dynamic and static mechanical properties of the composites with various types of staggered architectures. Then, the Floquet-based bar-spring model has been successfully used to study the dynamic moduli of typical staggered composites and the comparisons with previous methods based on the tension-shear chain model and the finite element method results showed that the new method can give more accurate predictions. Its applicability to two- and three-dimensional arbitrarily staggered architectures was also demonstrated. Further, the Floquet-based bar-spring model has been developed to investigate the failure behavior and design optimization of bioinspired heterogeneous interfaces. Comparative analyses among end-concentrated, center-concentrated and uniformly distributed cosslinks showed that the end-concentrated design is superior in effective interface shear stiffness and strength, the center-concentrated design is superior in the effective interface shear strength, failure strain and work of fracture. Both the end- and center-concentrated designs yield a distinctly higher efficacy of crosslink utilization than that of the uniform design. The Floquet-based bar-spring model provides a powerful tool to study the structure-property relationship of natural load-bearing biological composites, and would facilitate the microstructure design and optimization of high-performance composites.

Kaijie Lin

Jiangsu Provincial Engineering Laboratory for Laser Additive Manufacturing of High-Performance Metallic Components, College of Materials Science and Technology, Nanjing University of Aeronautics and Astronautics
Yudao Street 29, Nanjing 210016, Jiangsu Province, PR China
Email: kaijie_lin@nuaa.edu.cn

Laser powder bed fusion of bio-inspired honeycomb structures: effect of twist angle on compressive behaviors

Abstract

In this study, novel honeycomb structures with twisted feature were designed and manufactured by laser powder bed fusion (LPBF). The manufacturability, microstructure evolution of LPBFed honeycomb components with twisted feature were studied. The influence of twist angle on the compressive behavior of components was experimentally investigated and the underlying mechanism was revealed using FE simulation. Results revealed that the material relative density of LPBFed components was reduced with the increase of twist angle, caused by the enlarging overhanging area. Different cooling rate of melt pool at different parts along the building direction resulted in different microstructures. The twist angle significantly affected the compressive behaviors of honeycomb structures. When the cell number along each side was 3, the honeycomb structure with 30° twist angle exhibited the most uniform stress distribution under compression, leading to the highest specific compressive strength and energy absorption ability. The influence of cell number and wall thickness on compressive properties of honeycomb structures with 30° twist angle were investigated through finite element simulation, and results revealed that the structure with 0.75 mm wall thickness and 3 unit cells along each side showed the highest specific energy absorption ability.

Session 3: Nature-inspired robots and flexible electronics

17 July, Saturday (Day 1)

13:30-15:10	Session 3 Nature-inspired robots and flexible electronics - I
	Room III (ID: 926 8093 0537)

Chair: Chuanfei Guo, Zhiyuan Liu, Xing Ma

13:30-13:50	KEYNOTE TALK
	Biomimetic on gecko locomotion: from researches to applications
	Zhendong Dai, *Nanjing University of Aeronautics and Astronautics*
13:50-14:10	KEYNOTE TALK
	Bioinspired soft robots with new locomotion and manipulation ability
	Guoying Gu, *Shanghai Jiaotong University*
14:10-14:25	INVITED TALK
	A Fast Autonomous Healing Magnetic Elastomer for Instantly Recoverable, Modularly Programmable, and Thermo-recyclable Soft Robots
	Yin Cheng, *Shanghai Institute of Ceramics, CAS*
14:25-14:40	INVITED TALK
	Bio-inspired flexible pressure sensors
	Zhuo Li, *Fudan University*
14:40-14:55	INVITED TALK
	A Neuromorphic Approach to Roughness Discrimination with A Bio-inspired Fingertip
	Longhui Qin, *Southeast University*
14:55-15:10	INVITED TALK
	Intracellular Ion Regulation mediated Self-enhanced Cisplatin Chemotherapy by Asymmetric Nanoparticles
	Jinjin Shi, *Zhengzhou University*

18 July, Sunday (Day 2)

08:30-10:10 Session 3 Nature-inspired robots and flexible electronics - II

Room III (ID: 926 8093 0537)

Chair: Chuanfei Guo, Zhiyuan Liu, Xing Ma

08:30-08:50	KEYNOTE TALK
	Bio-Inspired Flexible Electronics for Multifunctional Aerodynamic Measurement
	Yongan Huang, *Huazhong University of Science and Technology*
08:50-09:10	KEYNOTE TALK
	Gecko-inspired adhesive structures: fabrication and application
	Jinyou Shao, *Xian Jiaotong University*
09:10-09:25	INVITED TALK
	Nature-inspired Micro-nano Structures for Soft Neural Electrodes
	Dianpeng QI, *Harbin Institute of Technology*
09:25-09:40	INVITED TALK
	Physically Transient Memristor for neuromorphic computing
	Hong Wang, *Xidian University*
09:40-09:55	INVITED TALK
	Design and implementation of flight control system for honeybee based on EEG stimulation
	Jieliang Zhao, *Beijing Institute Technology*
09:55-10:10	ENTERPRISE TALK
	界面表征技术的前沿发展
	Song Luo, *Beijing Dataphys Instruments Co. Ltd*

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Keynote Speakers

Zhendong Dai

Institute of Bio-inspired Structure and Surface Engineering, Nanjing University of Aeronautics and Astronautics
Nanjing, 29 Yudao Street
Email: zddai@nuaa.edu.cn

Biomimetic on gecko locomotion: from researches to applications

Abstract

Geckos have been studied for many years for their excellent moving abilities on various substrates, including any inclines, even ceilings, and various rough surfaces. Here we report our studies on the gecko adhesive mechanism, attaching and detaching dynamics, locomotion behaviors on anti-adhesive substrate and confined space, bio-inspired adhesive materials and gecko-inspired robot for micro-gravity condition. We have obtained following results: 1) The contact/ tribo-electrifiction is a mechanism more than Van der Waals force for gecko adhesion, we designed an experiment and measured the results showed the evidence of influence of contact / tribo-electrifiction on adhesion. 2) Gecko smartly uses technique of adducting and abducting to make attachment and detachment, this behavior inspired us to design a new pad for gecko-mimicking robot, instand of peeling from substrate. 3) Geckos developed positive and active synergy methods to overcome the difficult to move on anti-adhesive substrate. 4) We have developed bio-inspired adhesive materials and tested they performance for gecko mimicking robot. 5) Then we developed gecko-inspired robot for several possible applications.

Biography

Dr. Zhendong Dai, Professor, director and founder of the Institute of Bio-inspired Structure and Surface Engineering (IBSS) at Nanjing University of Aeronautics and Astronautics (NUAA), fellow of international society of Bionic Engineering. His research interesting include tribo-irreversible thermodynamics, biomimetic on gecko locomotion, Bio-inspired lightweight structure, brain stimulation of animal moving.

Guoying Gu

Robotics Institute, School of Mechanical Engineering, Shanghai Jiao Tong University, Shanghai 200240, China
Email: guguoying@sjtu.edu.cn

Bioinspired soft robots with new locomotion and manipulation ability

Abstract

Different from the conventional robots using rigid structural elements and high-output actuators, soft robots are mainly composed of muscle-like soft materials and the robotic functions can be created by using the concept of mechanical intelligence in soft materials. However, due to nonlinear large defamation and infinite degree-of-freedom of soft materials and structures, there are grand challenges in design, control and applications of soft robots. Mimicking the functions and movements of locomotion and manipulation in biological organisms provides more opportunities for soft robot design and many novel soft robotic systems have been created in the field of robotics. In this talk, I will give an overview of our recent development on bioinspired soft robots, including soft climbing robots, soft robotic hands and their preliminary applications. These examples may also demonstrate that the concept of mechanical intelligence simplifies the design of bioinspired mechanisms and enables new opportunities to bridge the gap between robots and organisms.

Biography

Prof. Guoying Gu received the B.E. degree in electronic science and technology, and the Ph.D. degree in mechatronic engineering from Shanghai Jiao Tong University (SJTU), Shanghai, China, in 2006 and 2012, respectively.

Since October 2012, he has worked at SJTU, where he is currently appointed as a Professor of School of Mechanical Engineering. He was a Humboldt Fellow with University of Oldenburg, Germany. He was a Visiting Scholar at Massachusetts Institute of Technology, National University of Singapore and Concordia University. His research interests include soft robotics, bioinspired and wearable robots, smart materials sensing, actuation and motion control. He is the author or co-author of over 100 publications, which have appeared in Science Robotics, National Science Review, IEEE Trans., etc., as book chapters and in conference proceedings.

Prof. Gu received the National Science Fund for Distinguished Young Scholars. Now he serves as Associate Editor of IEEE Transactions on Robotics and IEEE Robotics and Automation Letters. He has also served for several journals as Editorial Board Member, Topic Editor, or Guest Editor, and several international conferences/symposiums as Chair, Co-Chair, Associate Editor or Program Committee Member.

Yongan Huang

State Key Laboratory of Digital Manufacturing Equipment and Technology, Huazhong University of Science and Technology
Email: yahuang@hust.edu.cn

Bio-Inspired Flexible Electronics for Multifunctional Aerodynamic Measurement

Abstract

The flow characteristics of whole complex surface is imperative to perceive and improve aerodynamic performances. However, developing a fully-covered, multifunctional smart skin that endows the objects the capabilities to actively sense external airflow and internal structural state is very challenging. Historically, the great ideas in science and technology often arise from studying nature. Thus bio-inspired flexible electronics are promising solution to address the current issues like multitype, large-area sensing networks, conformal challenge of non-stretchable devices on complex surfaces, etc. This presentation mainly introduces a bio-inspired strategy to design the intelligent flexible sensing (iFlexSense) skin with unstretchable materials for multifunctional aerodynamic measurement:

Biography

Yongan Huang, professor of Huazhong University of Science and Technology (HUST), vice director of State Key Laboratory of Digital Manufacturing Equipment and Technology, and a winner of The National Science Fund for Distinguished Young Scholars. He focuses on the research of design and manufacturing for flexible electronics like flexible printed display, smart skin of aircrafts, electronic skin of robots and epidermal electronics for human, has developed commercial EHD printer and laser lift-off equipment, and has published more than 100 papers in journals including Science Advances, Advanced Materials, Advanced Functional Materials, Materials Horizon, Nano Energy, Small, Nature Comm., etc, and also published 3 monographes. He has won first prize of Natural Science in Hubei Province, Gold/Special Gold Award on International Exhibition of Inventions in Geneva, Switzerland.

Jinyou Shao

Xi'an Jiaotong University
Email: jyshao@xjtu.edu.cn

Gecko-inspired adhesive structures: fabrication and application

Abstract

Inspired by the outstanding climbing ability from geckos, the design of biomimetic dry adhesive functional structures as well as the study of their interface behaviors have attracted widely attention in academic field. Recently, “mushroom-shaped” micro/nano-scale feature has been confirmed as an optimal structural design for artificial surfaces with strong adhesion function because of its prominent adhesive strength, and has exhibited potential application prospects in grasping manipulators, biomimetic climbing robots and space operations. However, the fabrication of the mushroom-shaped structures in a simple and low cost method becomes a limit on the application of bioinspired mushroom-shaped structures. Here, electrically-induced pre-patterned polymer rheology fabrication technique is proposed to engineer the “mushroom-shaped” dry adhesive structures. This method solved the problems faced by conventional methods that the structure size, especially for the terminal size, cannot be easily and precisely defined. The pre-patterns were fabricated by the hot embossing process and then electrohydrodynamically driven by the Maxwell tensor acting on the polymer/air interface to grow upwards until being contact with the top electrode. Subsequently, the electrowetting effect occurred and a “mushroom-shaped” terminal was formed. Based on the linearly unstable analysis of the pre-patterned film, the rheological behavior in initial, intermediate and final stages of the process was studied. The quantitative relationship between the applied threshold voltage and geometrical and material parameters were established. The Taylor cone was observed in the intermediate stage, demonstrating the possible connection between two structuring techniques of electrically-induced formation and electrostatic spinning. The electrowetting phenomenon was analyzed in the final stage, and the dielectric layer coated on the top electrode surface is demonstrated to be significant in forming the “mushroom-shaped” terminal structure. Finally, a two-phase flow-based electrohydrodynamic model was established, upon which the approach for controlling the structural size was derived. Based on the fabricated mushroom-shaped structures, the potential applications of the dry adhesive functional surface in conventional grasping techniques was demonstrated. Being focused on the issue of how to achieve the controllable releasing upon that strong adhesion has been generated, a new detachment process was proposed based on the pneumatically-controlled interfacial stress distribution and contact area. The relationship between pull-off force and air pressure was established, successfully realizing the grasp and release of several typical objects with different surface morphologies and weights.

Biography

Jinyou Shao received the Ph.D. degree from Xi'an Jiaotong University, Xi'an, China, in 2009. He is currently a Professor at the State Key Laboratory for Manufacturing Systems Engineering, Xi'an Jiaotong University, and the leader of the Youth Innovation Team of Shaanxi Universities. His research interests include micro/nano-manufacturing techniques, flexible electronics and systems, nanosensors and devices. Prof. Shao is/was the Principal Investigator in several projects funded by National Natural Science Foundation of China and Department of science and technology of China. He has published more than 100 papers in prestige international journals, including more than 10 front and back covers in multi-disciplinary journals Advanced Materials, Advanced Functional Materials and Small. Moreover, he holds 30 patents including two United States patents. Prof. Shao received the First Prize Technology Invention Award of the Ministry of Education of China in 2015. He is awarded NSFC Fund for Distinguished Scholars, NSFC Fund for Excellent Young Scholars, Changjiang Scholars –Young Category, New Century Excellent Talents by MoE of China, Shaanxi Young Talents in Science and Technology, etc.

Invited Speakers

Yin Cheng

Department of Electrical and Computer Engineering, National University of Singapore, 4 Engineering Drive 3, Singapore 117583, Singapore.
E-mail: elehgw@nus.edu.sg

A Fast Autonomous Healing Magnetic Elastomer for Instantly Recoverable, Modularly Programmable, and Thermo-recyclable Soft Robots

Abstract

Intrinsically self-healing stretchable polymers are intensively explored for soft robotic applications due to their mechanical compliance and damage resilience. However, their prevalent use in real-world robotic applications is currently hindered by various limitations such as low mechanical strength, long healing time, and external energy input requirement. Here, we introduce a self-healing supramolecular magnetic elastomer (SHSME), featuring a hierarchical dynamic polymer network with abundant reversible bonds. The SHSME exhibits high mechanical strength (Young’s modulus of 1.2 MPa, similar to silicone rubber), and fast self-healing capability (300% stretch strain after 5s autonomous repair at ambient temperature). We showcase a few SHSME-based robotic demonstrations namely rapid amphibious function recovery, modular-assembling-prototyping soft robots with complex geometries and diverse functionalities, as well as a dismembering-navigation-assembly strategy for robotic tasking in confined spaces. Notably, the SHSME framework supports circular material design being thermo-reformable for recycling, auto-repair for extended lifespan and modularizable for customized constructs and functions.

Zhuo Li

Affiliation: Fudan University
Email: zhuo_li@fudan.edu.cn

Bio-inspired flexible pressure sensors

Abstract

Although high-performance flexible pressure sensors have been extensively investigated in recent years owing to their diverse applications in biomedical and information technologies, fabricating ultrasensitive sensors with high pixel density based on current transduction mechanisms still remains great challenging. Inspired by the structure of sea urchin, we demonstrate a design idea based on Fowler-Nordheim tunnelling effect for fabrication of pressure sensors with ultrahigh sensitivity and sensing density by spin-coating extremely low urchin-like hollow carbon spheres (less than 1.5 wt.%) dispersed in polydimethylsiloxane, which is distinct from the current transduction mechanisms. This sensor exhibits an ultrahigh sensitivity of 260.3 kPa−1 at 1 Pa, a proof-of-concept demonstration of a high sensing density of 400 cm−2, high transparency and temperature noninterference. In addition, it can be fabricated by an industrially viable and scalable spin-coating method, providing an efficient avenue for realizing large-scale production and application of ultrahigh sensitivity flexible pressure sensors on various surfaces and in in vivo environments.

Longhui Qin

School of Mechanical Engineering, Southeast University, Nanjing 211189, People's Republic of China
lhqin@seu.edu.cn

A Neuromorphic Approach to Roughness Discrimination with A Bio-inspired Fingertip

Abstract

Inspired by human hand, we developed a type of tactile fingertip to sense dynamic forces from external forces, based on which an enhanced signal processing system was developed to discriminate different surface roughness. Considering that signals transit in the form of electronic pulses, i.e., spikes, in human body, it is significant to develop an algorithm to process spike train signals mimicking the biological mechanism of human brain due to a lot of merits, such as low energy cost, high robustness, and fast transmission etc. However, traditional mature classification models cannot tackle the spike train signals directly while most specialized spiking neural networks are not free to access, which prevents the widely spread and development of neuromorphic approaches. In this work, we proposed a reference spike train based neurocomputing method to process spike train signals via a combination of traditional classifiers and three categories of features, which made it possible to tackle spike signals in a traditional way while high accuracy was maintained. The three categories included statistical features, spike metric features, and vector features. They were extracted from tactile signals after a differential spike train computation and binning. Relevant techniques were further analyzed and discussed to explore how to configure an optimal reference spike train in order to achieve higher performance. Finally, effectiveness of the proposed method was validated when it was applied to tactile signal processing for roughness discrimination. The neurocomputing method is also applicable to other occasions that require for classifications in a neuromorphic way.

Jinjin Shi

School of Pharmaceutical Sciences, Zhengzhou University, Zhengzhou 450001, China
Email: shijinyxy@zzu.edu.cn

Intracellular Ion Regulation mediated Self-enhanced Cisplatin Chemotherapy by Asymmetric Nanoparticles

Abstract

Despite the broad antitumor spectrum of cisplatin, its clinical benefit is compromised by inadequate accumulation of Pt-DNA adducts in tumor cells and systemic side effects. Specifically, the formation and maintenance of Pt-DNA are affected by the dechlorination of cisplatin and intracellular activity of DNA repair enzymes. Here, an asymmetrically structured ion nanoregulator (AINR) is developed that can simultaneously down-regulate intracellular Cl-/Fe2+ to promote dechlorination of cisplatin synergize with DNA repair enzymes inhibition for enhanced chemotherapy of cisplatin. AINR could induce the production of H2O2 in

IYCBSE 2021

tumor cells, which in turn accelerates the down-regulation of Cl- with the assistance of Ag NPs, realizing a self-enhanced formation of Pt-DNA. Meanwhile, AINR could reduce intracellular Fe2+ to inhibit Fe2+-dependent DNA repair enzymes for improving the maintenance of Pt-DNA. We have found that intracellular dual-ion regulation significantly increases the accumulation of Pt-DNA, affording almost complete tumor growth inhibition with negligible toxicity. Interestingly, AINR displays a strong tumor penetration fueled by H2O2. Our work sheds light on the possibility of using an ion-regulation strategy to enhance the therapeutic efficiency of cisplatin.

Zhuangzhi Sun

Northeast Forestry University
Email: sunzhuangzhi@nefu.edu.cn

Bioinspired natural energy collection and biomass resource utilization strategy

Abstract

The long-lasting and stable cycle of natural organisms in the low-carbon consumption of the ecosystem has given us a lot of inspiration. Under the guidance of the country's "carbon peak and carbon neutrality", the use of natural resources with low carbon consumption is a major future development trend. The new strategy of low-grade environmental energy collection and intelligent use of biomass resources has great socio-economic significance. In response to the above problems, we propose a water vapor collection method based on the principle of solar interface light-heat and an energy collection strategy based on the comprehensive utilization of solar and ocean energy. Through the bionic functional design of the surface, the efficiency of solar interface light-heat induced water vapor evaporation is greatly improved. Through the utilization of the capillary channel inside the biomass resources, the efficiency of water vapor evaporation is effectively improved. Through the comprehensive utilization of solar and ocean energy, the efficiency of electric energy collection is improved through natural method. This technology is a potential environmentally friendly sustainable development strategy.

Dianpeng Qi

School of Chemistry and Chemical Engineering, Harbin Institute of Technology, P.R. China:
Email: dpqi@hit.edu.cn

Nature-inspired Micro-nano Structures for Soft Neural Electrodes

Abstract

Stretchable microelectrode arrays (MEAs) are emerging as the new generation of bio-integrated microelectrodes, which interface living tissues with electrical hardware and provide a powerful tool for the transduction of original electrochemical signals in living tissues to external electrical circuits. So far, the challenge of stretchable MEAs lies in the competition of high stretchability and good electrode-substrate adhesion, where the larger the stretchability, the easier the delamination of electrodes from the substrate. In our work, by taking advantage of nature-inspired wavy structure and nanowire-based transition layer, for the first time, we fabricate stretchable polymeric MEAs with both high stretchability (~130%) and good electrode-substrate adhesion (1.9MPa). In addition, low Young's modulus (450 kPa), excellent recycling stability (10 000 cycles of stretch) and high conductivity of the MEAs are also achieved. As a proof of concept, the stretchable MEAs are successfully used for conformably recording the electrocorticograph (ECoG) signals from rats in normal and epileptic state, respectively. Further, these stretchable MEAs are also successful in stimulating the ischiadic nerve of the rat. Our strategy provides a new perspective to the high stretchable and mechanical stable MEAs which is vital for compliant neural electrodes.

Hong Wang

School of Microelectronics, Key Laboratory of Wide Band Gap Semiconductor Technology, Xidian University, Xi'an, 710071, China
Email: hongwang@xidian.edu.cn

Physically Transient Memristor for neuromorphic computing

Abstract

In human brain, there exist a large number of synapses and neurons, which constitute a neural network structure with high efficiency and computational capabilities. It can simultaneously store and calculate information, learn and process multidimensional information, such as language understanding, image recognition, abstract reasoning and other complex functionality. Brain-inspired electronic synapses can construct highly efficient neuromorphic computational systems to simulate the functions of biological synapses. Memristor-based electronic synapse are promising building block for neuromorphic computing owing to its low energy consumption and high efficiency in computing.On the other hand, physically transient electronic devices that can fully or partially dissolved by chemical or physical processes after completing the function within a specific time, which plays a significant role in military security electronics systems, green consumer devices for solving the environmental pollution problems, and biodegradable platforms for temporary biomedical implants. Meanwhile, combined advantages of transient devices and synapse devices to build physically transient/biodegradable synapse electronics, has great advantages in security neuromorphic computing electronics, as well as implantable neuron-medicine. What's more, biocompatible synapse devices based on memristors for neuromorphic computing are highly desired in brain-computer interface technology. Therefore, fully physically transient synapse based on biodegradable memristor is promising and highly desirable for security neuromorphic computing and bio-integrated technology. In this presentation, transient memristor materials, larger –area fabrication technology and novel computing will be presented.

Jieliang Zhao

School of Mechanical Engineering, Beijing Institute Technology, Beijing 100081, PR China
Email:jielzhao@bit.edu.cn

Design and implementation of flight control system for honeybee based on EEG stimulation

Abstract

Cyborg insect robots have important application value in future military operations and disaster relief due to their high concealment and long endurance. However, the current neural regulation of the flight behavior of insects remained to be elucidated. The effective methods for artificial intervention to control the stable and precise flight of insects were deficient. This research measured the extracellular field potentials evoked in the medullae of a honeybee brain responding to the onset and the extinction of a light stimulus. Additionally, we developed a model to elucidate the measured responses with reference to ion fluxes in the extracellular environment. The polarity of medullary potential was negative in the light changing from bright to dark, and gradually decreased with increasing light intensity. A biophysical model was constructed, where, the medullary potential was effectively simulated by solving the numerical solution of the biophysical model. Based on exploring the neural regulation mechanism of flight behavior under visual guidance, a micro control backpack is designed by using programmable micro control chip and radio receiving module, which takes into account the wireless communication distance and load capacity of honeybee. Furthermore, the flight control effect on the bee robot is verified by embedded micro intelligence backpack to the back of the abdomen. The development of the micro control backpack provides a hardware basis for the flight control research of the bee robot, which also provides a theoretical basis for the optimization of the biological control backpack.

Session 4: Nature-inspired energy transport, storage, conversion and harvesting

17 July, Saturday (Day 1)

15:30-17:45 **Session 4 Nature-inspired energy transport, storage, conversion and harvesting - I**

Room IV (ID: 925 7171 1971)

Chair: Xu Hou, Jun Yin, Ronggui Yang

15:30-15:50	KEYNOTE TALK Radiation to Outer Space: Cooling with Zero Energy Consumption Ronggui Yang, *Huazhong University of Science and Technology*
15:50-16:05	INVITED TALK Mass transport in atomic-scale confinements Sheng Hu, *Xiamen University*
16:05-16:20	INVITED TALK Study on Bio-inspired Carbon Materials in Solar-thermal Conversion Meng Li, *Chongqing University*
16:20-16:35	INVITED TALK Liquid-solid electricity generator based on bulk effect Xiaofeng Zhou, *East China Normal University*
16:35-16:50	INVITED TALK Self-assembly in Nanomaterials, Dynamic Materials, and Micro-robots Wendong Wang, *Shanghai Jiaotong University*
16:50-17:05	INVITED TALK Droplet-Based Self-Propelled Mini-Boat Jinlong Song, *Dalian University of Technology*
17:05-17:15	ORAL PRESENTATION How to make a hairy biological surface both flexible and rigid: material stiffness variation in honey bee tongue facilitates multifunctions Yu Sun, *Sun Yat-Sen University*
17:15-17:25	ORAL PRESENTATION Design and Analysis of a New Type of Twisting Pneumatic Artificial Muscle Wei Xiao, *Hunan University*
17:25-17:35	ORAL PRESENTATION Research in kinematics of jerboa hopping on sand and the jerboa-like robot model Hao Pang, *Jilin University*
17:35-17:45	ORAL PRESENTATION Fabrication of flexible ionic hydrogel battery inspired by electric eels Pei He, *Xi'an Jiaotong University*

18 July, Sunday (Day 2)

13:30-14:15 **Session 4 Nature-inspired energy transport, storage, conversion and harvesting - II**

Room I (ID: 994 2266 9485)

Chair: Xu Hou, Jun Yin, Ronggui Yang

13:30-13:45	INVITED TALK Optical Wood with Switchable Transmittance of Solar Irradiation for Thermal Management Hongbo Xu, *Harbin Institute of Technology*
13:45-14:00	INVITED TALK Nonlinear vibration energy harvesters: Design, analysis and experiment Shengxi Zhou, *Northwestern Polytechnical University*
14:00-14:15	INVITED TALK Biomorphic ceramics embedded molten salts for ultrafast thermal and solar energy Xianglei Liu, *Nanjing University of Aeronautics and Astronautics*

Keynote Speakers

Ronggui Yang
Huazhong University of Science and Technology
Email: ronggui@hust.edu.cn

Radiation to Outer Space: Cooling with Zero Energy Consumption

Abstract

Radiative sky cooling cools an object on the earth by emitting thermal infrared radiation to the cold universe through the atmospheric transparent window. It consumes no electricity and has great potential to be explored for cooling of buildings, vehicles, solar cells, and even thermal power plants. Very recently, daytime radiative sky cooling to achieve sub-ambient temperatures under direct sunlight has been experimentally demonstrated, which attracts great interests. I will talk about the fundamentals, innovative materials and applications of radiative sky cooling.

Biography

Ronggui Yang is currently a Professor in the School of Energy and Power Engineering at Huazhong University of Science and Technology (HUST). Professor Yang was a Professor of Mechanical Engineering at the University of Colorado Boulder in 2006-2018 after receiving his Ph.D from MIT in February 2006. Ronggui Yang's research focuses at the intersection of the fundamentals of thermal transport and micro/nano-structured materials, for solving thermal grand challenges. His innovative research has won him numerous awards including the 2020 Nukiyama Memorial Award, the PhysicsWorld Top 10 Breakthroughs in 2017, ITS Young Investigator in Thermoelectrics in 2014 and the Goldsmid Award in 2005 from International Thermoelectric Society (ITS), the 2010 ASME Bergles-Rohsenow Young Investigator Award in Heat Transfer, an NSF CAREER Award in 2009, the MIT Technology Review's TR35 Award and the DARPA Young Faculty Award in 2008.

Invited Speakers

Sheng Hu
College of Chemistry and Chemical Engineering, State Key Laboratory of Physical Chemistry of Solid Surfaces, Collaborative Innovation Center of Chemistry for Energy Materials (iChEM), Xiamen University, Xiamen, 361005, P. R. China.
Email: sheng.hu@xmu.edu.cn

Mass transport in atomic-scale confinements

Abstract

Ion and molecule transport in nano-confinements exhibit fundamentally new behaviors, and is increasingly explored as a new platform for developing novel separation technologies. Here we report our results of mass transport in pores and channels with dimensions down to atomic scale. First, we introduce several methods of fabricating artificial atomic scale confinements. Second, we demonstrate proton transport and hydrogen isotope separation through the lattice rings of one-atom-thick crystals, and room temperature quantum sieving effects and complete steric exclusion of ions discovered in atomic-scale channels created using van der Waals assembly. At last, we discuss strategies of atomic scale pores design for highly efficient osmotic energy conversion.

Meng Li
MOE Key Laboratory of Low-grade Energy Utilization Technologies and Systems, CQU-NUS Renewable Energy Materials & Devices Joint Laboratory, School of Energy & Power Engineering, Chongqing University, Chongqing 400044, China
Email: limeng@cqu.edu.cn

Study on Bio-inspired Carbon Materials in Solar-thermal Conversion

Abstract

Facing the increasingly serious global water scarcity and energy crisis, interfacial solar evaporation system is becoming an important research frontier due to its zero-energy consumption. However, compared to traditional desalination technologies, because of narrow solar spectrum absorption and low solar-thermal conversion efficiency of the solar-thermal materials, a low fresh water production rate of the system confines its further industrial application. Therefore, the key issue on lifting the water yield for system is the solar-thermal conversion property of solar-thermal materials, and multiscale structure design to the materials is an important solution. Surprisingly, many living creatures are adept to absorbing solar energy through their natural multiscale structure obtained from millions-of-years evolution. Inspired by the biomass in nature, with an interdisciplinary research strategy including engineering thermophysics and biological and bio-inspired engineering, we mainly focus on constructing bioinspired structures for the carbon-based solar-thermal materials as well as the energy conversion and mass transport in the device. First, we introduce tree-inspired fractal structure designed for carbon-based solar-thermal materials, and synthesize a novel low-cost solar-thermal material, fractal carbonized pomelo peels, based on a common bio-waste. This bio-inspired system shows an extremely high solar spectrum absorption and marvelous evaporation rate. In addition, the mechanisms of the evaporation enhancement by bio-inspired fractal structural design are identified through numerical and experimental methods. Then, drawing inspiration from structural color of butterfly, we develop a novel solar thermal membrane with reduced graphene oxide substrate and bio-inspired light-trapping nanostructure, which remarkably facilitate light harvesting. Besides, inspired by ion selective membrane of cell, the distance

regulation between sublayer of rGO can suppress the transport of hydrated ions, thus reduce salt accumulation and enhance the duration. Finally, with an interdisciplinary strategy, we quantitatively reveal a strong correlation between evaporation efficiency and porosity of 1D water path in isolation configuration; the optimum range of porosity for evaporation is also identified through numerical simulation method.

Xiaofeng Zhou

East China Normal University
Email: xfzhou@ee.ecnu.edu.cn

Liquid-solid electricity generator based on bulk effect

Abstract

Water covers about 70 % of the earth and contains tremendous energy. Water energy, as a renewable and clean energy, is widely converted into other forms of energy, such as chemical energy, thermal energy and kinetic energy, which is making contribution to the daily life. To date, extensive efforts have been made for water energy harvesting. Water energy can be harvested both in large scale such as river/ocean and in small scale such as raindrop, based on contact electrification effect, osmotic pressure difference effect, electro-kinetic effect, hydro-voltaic effect, bulk effect, etc. The representative triboelectric nanogenerator (TENG) is characterized by the arrangement of the electrode directly underlying the dielectric material. In this case, the electrostatic energy is obtained through the triboelectrification and the electrostatic interaction between the water and the dielectric materials. The existence of the interfacial effects based on the solid-liquid interface limits the output performance. Recently, a novel droplet-based electricity generator (DEG) with a transistor-like structure is developed, converting the droplet kinetic energy into electricity through the bulk effect. The output performance is dramatically enhanced by breaking the interfacial effect at the liquid-solid interface. The report will mainly focus on the development and the applications of the electricity generators based on bulk effect. This report will start from this droplet-based electricity generator and the bulk effect. Next, an electricity generator based on the bulk effect for harvesting the water energy in closed system will be introduced. Moreover, a universal single electrode droplet-based electricity generator based on bulk effect represent a new dimension in ability to harvest abundant hydrodynamic energy everywhere. Finally, with the design of 3D electrodes, an arrayed generator based on bulk effect shows potential capabilities for wave energy harvesting.

Wendong Wang

University of Michigan – Shanghai Jiao Tong University Joint Institute, Shanghai Jiao Tong University
Email: wendong.wang@sjtu.edu.cn

Self-assembly in Nanomaterials, Dynamic Materials, and Micro-robots

Abstract

Self-assembly is the Nature's way of making materials. It is also the underlying principle in the synthesis and fabrication of many artificial materials. This talk will showcase the role of self-assembly in the diverse materials systems across different length scales, from nanometers to centimeters. I will first show templated-directed self-assembly of mesoporous materials for use as insulating materials in semiconductor

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microprocessors. I will then show the work on the ferrofluid-infused porous surface (FLIPS), a dynamic material system capable of various functions across multiple length scales, including transporting colloids, controlling droplet flows, removing biofilms for potential clean energy applications. Finally, by combining both dynamic and programmable self-assembly, I will show a system of spinning micro-rafts at the air-water interface and their use as microrobots in collective navigation and object manipulation for potential medical and robotic applications. The talk will conclude with a discussion on the development of Nature-inspired dynamic materials systems for healthcare and clean energy applications in the future.

Jinlong Song

Key Laboratory for Precision and Non-traditional Machining Technology of the Ministry of Education, Dalian University of Technology, Dalian 116024, P. R. China.
Email: songjinlong@dlut.edu.cn

Droplet-Based Self-Propelled Mini-Boat

Abstract

Self-propelled autonomous devices have huge application prospects in the field of environment protection and energy. Nonetheless, the requirement of special chemicals or external electric and thermal energy limits their practical application. Here, we reported a green self-propelling method based on water droplet. We first fabricated a triangle-shaped mini-boat composed of a superhydrophobic plate with an inclined superhydrophilic pore by laser etching, fluoroalkylsilane modification, and laser drilling. Water droplet putted on superhydrophilic pore passed through the pore and formed a jellyfish-like jet which further propel the mini-boat to move spontaneously and directionally. The main propelling force for the mini-boat was originated from Laplace pressure of water droplet. We also found the propelling distance, propelling time and instantaneous propelling velocity of the mini-boat were greatly affected by the pore size and the initial water droplet volume. Then, two types of devices were designed and installed on the mini-boat to successively provide small water droplets from the reservoir or rain to realize the continuous and long-distance self-propelled motion. Moreover, we also designed a spindle-shaped mini-boat with two or four symmetrical and inclined pores. Under propelling by the torque, the spontaneous and continuous rotation motion was also achieved. Our finding will open a new avenue for a wide range of applications ranging from the detecting mini-robot on water surface to power generation device from rain.

Hongbo Xu

Harbin Institute of Technology, 150001 Harbin, China

Optical Wood with Switchable Transmittance of Solar Irradiation for Thermal Management

Abstract

Passive daytime radiant cooling and daylight harvesting are of great significance to reduce electricity usage and the cost of controlling indoor temperature. However, pairing them together in a single thermal management material is challenging due to the mismatch of light absorption and reflectivity. The traditional method is to compound and switch between two different structures, but it has poor mechanical stability and harms the integrity of the entire system. Herein, we developed an optical wood (OW) with switchable reflectance and transmittance of solar irradiation through phenylethanol impregnation. After delignification

from the natural wood, the optical wood (defined as OW-Ⅰ) exhibits a high reflectivity (95.9%) in sunlight band (250-2500 nm) and high emissivity (0.93) in infrared band (2.5-25 μm). After impregnation with phenylethanol, the OW-Ⅰ can be transformed into a new state (OW-), which displays significantly increased transmittance (81.3%) and haze (94%). Our switchable optical wood enables efficient radiative cooling to 7.6 °C below (in summer by using OW-Ⅰ), and daylight heating to 5.6 °C above ambient temperature (in winter by using OW-). It is thereby suitable for all-season usage with excellent energy saving efficiency (cooling power 81.4 W/m2, heating power 229.5 W/m2). With its good mechanical strength, monolithic structure, and fast switching speed, our optical wood could be a promising candidate of energy efficient building materials.

Shengxi Zhou

Northwestern Polytechnical University
Email: zhoushengxi@nwpu.edu.cn

Nonlinear vibration energy harvesters: Design, analysis and experiment

Abstract

There are a lot of time-varying vibrations induced by mechanical machines, vehicles, human motions, wind, and ocean waves, and so on. However, the broadband and time-varying characteristics of environmental vibrations are difficult to match and energy harvesting from low level excitations is inefficient even disabled. The nonlinear vibration energy harvester is one of most effective harvesters to convert broadband vibration energy into usable electric energy. This presentation will review and discuss the design, advanced analysis methods, experiments and the application of nonlinear vibration energy harvesters.

Xianglei Liu

School of Energy and Power Engineering, Nanjing University of Aeronautics and Astronautics, Nanjing 210016, China
Email: xliu@nuaa.edu.cn

Biomorphic ceramics embedded molten salts for ultrafast thermal and solar energy storage

Abstract

Phase change materials (PCMs) are regarded as one of the most promising candidates for thermal energy storage due to possessing large energy storage densities and maintaining nearly a constant temperature during charging/discharging processes. However, the intrinsically low thermal conductivity of PCMs has become a bottleneck for rapid energy transport and storage. Here, we present a strategy to achieve ultrafast solar and thermal energy storage based on biomorphic ceramic skeletons embedded molten salts. A record-high thermal conductivity of 116 W/mK is achieved by replicating cellular structure of oak wood, leading to an ultrafast thermal energy storage rate compared with molten salts alone. By further decorating TiN nanoparticles on SiC skeletons, the solar absorptance is enhanced to be as high as 95.63 % via exciting broadband plasmonic resonances. Excellent thermal transport and solar absorption properties enable designed composites to have bifunctional capabilities of harvesting both thermal energy and solar energy very rapidly. This work opens a new route for the design of bifunctional energy storage materials for ultrafast solar and thermal energy storage.

Session 5: Bionic implants, organs and systems

17 July, Saturday (Day 1)

15:30-18:00	**Session 5: Bionic implants, organs and systems -I**
	Room III (ID: 926 8093 0537)
	Chair: Zhou Li, Pengyuan Wang, Chao Zhong
15:30-15:50	KEYNOTE TALK Nitrate-functionalized biomaterials for cardiovascular regeneration Qiang Zhao, *Nankai University*
15:50-16:10	KEYNOTE TALK The Fabrication and Precision Measurement of Organs-on-a-Chip Zhongze Gu, *Southeast University*
16:10-16:25	INVITED TALK Rationally Designed Synthetic Protein Hydrogels with Predictable and Controllable Mechanical Properties Yi Cao, *Nanjing University*
16:25-16:40	INVITED TALK Soft, 3D Microsystems for Biomedicine Mengdi Han, *Peking University*
16:40-16:55	INVITED TALK Bioactive biomaterials and systems: design and biomedical applications Linlin Li, *Beijing Institute of Nanoenergy and Nanosystems, CAS*
16:55-17:10	INVITED TALK Protocells: A New Kind of Artificial Cells Jianbo Liu, *Hunan University*
17:10-17:25	INVITED TALK Research on Construction of in vitro GBM Model Based on 3D Bioprinting Liang Ma, *Zhejiang University*
17:25-17:35	ORAL PRESENTATION Independent Pattern Formation and Parallel Locomotion of Two Microrobotic Swarmsunder a Global Input Xingzhou Du, *The Chinese University Hong Kong*
17:30-17:40	ORAL PRESENTATION Modulating Neural Subtype Specification with Employing cSAPs Substrates for Neural Direct Conversion of Human Fibroblast Javad Harati, *Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences*
17:45-17:55	ORAL PRESENTATION Deciphering the role of perinuclear actin cap (pnAC) in nanocarrier trafficking and gene transfection in skeletal myoblasts on nanopillars Rui Zhang, *Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences*
17:55-18:05	ORAL PRESENTATION Mimicking Schooling Fishes to Construct a 3D Reconfigurable Microswarm for On-Demand Reaction-Rate Control Fengtong Ji, *The Chinese University of Hong Kong*

18 July, Sunday (Day 2)

10:30-11:45	**Session 5: Bionic implants, organs and systems -II**
	Room III (ID: 926 8093 0537)
	Chair: Zhou Li, Pengyuan Wang, Chao Zhong
10:30-10:45	INVITED TALK
	Biomimetic construction of functional myocardial patch using natural biomaterials
	Honghao Hou, *School of Basic Medical Science, Southern Medical University*
10:15-11:00	INVITED TALK
	Bioinspired Materials and Technology for Cryopreservation
	Wei Rao, *Technical Institute of Physics and Chemistry, CAS*
11:00-11:15	INVITED TALK
	Bionic self-powered biosensors
	Bojing Shi, *Beihang University*
11:15-11:30	INVITED TALK
	Enzyme-powered Artificial Cell Models
	Lei Wang, *Harbin Institute of Technology*
11:30-11:45	INVITED TALK
	Cell mechanoresponse
	Qiang Wei, *Sichuan University*

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Keynote Speakers

Qiang Zhao

State key Laboratory of Medicinal Chemical Biology, College of Life Sciences, Nankai University, Tianjin 300071, China
Email: qiangzhao@nankai.edu.cn

Nitrate-functionalized biomaterials for cardiovascular regeneration

Abstract

Dr. Qiang Zhao received B. Eng degree from Northwestern Polytechnical University in 2001, and Ph.D. degree in Materials Science & Engineering from Tianjin University (China) in 2006. After completing three years of postdoctoral research at City University of Hong Kong, he joined College of Life Sciences, Nankai University (China) as associate professor in 2009, and was promoted to full professor in 2014. Dr. Zhao is the Director of Tianjin Key Laboratory of Bioactive Materials as well as the PI of State Key Laboratory of Medicinal Chemical Biology. He was the recipient of Distinguished Young Scholar (2019) and Excellent Young Scientist of NSFC (2015). Currently his research interest focuses on cardiovascular biomaterials and regenerative medicine, including the cardiovascular tissue engineering and therapeutic biomaterials and techniques for cardiovascular diseases. He was awarded the First Prize of the Natural Science Award of Tianjin (2019, 2/11) and the Second Prize for Progress in Science and Technology of Tianjin (2016, 1/8), and has authored over 70 peer-reviewed research papers (including Nat Chem Biol, Circ Res, Adv Mater, Adv Sci, J Am Soc Nephrol, Biomaterials, J Control Release, etc.), five book chapter, and 8 patents granted or pending.

Biography

Nitric oxide (NO) is a short-lived signalling molecule that plays a pivotal role in cardiovascular system. Organic nitrates represent a class of NO-donating drugs for treating coronary artery diseases, acting through the vasodilation of systemic vasculature that often leads to adverse effects. Herein, we designed a nitrate-functionalized patch, wherein the nitrate pharmacological functional groups were covalently bound to biodegradable polymers, thus transforming small-molecule drugs into therapeutic biomaterials. When implanted onto the myocardium, the patch released NO locally through a stepwise biotransformation, and NO generation was remarkably enhanced in infarcted myocardium because of the ischaemic microenvironment, which gives rise to mitochondrial-targeted cardioprotection as well as enhanced cardiac repair. The therapeutic efficacy was further confirmed in a clinically relevant porcine model of myocardial infarction. All these results support the translational potential of this functional patch for treating ischaemic heart disease by therapeutic mechanisms different from conventional organic nitrate drugs.

Zhongze Gu

School of Biological Science & Medical Engineering, Southeast University,
SiPaiLou #2, Nanjing, Jiangsu 210096, China.
Institut of Medical Devices (Suzhou) Southeast University, JinFeng Rd #8,
Suzhou, Jiangsu 215163, China,
Email: gu@seu.edu.cn

The Fabrication and Precision Measurement of Organs-on-a-Chip

Abstract

Organs-on-a-chip (OOC) system, or microphysiological system (MPS), is a new type of biomedical research method that aims to recapitulate organ-level tissue structures and functions for drug evaluation and disease modeling. The MPS can be used to simulate the microstructure, microenvironment, and functional features of human organs, and applied in drug screening and clinical diagnosis and treatment. In previous study, we have developed multiple organ-on-a-chip systems including biomimetic blood vessels, kidney, liver, heart, etc. [1-2] Our previous work demonstrated that the miniature organs made with advanced microfabrication, 3D printing, microfluidics and tissue engineering techniques could form tissue-specific structures and could maintain some desirable organ functions for drug screening and disease modeling purposes [3-5].

In this presentation, we report the development of a two/multi-photon based 3D printing systems for the OOC fabrication and microenvironment formation, and the fabrication of multiple microphysiological systems for disease modeling, and the development of an automated high-content organs-on-a-chip imaging system for automated drug screening together with deep-learning based AI-algorisms for data analysis. The systems that we reported here have been widely applied in drug discovery and toxicity evaluation in collaboration with top-tier pharmaceutical companies in China, and have been used for precision medicine in collaboration with top-tier hospitals. We also report design and development of a functional Lung-on-a-Chip system for lung bacterial/viral infection, inflammation studies. Lastly, our system and platform have been successfully applied in Covid-19 and other virus infectiousness evaluation, testing of efficacy for drug, neutralizing antibodies (including vaccines from Pfizer, BioNTech etc.), and other protective measures. In summary, our work demonstrated the usefulness and progressive applications of OOC in the multidisciplinary fields in China.

Biography

Prof. Gu Zhongze, Yangtze river scholars Distinguished Professor, National Outstanding Youth Fund winner and the Head of Ministry of Education Innovation Team and Discipline Intellectual Base. He graduated from Southeast University in 1989 and got his M.S. in 1992 there. He went to The University of Tokyo in 1994 and obtained his Ph.D. in 1998. He is currently the dean of the School of Biological Science & Medical Engineering of Southeast University and the director of the Institute of Biomaterials and Medical Devices of Jiangsu Institute of Industrial Technology, and mainly engaged in human organ chip research. He has undertaken a number of scientific research projects such as the national key research, development plan, and the National Natural Science Foundation. He has published more than 300 papers in international core journals, which has been cited over 10,000 times. 45 patents were granted and 6 were transferred. The research results won 7 provincial and ministerial awards.

Invited Speakers

Yi Cao

Nanjing University
Email: caoyi@nju.edu.cn

Rationally Designed Synthetic Protein Hydrogels with Predictable and Controllable Mechanical Properties

Abstract

Designing synthetic protein hydrogels with tailored mechanical properties similar to naturally occurring tissues remains an enduring challenge in tissue engineering and stem cell and cancer research. Although there have been attempts to correlate the mechanical properties of protein hydrogels with the nanomechanics of individual building blocks, the correlation has been qualitative rather than quantitative. In this talk, we use single-molecule force spectroscopy, protein engineering and theoretical modeling to prove that the mechanical properties of protein hydrogels are directly linked to the mechanical hierarchy of the crosslinkers and the load-bearing modules at the molecular level and the network structures. These findings provide a framework for rationally designing protein hydrogels with independently tunable elasticity, extensibility, toughness, self-healing and anti-fatigue properties. Using this principle, we demonstrate the engineering of various hydrogels with predictable and tunable mechanical properties. We expect that this principle can be generalized for the construction of protein hydrogels with customized mechanical properties for biomedical applications.

Mengdi Han

Department of Biomedical Engineering, Peking University
No. 5 Yiheyuan Road, Haidian District, Beijing, China
Email: hmd@pku.edu.cn

Soft, 3D Microsystems for Biomedicine

Abstract

Many minimally invasive surgeries rely on catheters equipped with elements for sensing and/or actuation to deliver, through small incisions, diagnostic measurements and therapeutic interventions for a range of diseases and conditions. The rigid physical properties of these devices and their relatively primitive modes of operation impede their conformal contact with soft tissue surfaces, limit the scope of their uses, lengthen the times for the surgeries and increase the required levels of surgical skill. In this talk, I will mainly introduce materials, three-dimensional (3D) multilayer architectures and fabrication approaches for integrating advanced electronic functionality with such types of surgical tools, with a specific focus on balloon catheter systems. The multimodal, multiplexed soft electronic systems in multilayered configurations support capabilities that range from high-density spatiotemporal mapping of temperature, pressure and electrophysiological parameters, to options in programmable high-density actuation of thermal inputs and/or electrical stimulation, radio frequency (RF) ablation and irreversible electroporation (IRE). The

resulting advanced classes of medical instruments enable soft contacts to curved tissue surfaces, with ability to address broad requirements in minimally invasive surgeries. Demonstrations with endocardial balloon catheter devices in plastic heart models and on Langendorff-perfused animal and human hearts, together with numerical multi-physics modeling of their operation, highlight some of the essential features of the technology. Next, I will briefly introduce other 3D flexible devices with applications in (1) wireless, continuous monitoring of pressure at the skin-prosthetic interface, (2) efficient mechanical energy harvesting from environment and biology, (3) electronic scaffolds for cells/tissues/organoids, and (4) aquatic and terrestrial microrobots.

Honghao Hou

Guangdong Provincial Key Laboratory of Construction and Detection in Tissue Engineering, School of Basic Medical Science, Southern Medical University, Guangdong, Guangzhou 510515, China.

Email: ss.hhh89@hotmail.com

Bioactive biomaterials and systems: design and biomedical applications

Abstract

Tissue engineering scaffolds based on natural biomaterials are endowed with obviously inherent advantages, but how to use natural biomaterials to achieve biomimetic construction of the composition, structure and function of human tissues and organs is still a big challenge. We take full use of mussels, sea squirts cellulose, fish swimming bladder and other natural-source biomaterials, to construct a series of bionic functional myocardial patch through the concise and rational design and modification, and used for the repair of myocardial infarction. In-vivo and in-vitro experiment results demonstrated well repair effect of myocardial infarction. Bionic anisotropic microstructures are proven to be efficiently at regulating the behave of different tissue and stem cells such as cardiomyocytes and C2C12 myoblast and accelerating the repair of tissue injury, inspiring the new direction of functionally biomimetic bio-surfaces. We hope this work provides a new envision for building functional myocardial patches to repair the myocardial infarction.

Linlin Li

Beijing Institute of Nanoenergy and Nanosystems, Chinese Academy of Sciences, Beijing, 100140, China

Email: lilinlin@binn.cas.cn

Bioactive biomaterials and systems: design and biomedical applications

Abstract

Biomimetic electrostimulation can modulate a myriad of biological processes, from cell cycle, migration, proliferation and differentiation to neural conduction, muscle contraction, embryogenesis, tissue regeneration. And electrical stimulation is also developed for drug delivery and cancer therapy. For these biomedical applications, design and fabrication of electroactive biomaterials and systems that has high biocompatibility and controllable modulation on cells and tissues is the key for their further applications. To

this end, our group have designed a series of bioactive biomaterials, including conductive and piezoelectric biomaterials with high biocompatibility and micro/nanotopography. We also developed self-powered systems for delivering electrical stimulation to biosystems. Through these designs, we can realize the modulation of cell attachment, proliferation, controlled differentiation of stem cells. We also developed self-powered drug delivery system for delivering bioactive molecules into cells and tissues. These works pave new direction for the design and application of bioactive biomaterials and systems.

Jianbo Liu

State Key Laboratory of Chemo/Biosensing and Chemometrics, College of Chemistry and Chemical Engineering, Key Laboratory for Bio-Nanotechnology and Molecular Engineering of Hunan Province, Hunan University, Changsha, P. R. China.

Email: liujianbo@hnu.edu.cn

Protocells: A New Kind of Artificial Cells

Abstract

Protocell is defined as a kind of artificial cell with a simple and primitive chamber structure, which is an image of the origin of life on the earth. Because the cell is the smallest unit of life. The appearance of protocells marked the birth of life and was a milestone in the evolution of life. The study of protocells will provide a theoretical and experimental basis for the study of the origin of life, and provide important guidance for understanding the essence of the origin of life. At the same time, protocells, as a bionic cell model and micro-reaction device, demonstrate wide applications in the fields of biological analysis and detection, biomedical diagnosis and treatment, etc.

Liang Ma

State Key Laboratory of Fluid Power & Mechatronic Systems, Zhejiang University, Hangzhou, 310058, P.R. China

School of Mechanical Engineering, Zhejiang University, Hangzhou, 310058, P.R. China

Email: liangma@zju.edu.cn

Research on Construction of in vitro GBM Model Based on 3D Bioprinting

Abstract

Treatments for lesions in central nervous system (CNS) are always faced with challenges due to the anatomical and physiological particularity of the CNS despite of the fact that several achievements has been made in early diagnosis and precision medicine to improve the survival and quality of life of patients with brain tumors in recent years. Specifically, glioblastoma multiforme (GBM), the most aggressive tumor within the brain, frequently kills patients within a year of diagnosis. The invasive growth feature of GBM is the main cause that is responsible for the high recurrence rate, high mortality and poor clinical efficacy. The microenvironment of a tumor consists of multiple biochemical cues and the interaction between tumor cells,

stromal cells, and extracellular matrix (ECM) plays a key role in tumor initiation, development, angiogenesis, invasion and metastasis. To better understand the biological features of GBM and reveal the critical factors of therapeutic treatments against GBM, it is of great significance to build in vitro GBM models that could recapitulate the stages of GBM progression and mimic tumor behaviors in vivo for efficient and patient-specific drug screening and biological studies. In the meantime, three-dimensional (3D) bioprinting techniques have gradually found its applications in tumor microenvironment modeling with accurate composition and well organized spatial distribution of tumor-related cells and extracellular components in the past decades. The capabilities of building tumor models with a large range of scale, complex structures, multiple biomaterials and vascular network with high resolution and throughput make 3D bioprinting become a versatile platform in bio-manufacturing as well as in medical research. In this study, a 3D bioprinted in vitro brain matrix-mimetic microenvironment model with Hyaluronic Acid (HA) and glial cells (HEB) is firstly developed using an extrusional based bioprinting system to simulate both mechanical and biological properties of human brain microenvironment in vivo through investigation of the formulation of bioinks and optimization of printing process and parameters to study the effects of different concentration of gelatin (GA) within the bioink and different printing structures of the scaffold on the performance of the brain matrix-mimetic microenvironment models. Then 3D GBM spheroids are generated and cultured to simulate neoplastic tissues in vitro, and injected into the brain matrix-mimetic microenvironment model to construct a tumor-stroma co-culture system with GBM as well as cerebral environment model. The study provides reliable experimental platforms for exploration of the multiple factors in the brain microenvironment as well as GBM invasion study such as the differences of gene expression before and after GBM invasion and the induction of GBM invasive progress by glucose concentration gradient. The GBM model could also be adapted to other biological systems and be used as a valuable tool to model cell-cell interactions and to control microenvironment in other systems.

Wei Rao

CAS Key Laboratory of Cryogenics, Technical Institute of Physics and Chemistry, Chinese Academy of Sciences, Beijing, 100190, China
29 Zhongguancun East Road, Haidian District, Beijing, 100190, PR China.
Email: weirao@mail.ipc.ca.cn

Bioinspired Materials and Technology for Cryopreservation

Abstract

Cryopreservation is a frontier field of life science and clinical medicine, it has been playing a key role in transplantation medicine, cancer treatment, tissue engineering and reproductive technology, the corresponding technology has become almost the only way to store cells for long times. However, it remains difficult to effectively cryopreserve certain sensitive cells, tissues, and reproductive organs. A coordinated effort from the perspective of the whole frozen biological system is needed to advance cryopreservation technology. Animals that survive in cold temperatures, such as hibernators and cold-tolerant insects, offer excellent natural models. Their anti-cold strategies, such as programmed suppression of metabolism and self-synthesis of cryoprotectants, are worth studying systematically. Furthermore, the discovery and synthesis of biomaterials (e.g., metabolic regulators and cryoprotectants) and biotechnological breakthroughs can also promote the development of bioinspired cryopreservation. Further advances in the quality and length of biosample storage inspired by nature will promote the application of cryopreserved biosamples in clinical practices. This presentation is to demonstrate the up-to-date advancement of novel materials and techniques for cryopreservation applications.

IYCBSE 2021

Bojing Shi

Beijing Advanced Innovation Centre for Biomedical Engineering, Beihang University, Beijing 100191, China
Email: bjshi@buaa.edu.cn

Bionic self-powered biosensors

Abstract

Self-powered biosensors have been developed rapidly in recent years, which can be used for detecting physiological parameters such as heart beating, respiration and pulse wave. Bionics is an important trend for developing novel sensors. Here, self-powered sensors inspired by electric eel and plant nyctinasty have been introduced. By mimicking the structure of ion channels on the cytomembrane of electrocyte in an electric eel, a mechanical control channel is manufactured by the effect of stress-mismatch between polydimethylsiloxane (PDMS) and silicone. Two kinds of unique working modes allow the BSNG to achieve over 170 V open-circuit voltage in dry conditions and over 10 V in liquid environment, which are combined with the advantages of the TENG and can be used for energy harvesting and underwater sensing. Owing to its advantages of excellent flexibility, stretchability, mechanical responsiveness and output performance, the BSNG is expected to be a human body motion monitor and a promising alternative power source for wearable electronics in dry and wet environments. Other example is a flexible self-arched biosensor for pulse sensing which is inspired by the phenomenon of plant nyctinasty. The sensor is based on the combined effect of triboelectricity and piezoelectricity, which can enhance the outputs, the signal-to-noise ratio and stability of the device when detecting pulse signals. The output properties of the sensor are related to the morphology of the self-arched structure, which can be easily regulated by adjusting the mass ratio of two types of silicone elastomers of PDMS and Ecoflex. It is a convenient approach compared to conventional ones that should make a different special mold to obtain arched structures. For pulse sensing, the sensitivity and the stability of the sensor are qualified due to its unique self-arched structure and hybrid effect of triboelectric and piezoelectric for converting tiny mechanical signals into electric ones effectively.

Lei Wang

School of Chemistry and Chemical Engineering, Harbin Institute of Technology
92 West Dazhi Street, Harbin 150001, China
Email: Leiwang_chem@hit.edu.cn

Enzyme-powered Artificial Cell Models

Abstract

The past decades has witnessed the great advancement in the field of artificial swimmers, due to their broad applications in both life science, nanomedicine as well as environmental remediation. Enzymes, with efficient catalytic ability, nice biocompatibility and degradability, are excellent engine candidates for these

artificial swimmers. Herein, to further broaden the library of enzyme engines and the biomimetics of cellular functions, different enzymes were explored to trigger the motion of artificial cell models. Besides, these models were either endowed with programmed autonomic behaviors, the blood lipid remover or artificial predators, thus providing new artificial platforms for future research on biomimicry, biomedical or environmental issues.

Qiang Wei

College of Polymer Science and Engineering, College of Biomedical Engineering, State Key Laboratory of Polymer Materials and Engineering, Sichuan University, Chengdu 610065, China
Email: wei@scu.edu.cn

Cell mechanoresponse

Abstract

Chemical and physical cues at cell-material interface mediate various of cellular behaviors, including adhesion, migration, differentiation, etc. Cells mechanically sense and respond to these cues to initiate mechanotransduction pathways and alter cellular phenotype and function[1]. The profile of cell mechanoresponse and the molecular levels of such regulations are not yet well understood. Here, we systematically investigated cell mechanical behaviors at the interfaces with different ligand diversity, spatial ligand patterning, and mechanical properties. The crosstalk between mechanotransduction pathways and growth factor signaling was further revealed.

Session 6: Youth Forum of Guangdong -Hong Kong-Macao Greater Bay Area

17 July, Saturday (Day 1)

13:30-15:25	**Session 6: Youth Forum of Guangdong-Hong Kong-Macao Greater Bay Area -I**
	Room IV (ID: 925 7171 1971)

Chair: Steven Wang, Zhengbao Yang, Xinge Yu

13:30-13:50	KEYNOTE TALK
	Musculoskeletal Mechanics and Mechatronics: Bionic Healthcare Engineering from Human and for Human
	Lei Ren, *Jilin University*
13:50-14:10	KEYNOTE TALK
	No more laundry?
	Liqiu Wang, *The University of Hong Kong*
14:10-14:25	INVITED TALK
	Versatile biomanufacturing through cell-material feedback
	Zhuojun Dai, *Shenzhen Institute of Advanced Technology, CAS*
14:25-14:40	INVITED TALK
	Harnessing biointerfacial property to control cell
	Pengyuan Wang, *Shenzhen Institute of Advanced Technology, CAS*
14:40-14:55	INVITED TALK
	Facile fabrication of transparent anti-reflection surface with superamphiphobic by template-assisted spraying coating
	Yanan Li, *Sun Yat-sen University*
14:55-15:10	INVITED TALK
	Bio-inspired metallic microlattice metamaterials
	Yang Lu, *City University of Hong Kong*
15:10-15:25	INVITED TALK
	Decellularized man-made hyaline cartilage graft for cartilage tissue engineering
	Dongan Wang, *Chinese University of Hong Kong*

18 July, Sunday (Day 2)

08:30-10:25 Session 6: Youth Forum of Guangdong-Hong Kong-Macao Greater Bay Area - II

Room IV (ID: 925 7171 1971)

Chair: Steven Wang, Zhengbao Yang, Xinge Yu

08:30-08:50	KEYNOTE TALK Insect Tracheal Systems Qi-Huo Wei, *Southern University of Science and Technology*
08:50-09:10	KEYNOTE TALK Development of biocompatible bulk metallic glasses Guoqiang Xie, *Harbin Institute of Technology (Shenzhen)*
09:10-09:25	INVITED TALK Crack engineering as a new route for the construction of arbitrary hierarchical architectures Kangning Ren, *Hong Kong Baptist University*
09:25-09:40	INVITED TALK Liquid-organelle-inspired engineering of all-aqueous droplets Anderson Shum, *The University of Hong Kong*
09:40-09:55	INVITED TALK Nanorobot Controlled with Collective Intelligence Jingyao Tang, *The University of Hong Kong*
09:55-10:10	INVITED TALK Biohybrid stem cell microrobots with endoluminal delivery Ben Wang, *Shenzhen University*
10:10-10:25	INVITED TALK Interface Engineering in Multiphase Microfluidic Tiantian Kong, *Shenzhen University*

10:30-12:00 Session 6: Youth Forum of Guangdong-Hong Kong-Macao Greater Bay Area -III

Room IV (ID: 925 7171 1971)

Chair: Steven Wang, Zhengbao Yang, Xinge Yu

10:30-10:45	INVITED TALK Pattern recognition techniques for sand particles Jeff Jianfeng Wang, *City University of Hong Kong*
10:45-11:00	INVITED TALK Advanced Designs for Sustainable Solar-Energy-Water Nexus Peng Wang, *The Hong Kong Polytechnic University*
11:00-11:15	INVITED TALK Mechanoluminescence of Quaternary Piezoelectric Semiconductors for Advanced Lighting and Sensing Applicationsg Dengfeng Peng, *Shenzhen University*
11:15-11:30	INVITED TALK A nature-inspired fluid mechanics approach for phase separation Steven Wang, *City University of Hong Kong*
11:30-11:45	INVITED TALK Micro/Nano-devices for Biomedical Applications Xi Xie, *Sun Yat-sen University*
11:45-12:00	INVITED TALK Bionics for Decoding Biological Motion Intelligence Xiaofeng Xiong, *University of Southern Denmark*

13:30-14:45 Session 6: Youth Forum of Guangdong-Hong Kong-Macao Greater Bay Area - IV

Room III (ID: 926 8093 0537)

Chair: Steven Wang, Xinge Yu

13:30-13:45	INVITED TALK Mechanics underlying the structure-property relations unveiled from natural biomaterials Haimin Yao, *The Hong Kong Polytechnic University*
13:45-14:00	INVITED TALK Soft actuators in skin-integrated electronics for VR/AR Xinge Yu, *City University of Hong Kong*
14:00-14:15	INVITED TALK Liquid-Solid Hybrid Soft Packaging Materials Yanhao Yu, *Southern University of Science and Technology*
14:15-14:30	INVITED TALK Bio-inspired Magnetic Microrobots: From Individual to Swarm Li Zhang, *Chinese University of Hong Kong*
14:30-14:45	INVITED TALK When biomimetics meets microfluidics Pingan Zhu, *City University Hong Kong*

13:30-14:30 Session 6: Youth Forum of Guangdong-Hong Kong-Macao Greater Bay Area -V

Room IV (ID: 925 7171 1971)

Chair: Zhengbao Yang

13:30-13:45	INVITED TALK IceMicroneedles for intradermal delivery of vaccines Chenjie Xu, *City University of Hong Kong*
13:45-14:00	INVITED TALK Achieving adjustable elasticity with non-affine to affine transition Lei Xu, *Chinese University of Hong Kong*
14:00-14:15	INVITED TALK Triboelectric Nanogenerator towards Low-Frequency Hydrodynamic Energy Harvesting Xiya Yang, *Jinan University*
14:15-14:30	INVITED TALK Vibration Energy Harvesting and Flexible Piezoelectric Devices Zhengbao Yang, *City University of Hong Kong*
14:30-14:45	INVITED TALK Introduction to The International Society of Bionic Engineering To be determined, *The International Society of Bionic Engineering*

Keynote Speakers

Lei Ren

School of Mechanical, Aerospace and Civil Engineering, University of Manchester
Key Laboratory of Bionic Engineering, Ministry of Education, Jilin University
Email: lei.ren@manchester.ac.uk

Musculoskeletal Mechanics and Mechatronics: Bionic Healthcare Engineering from Human and for Human

Abstract

Bionic healthcare engineering aims to advance human health and welling using the state-of-the-art approaches inspired from biological world. This may have great potential in the development of innovative diagnostic, preventative, rehabilitative and therapeutic programs and devices. This talk presents our recent studies in bionic healthcare engineering by exploring the fundamental working principles of the human musculoskeletal system, whilst by developing biologically inspired human-centred robotics and healthcare devices based on learnt biological principles. This involves a range of studies into the biomechanics and motor control of human motions using an integrated experimental, computational and bio-robotic approaches with the long term aim to gain comprehensive understanding of the functions of musculoskeletal systems and the interactions between the musculoskeletal and neuromotor systems. This also includes a range of researches in the development of smart bionic lower limb prosthetics inspired from human musculoskeletal biomechanics, bio-inspired robotic/prosthetic hands with human-like structures, and biologically inspired soft actuation and sensing techniques for healthcare devices.

Biography

Prof. Ren is a researcher in Biomechanics and Biorobotics at School of Mechanical, Aerospace and Civil Engineering, University of Manchester, and the leader of the Biomechanics Research Specialism. He also holds an honorary professorship at Key Laboratory of Bionic Engineering, Ministry of Education, Jilin University. He researches in the field of bionic healthcare engineering. He has been the PI and Co-I of over 30 research projects funded by UK EPSRC, BBSRC, NSFC and MoST etc. Prof. Ren has over 200 peer-reviewed publications. His research works have been reported by many major international medium including Nature, Science News, Wired, Telegraph, Science Daily and BBC etc. He sits in the Council of Chairs, Biomedical Engineering Society (BMES), and also serves as the associate editor-in-chief of Journal of Bionic Engineering, associate editor of Frontiers in Bioengineering and Biotechnology, the editorial board members of Chinese Journal of Mechanical Engineering and Journal of Healthcare Engineering etc. He is the member of UK EPSRC Peer Review College and also grant expert reviewers for UK EPSRC, BBSRC, MRC, Leverhulme Trust, French National Research Agency, NSFC and UNESCO etc.

IYCBSE 2021

Liqiu Wang

Department of Mechanical Engineering, the University of Hong Kong
Email:lqwang@hku.hk

No more laundry?

Abstract

Liquid-repellent materials repel liquids instead of allowing droplets to adhere. These materials are important in many fields including self-cleaning clothes and kitchenware, enhanced heat transfer, scald-burns protection, and anti-fouling, anti-corrosive and drag reduction coatings. The dream of research and development on liquid-repellents is a structure that has robust liquid repellency, strong mechanical stability, and is inexpensive to produce on a commercial scale. However, the functional outcomes of existing liquid-repellent materials have not been satisfactory, because of inadequacies of conventional structural design and fabrication approaches in engineering microstructures and properties. We developed a low-cost scalable approach for the fabrication of well-defined porous materials with robust liquid repellency and strong mechanical stability. The design of the liquid-repellent materials is inspired by structures on springtail cuticles, which can effectively resolve the longstanding conflict between the liquid repellency and the mechanical stability. Springtails are soil-dwelling arthropods whose habitats often experience rain and flooding. As a consequence, springtails have evolved cuticles with strong mechanical durability and robust liquid repellency to resist friction from soil particles and to survive in watery environments. We design the porous materials to be composed of interconnected honeycomb-like microcavities with a re-entrant profile: the interconnectivity ensures mechanical stability and the re-entrant structure yields robust liquid repellency. The cuticle-like porous materials are fabricated by self-assembly using microfluidic droplets, which takes full advantage of bottom-up and top-down fabrications and the capabilities of microfluidics in terms of scalability and precise-handling of small fluid volumes. This breakthrough enables inexpensive, commercial-scale production of fluoride-free, durable omniphobic materials that can be made hot-water super-repellent and under-liquid super-repellent as well, and make the dream of no more laundry and no more kitchen-cleaning come true.

Biography

Prof. Liqiu Wang received his PhD from University of Alberta, Canada, and is currently a chair professor in the Department of Mechanical Engineering, the University of Hong Kong (HKU). He also serves as the Director and the Chief Scientist for the Laboratory for Nanofluids and Thermal Engineering at the Zhejiang Institute of Research and Innovation (HKU-ZIRI), the University of Hong Kong. Prof. Wang has 25 years of HKU experience in transport phenomena, materials, nanotechnology, biotechnology, energy & environment, thermal & power engineering, and mathematics, and ~2 years of industry experience in technology and IP development/management/transfer as the Chief Scientist & the Global CTO. In addition to 6 authored scholarly monographs/books, 4 edited scholarly monographs, 5 book chapters, 76 keynote lectures at international conferences and 166 invited lectures in universities/industries/organizations, Prof. Wang has published 489 papers, many of which have been widely used by researchers all over the world and been ranked amongst the top 1% of most-cited scientists according to Clarivate Analytics' Essential Science Indicator. Prof. Wang has also filed 37 patents/software copyrights, and developed, with an international team consisting of about 100 scientists and engineers, a state-of-the-art thermal control system for the Alpha Magnetic Spectrometer (AMS) on the International Space Station (ISS) that ensures AMS and all its sub-detectors working at their designed temperatures ± 1 ℃ for an environment temperature variation from -40 ℃ to 60 ℃ every 90 minutes.

Prof. Wang's work has been widely featured by local, national and international media/journals, and received recognition through a number of awards, including the Gold Medal of the International Exhibition of Inventions of Geneva (2021), the TechConnect Global Innovation Award (2018), the Silver Medal of the International Exhibition of Inventions of Geneva (2018), the OSA Innovation Award (2017), and the First Outstanding Achievement Award of Hangzhou Oversea Scholars (2016).

Qihuo Wei

Department of Mechanical and Energy Engineering, Southern University of Science and Technology, Shenzhen, China
Email: weiqh@sustech.edu.cn

Insect Tracheal Systems

Abstract

Insects use an intricate network of microtubes known as tracheae to transport respiratory gases. Prior studies have established that for insect size below 1 cm, pure diffusion can provide sufficient oxygen intake and CO2 exit. However, we know many insects having body sizes larger than 1cm. For example, Darwin's moths have proboscises as long as 30 cm. How insects overcome this challenge remains unknown. Here I will present some recent work we did to understand this question, and talk about what this means for potential biomimetic applications.

Biography

Qihuo Wei joined the Department of Mechanical and Energy Engineering at the Southern University of Science and Technology in 2020 as a professor. Before that, he was a tenured professor at the Liquid Crystal Institute and Department of Physics in Kent State University in the US. He was a recipient of Alexander von Humboldt research fellowship and the CAREER award of National Science Foundation, and is an elected SPIE fellow. Prof. Wei has made original contributions in a number of research fields including single-file diffusion, nanoparticle plasmonics, Brownian motion, active matter, and molecular photopatterning.

Guoqiang Xie

School of Materials Science and Engineering, Harbin Institute of Technology (Shenzhen), 518055, China
Email: xieguoqiang@hit.edu.cn

Development of biocompatible bulk metallic glasses

Abstract

Bulk metallic glasses (BMGs) exhibit many superior properties such as high mechanical strength, high hardness, good fracture toughness, excellent corrosion resistance, good wear resistance and so on, compared with conventional crystalline metallic alloys. Such materials have attracted increasing attention in recent years due to their scientific and engineering significance. So far, many BMG systems have been developed. Among them, Ti-based and Mg-based BMGs are recently in great interest to be used as biomaterials.

We developed Ni- and Be-free Ti-based (Ti-Zr-Cu-Pd) BMGs with high glass-forming ability (GFA), high strength and good corrosion resistance. We also produced porous Ti-based BMG samples with the diameter over 15 mm by spark plasma sintering process. The porous BMG samples having high strength and low Young's modulus approximating to that of natural bone had been obtained. In vivo evaluation of the biocompatibility of the developed Ti-based BMGs had also been carried out by implantation the Ti-based BMG bars under the skin and in the bone of rats. The Ti-based BMG bars exhibited excellent biocompatibility in both soft tissue and hard tissue. It also showed nice osteoconductivity when implanted in bone tissue, and no metal ion diffusion was detected up to three months after operation.

New biodegradable Mg-based (Mg-Zn-Ca) BMGs with high strength and high corrosion resistance have been developed. Using spark plasma sintering (SPS) of the ball-milled powders, Mg-based BMGs satisfying large-size requirements were produced. The consolidated Mg-based glassy alloys exhibited high strength over 450 MPa, and had higher corrosion resistance than commercial Mg alloys. The Mg-based BMGs had also been demonstrated a great reduction in hydrogen evolution during in vitro and in vivo degradation, presenting the potentials for application as biomedical materials.

Biography

Guoqiang Xie is a professor at Harbin Institute of Technology (Shenzhen). He received a BS degree in physics from University of Science and Technology Beijing and Ph.D in materials science from Niigata University (Japan). Prior to joining Harbin Institute of Technology (Shenzhen), he had been employed in China Institute of Atomic Energy (CIAE, China, 1987-1998) as an Assistant Professor, then Associate Professor; National Institute for Materials Science (NIMS, Japan, 1998-2005) as a Researcher Fellow; Tohoku University (Japan, 2005-2016) as an Assistant Professor, then Associate Professor. He is mainly engaged in the research and development of new materials (biomedical materials, amorphous or high-entropy alloys and their composites, porous materials, etc.), powder metallurgy process research, nuclear material development and radiation damage and surface modification.

Invited Speakers

Zhuojun Dai

Institute of Synthetic Biology, SIAT, Chinese Academy of Sciences
Email: zj.dai@siat.ac.cn

Versatile biomanufacturing through cell-material feedback

Abstract

Small-scale production of biologics has great potential in facilitating individualized medicine and enhancing the accessibility of biomanufacturing. By exploiting cell-material feedback, we designed a concise platform to achieve versatile production, analysis, and purification of diverse proteins and protein complexes. The core of our technology is a microbial swarmbot, which consists of a stimulus-sensitive polymeric microcapsule encapsulating engineered bacteria. By sensing the confinement, the bacteria undergo programmed partial lysis at a high local density. Conversely, the encapsulating material shrinks in response to the changing chemical environment caused by cell growth and death, squeezing out the protein products released from bacterial lysis. This platform is then integrated with downstream modules to enable quantification of enzymatic kinetics, purification of diverse proteins, quantitative control of protein interactions, and assembly of functional protein complexes and multi-enzyme metabolic pathways through division of labor. Our work demonstrates the use of the feedback between living cells and materials to engineer a modular and flexible platform with sophisticated yet well-defined programmed functions.

Tiantian Kong

Affiliation: Shenzhen University
Email: ttkong@szu.edu.cn

Interface Engineering in Multiphase Microfluidic

Abstract

Developing advanced techniques for creating multi-scale architectures from biomaterials is driven by applications such as regenerative medicine, organ chips and human-machine interfacing. Microfluidics enables the precise fluidic control at small scales and facilitates high throughout testing for investigating complex interactions. These attributes motivate the integration of microfluidics with biomaterials to construct tissues/organs mimics for understanding physiological processes by bottom-up approach and for

accelerating the discovery/safety evaluation of drugs/therapy. To achieve this long-term goal, we focused on the bioinspired strategies for fluidic control of microflows, material-specific biofabrication techniques and the development of microfluidic materials that are soft, biocompatible and functional. For instance, we develop charging strategies to manipulate complex fluids that are from viscous precursors of tissue constructs, by exploring the interplay of electric and hydrodynamic stresses of these microscale flows; We exploit interfaces of multiphase microfluidics to enable freeform three-dimensional printing of liquid-liquid architectures that are compatible with viable cells; We also engineer soft and robust hydrogels for the facile fabrication of microfluidic and bioelectronic devices. The microengineering of well-defined three-dimensional compartmentalized architectures with controlled micro-/nanosized features from precursor mixtures of hydrogels, polymers and viable cells is vital for developing next-generation tissue/organ mimics and human-machine interfacing devices. The confluence of biomaterials-based microfluidics and controlled cellular integration portends the realization of far-reaching applications that span the spectrum between basic science and technologies for advancing human health.

Yanan Li

School of Chemical Engineering and Technology, Sun Yat-sen University, Zhuhai 519082, China Address
Email: liyanan@iccas.ac.cn

Facile fabrication of transparent anti-reflection surface with superamphiphobic by template-assisted spraying coating

Abstract

Transparent superamphiphobic surface can repel low-surface-tension liquids and transmit visible light in abroad spectra range, which is attractive for many practical applications such as windows, screens, solar panels, military equipment and other optical instruments. However, fabrication of superamphiphobic surfaces needs to construct specific reentrant structure that usually involves complicate and expensive lithographic techniques, or time-consuming procedures, which severely limits its real applicability. Meanwhile, the surface roughness for superamphiphobic and transparency in general are mutually exclusive. Herein, we demonstrated a scalable yet facile template-assisted spray coating method to fabricate transparent superamphiphobic surfaces. By spray coating of polymer nanoparticle mixed silica sol-gel precursor, the reentrant structure can form by the solidification of the silica sol-gel between the spherical template particles after removed by sintering or dissolution. Thus, the porous SiO2 skeleton network obtained excellent liquid-repelling for various low surface tension liquids and stability against concentrated acids, salts and mechanical damages. The nanoporous shows little scattering to visible light that makes the structure also highly transparent. We believe this transparent superamphiphobic surface will possess attractive potential in various applications involving self-cleaning, anti-reflection and anti-counterfeiting.

Yang Lu

City University of Hong Kong
Email: yanglu@cityu.edu.hk

Bio-inspired metallic microlattice metamaterials

Abstract

Many natural materials such as bone, nacre, and bamboo possess mechanical properties that far outweighs their constituents and homogenous mixtures. This is due to the centuries of evolution which endows these natural materials with optimized porous and hierarchical architectures, a concept that has supported the early stages of our technological advancement. Mechanical metamaterials such as microlattices are man-made materials that can harness the benefits of architecture through their engineered three-dimensional (3D) geometries. This talk focuses on how these microlattices are combined with bio-inspired microstructures and nanoscale metals/alloys to produce metamaterials with superior and unique mechanical properties, providing an insight on overcoming traditional material property trade-offs, such as strength-ductility, which has limited our structural material selection for many years. An overall perspective on how these metamaterials can be designed, manufactured and used for a multitude of engineering applications will be discussed as well.

Dengfeng Peng

School of physics and Optoelectronic Engineering, Shenzhen University
E-mail: pengdengfeng@szu.edu.cn

Mechanoluminescence of Quaternary Piezoelectric Semiconductors for Advanced Lighting and Sensing Applications

Abstract

A myriad of materials in nature, either living or nonliving, exhibit luminescence. For example, jellyfish glow with the bioluminescent protein aequorin under mechanical stimulation[1]. Mechanoluminescence (ML) is a luminescence phenomenon that characterized by photon emission in response to dyanmic mechanical stimulus [1-16]. About half of inorganic materials and nearly one third of organic materials have been observed for ML. ML has a long history, natural stones containing silica have ML properties which infers that as early as 2 million years ago in the Stone Age, the phenomenon of ML has been observed in polished stone, however most natural minerals and man-made materials have ML properties only under certain conditions, mainly because such crystals do not have enough effective luminous centers, so the luminous intensity is very weak. They exhibit ML only when they break or plastic deformation, which belongs to the irreversible luminescence behavior. During the past decade, the research on ML is reviving in some inorganic phosphors such as ZnS:Mn/Cu and $SrAl_2O_4$: Eu/Dy for many practical applications. In this paper, we will introduce a novel type of mechanoluminescent quaternary piezoelectric semiconductors, the preparation, charaterizations and the demostration of potentional applications in battery-free lighting and stress sensing. Effective doping of rare earth ions and various transition metal ions and efficiently reproducible ML are realized, which greatly widens luminous spectrum range, while reducing the synthesis cost. Based on the developed ML materials, the applications for dynamic stress visualization, electronic signature pen, anti-counterfeiting label and fluorescent stick are demostrated.

Kangning Ren

Department of Chemistry, Hong Kong Baptist University, Kowloon, Hong Kong, China.
State Key Laboratory of Environmental and Biological Analysis, Hong Kong Baptist University, Kowloon, Hong Kong, China.
HKBU Institute of Research and Continuing Education, Shenzhen, China.
E-mail: kangningren@hkbu.edu.hk

Crack engineering as a new route for the construction of arbitrary hierarchical architectures

Abstract

Three-dimensional (3D) hierarchical morphologies widely exist in natural and biomimetic materials, which impart preferential functions including liquid and mass transport, energy conversion, and signal transmission for various applications. While notable progress has been made in the design and manufacturing of various hierarchical materials, the state-of-the-art approaches suffer from limited materials selection, high costs, as well as low processing throughput. Herein, by harnessing the configurable elastic crack engineering—controlled formation and configuration of cracks in elastic materials—an effect normally avoided in various industrial processes, we report the development of a facile and powerful technique that enables the faithful transfer of arbitrary hierarchical structures with broad material compatibility and structural and functional integrity. Our work paves the way for the cost-effective, large-scale production of a variety of flexible, inexpensive, and transparent 3D hierarchical and biomimetic materials.

Anderson Ho Cheung Shum

Department of Mechanical Engineering, The University of Hong Kong, Pokfulam Road, Hong Kong
Email: ashum@hku.hk

Liquid-organelle-inspired engineering of all-aqueous droplets

Abstract

Biological cells are fundamental building blocks of organisms; within them, various types of organelles are essential for the cellular activities. While organelles surrounded by membranes have been well studied, membranelles organelles, which consist of dynamically formed droplets, have aroused the interest of cell biologists and biophysicists. Aqueous phase separation has been shown to play an important role in the formation and assembly of these liquid organelles. Similar phase behaviors can be modeled in synthetic aqueous droplets, such as those formed by aqueous two-phase system (ATPS). The tunable nature of ATPS makes them ideal for understanding the unique physico-chemical behaviors of droplets that undergo aqueous phase separation. The versatility in coating the aqueous-aqueous interfaces with different macromolecules, including biomolecules, allow the simulation of behaviors that are traditionally only observed in biological systems. The ability to compartmentalize biochemical reactions also make these droplets suitable as reactors for observing the kinetics of confined micro-reactions. In this talk, I will discuss our works in exploring the dynamics of aqueous droplets characterized by aqueous phase separation.

Jingyao Tang

Department of Chemistry, The University Of Hong Kong Pokfulam, Hong Kong
Email: jinyao@hku.hk

Nanorobot Controlled with Collective Intelligence

Abstract

All interactions/forces between matters are originated from exchange particles, which bond fundamental particles into matters, while natural organisms can communicate with each other via exchange chemical information and form complex microstructures. From the physical point of view, these two kinds of interaction differ drastically, as the second category dissipates energy, which enables the emergence of complex high order dynamic structures, such as life itself. As the exchange interactions in dynamic system consume energy and generate entropy, many basic laws for common forces can be violated. However, the study of active exchange interaction has proven to be difficult due to the lack of theoretical tools as well as a simple enough experimental system.

Recently, synthetic active matters like micro/nanomotors (MNM) have aroused increasing interest due to their promising potential in biomedical applications, such as drug delivery and precision medicine, as well as serving as the perfect model for non-equilibrium physics. However, how to direct the MNM to desired therapeutic target remains an unsolved challenge. As the nanomotor itself is too simple in structure, it is not likely to incorporate complex electronic component inside for highly intelligent work. Here, we presented a synergetic synthetic active matter system, where two active particles interact with which each via simple ion-exchange interaction. The chemical base of the involved communication is astonishingly simple, while surprisingly, due to the dynamic nature of the interaction, complex structures emerged both from the microscopic scale to the macroscopic scale. We observed the emergence of macroscopic group intelligence similar to the ant colony, which finds the topological “defect” in the environment for resting. This process can be further extended to find biofilms for practical antibacterial application.

Ben Wang

Shenzhen University
Email: benwang@szu.edu.cn

Biohybrid stem cell microrobots with endoluminal delivery

Abstract

High-precision delivery of microrobots at the whole-body scale is of considerable importance for efforts towards targeted therapeutic intervention. However, vision-based control of microrobots, to deep and narrow space inside body, remains a challenge. Here we report a soft and resilient magnetic cell microrobot with high biocompatibility that can interface with the human body and adapt to the complex surroundings while navigating inside body. We achieve the time-efficient delivery of soft microrobots using an integrated platform called endoscopy-assisted magnetic actuation with dual imaging system (EMADIS). EMADIS enables the rapid deployment across multiple organ/tissue barriers at the whole-body scale and high-precision delivery of soft and biohybrid microrobots in real-time to those tiny regions with depth up to meter scale through natural orifice, that are commonly inaccessible and even invisible by conventional endoscope and medical robots. The precise delivery of magnetic stem cell spheroid microrobots (MSCSMs) by the EMADIS transesophageal into the bile duct with a total distance of approximately 100 centimeters can be completed within 8 minutes. The integration strategy offers a full-clinical imaging technique based therapeutic/intervention system, which broadens the accessibility of hitherto hard-to-access regions, by means of soft microrobots.

Dongan Wang

City University of Hong Kong
Kowloon, Hong Kong SAR
Email: dwang229@cityu.edu.hk

DECELLULARIZED MAN-MADE HYALINE CARTILAGE GRAFT FOR CARTILAGE TISSUE ENGINEERING

Abstract

Introduction:
The key challenge of lower-limb-joint osteochondral regeneration lies in restoration of the avascular articular cartilage. Articular cartilage repair has been a significant challenge due to the limited self-regenerative capability of cartilage tissue. A quality articular cartilage engraftment is validated by the graft's hyaline cartilaginous phenotype and genuine microstructural architecture. Current treatments are frequently reported to result in regeneration of mechanically inferior fibrocartilage.
Experimental methods:
In this study, we have developed a continuous methodology to directly set up a scaffold-free macro-scaled three-dimensional living hyaline cartilage graft (LhCG) with the aid of a biomaterial-based interim scaffolding system. The practical performance of allogeneic decellularized LhCG (dLhCG) is evaluated in the knees of pig models with full-thickness chondral defects beyond critical sizes for 6 months.
Results and discussions:
Sound regeneration of articular hyaline cartilage via allogeneic dLhCG engraftment in 6 months after implantation has been shown, including the recoveries in form and function with correct composition, structure, phenotype and mechanical property.
Conclusions:
The successful regeneration of articular cartilage defects in large animal models suggests the readiness of allogeneic dLhCG for clinical trials and applications.

Jianfeng Wang

City University of Hong Kong
Email: jefwang@cityu.edu.hk

Pattern recognition techniques for sand particles

Abstract

The pressing need to recognize and track individual sand particles in fundamental research on geomechnics has promoted the rapid development of particle tracking techniques in recent years. This talk presents the latest development of a few innovative pattern recognition techniques for identifying and matching intact and crushed sand particles. These techniques include particle volume-based tracking (PV-track), particle radius -based track (PR-track), spherical harmonics-based tracking (SH-track) and point cloud -based tracking (PL-track). Specifically, PV-track and PR-track are suitable for tracking particles within a neighborhood area but the tracking accuracy and reliability decreases with the increasing deformation of the sand specimen. SH-track is a much more powerful and robust technique which makes use of the SH invariant describing the multiscale morphological features of sand particles. However, the common limitation of PV-track, PR-track and SH-track is that they can only be applied to intact particles with solid structures (i.e., non-porous structure). In contrast, PL-track can deal with both intact and crushed sand particles and has been successfully used to match a group of crushed quartz particles. More importantly, PL-track can be integrated with machine learning techniques to achieve intelligent recognition and tracking, and has been successfully used to identify a group of highly porous carbonate sand particles. The implementation of all these particle tracking techniques is based on the X-ray microtomography scanning of a miniature specimen of sands, which provides the source data for the pattern recognition exercise.

Peng Wang

King Abdullah University of Science and Technology; The Hong Kong Polytechnic University
Email: peng.wang@kaust.edu.sa; peng1.wang@polyu.edu.hk

Advanced Designs for Sustainable Solar-Energy-Water Nexus

Abstract

Renewable energy, especially solar energy, is abundantly present. Wide utilization of solar energy is believed by many a solid solution leading to our ultimate sustainability and shall occupy a central piece in the up-and-coming circular economy. On the other hand, freshwater is getting scarce in many parts of the world where water security becomes national security. Sustainability at solar-energy-water nexus calls for effective use of solar energy to augment freshwater supply especially at decentralized scale, and, at the same time,

IYCBSE 2021

smart use of available water resources to promote solar energy generation to meet the growing demands by human society on both water and energy. In this talk, I will share some of the recent progresses in solar distillation to produce freshwater from seawater, sorption-based atmospheric water vapor harvesting and its application to cooling, and seawater desalination brine treatment with zero-liquid-discharge.

Pengyuan Wang

Shenzhen Key Laboratory of Biomimetic Materials and Cellular Immunomodulation, Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, Shenzhen, Guangdong 518055, China
1068 Xueyuan Avenue, Shenzhen University Town, Shenzhen, China
Email: py.wang@siat.ac.cn

Harnessing biointerfacial property to control cell fate

Abstract

Manipulation of cell fate is a critical process in regenerative medicine and cell therapies. Strategies in maintaining the stemness of stem cells and directing stem cells into specific cell types are limited. To date, a number of studies have reported that biophysical cues in the form of surface nanotopographies can influence stem cell attachment, proliferation, and differentiation. Specific surface nanotopographies can enhance the efficiency of cell reprogramming or maintain stemness of stem cells. While biochemical cues are generally efficient, biophysical cues have advantages such as scalability, cost-effectiveness, and longer lifetime, while they are also easy to be defined. In our group, we fabricated biomimetic structures, including nanogrooves, nanopillars, nanopores, and colloidal crystals using various nanotechnologies. Our results show that controlling surface nanotopographies and chemistry can direct cell fate decisions, which reveals the fundamental questions in cell biology and benefits cell therapy. We believe that combining optimal biophysical cues with current biological approaches has great potential to generate functional cells and benefit regenerative medicine and cell therapies.

Steven Wang

City University of Hong Kong
Email: steven.wang@cityu.edu.hk

A nature-inspired fluid mechanics approach for phase separation

Abstract

The motion of particles in fluids is a common phenomenon encountered in nature. It is well known that the dynamics of finite-sized particles can differ remarkably from the infinitesimal particle dynamics. When the

carrier flow is turbulent, a striking feature is the tendency of heavy particles to inhomogeneously distribute in space, forming spatial clusters, that is called preferential concentration. This particular concentration effect is closely linked to a number of natural phenomena: rainfall in warm clouds, and phytoplankton blooms. The vortical flows in addition to the particle inertia effect are mainly responsible for the preferential concentration phenomena.

Inspired by the vortical flows/preferential concentration effect generated in the ocean/sky, recently we used a very similar flow pattern and discovered a highly unexpected separation phenomena in which, under particular conditions, particles can be driven to spontaneously cluster into specific regions of a liquid. This phenomenon can be harnessed to facilitate a novel separation technique. Through the control of particle inertia, the location of spherical and irregular rigid particles can be controlled to enable separation of different particles. Remarkably this approach can also be extended to the separation of bubbles and oil droplets. We propose to harness this phenomenon to develop novel solid-liquid, liquid-gas, and liquid-liquid separation processes. This approach has the potential to become a platform technology for a range of separations – in particular, the ultra-high CO_2 capture efficiency suggests that our technology has a substantial environmental impact.

Xie Xi

Sun Yat-sen University
Email: xiexi27@mail.sysu.edu.cn

Micro/Nano-devices for Biomedical Applications

Abstract

Micro/nano system technology have greatly facilitate the development of bioinformatics research. In the field of bioelectronics and bioinformatics, researches have been greatly attracted by biological system modeling and disease predictions based on the understanding of intracellular protein dynamic expression. We have been focusing on the fundamental research on micro/nano-system for biomedical applications, trying to address the key issues on three levels, from the outside to the inside, in vitro – transdermal – and in vivo, aiming to overcome the key challenge of how to develop bio-safe technology to detect and regulate biological disease: 1) On the in vitro cellular level, we made breakthrough process on the development of nano-devices that could safely penetrate cell membrane, achieving regulation and sensing of the intracellular contents dynamically. 2) On the transdermal level, we systematically developed transdermal theranostic system, achieving precise and in situ detection and therapy of diseases. 3) On the in vivo level, we creatively develop bio-safe implantable theranostic system, achieving safe regulation and sensing of diseases in vivo. Our work holds great promise on facilitating the development of new tools for biomedical sensing detection and biomedical therapy, which would be critically important for the field of bioelectronics.

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Xiaofeng Xiong

Biorobotics, Maersk Mc-Kinney Moller Institute, University of Southern Denmark,Denmark
Email:xizi@mmmi.sdu.dk

Bionics for Decoding Biological Motion Intelligence

Abstract

Roboticists have developed bionic systems (biorobots) by emulating animal counterparts in nature. However, this emulation may refer to some neuroscience experiments on animals who suffer greatly. To reverse this, my research aims at showing a humane research way where biorobots are used as surrogates to decode motion intelligence underlying animals' manipulation. In my talk, computational models and biorobots will be presented to test the hypotheses of various biological skills such as insect locomotion and human manipulation (with soft tools). This testing aims to reveal geometry and timing principles in neuromechanical control, and provide new hypotheses that may be validated in neuroscience experiments.

Haimin Yao

Department of Mechanical Engineering, The Hong Kong Polytechnic University
Email: mmhyao@polyu.edu.hk

Mechanics underlying the structure-property relations unveiled from natural biomaterials

Abstract

Through millions of years' evolution, biological materials have developed delicate structures with exceptional mechanical properties to tackle the potential attacks from the environment. Unveiling the structure-property relations concealed in biological materials with mechanics theory and applying them to guide the design and manufacturing of engineering materials is now an emerging trend. In this talk, some important structure-property relations revealed recently from the biological materials are illustrated. The structural attributes to be covered include size, heterogeneity, shape and topology, chirality and hierarchy, and our attentions are mainly focused on the mechanical properties like strength, toughness, energy dissipation, adhesion and so on. All these structure-property relations as revealed not only prove the importance of structure in shaping the unique mechanical behaviors of biomaterials, but also imply a great promise of application in the design and manufacturing of novel biomimetic materials.

Xinge Yu

City University of Hong Kong
Email: xingeyu@cityu.edu.hk

Soft actuators in skin-integrated electronics for VR/AR

Abstract

Technologies for virtual and augmented reality (VR and AR) create human experiences through visual and auditory stimuli that replicate sensations associated with the physical world. The most widespread VR/AR systems use head-mounted displays, accelerometers and speakers as the basis for three-dimensional, computer-generated environments that can exist in isolation or as overlays with actual scenery. By comparison to the eyes and the ears, the skin is a relatively underexplored sensory interface for VR/AR technology that could, nevertheless, greatly enhance experiences, at a qualitative level, with direct relevance in areas ranging from communications and social media, to gaming, entertainment and prosthetics technology. Here we present materials, device structures, power delivery strategies and communication schemes as the basis for a wireless, battery-free platform of electronic systems and haptic interfaces capable of softly laminating onto the skin to communicate information via spatio-temporally programmable patterns of localized mechanical vibrations. The resulting technology, which we refer as epidermal VR, creates many opportunities where the skin provides an electronically programmable communication and sensory input channel to the body, as demonstrated through example applications in social media/personal engagement, prosthetic control/feedback and gaming/entertainment.

Yanhao Yu

Southern University of Science and Technology
Email: yuyh@sustech.edu.cn

Liquid-Solid Hybrid Soft Packaging Materials

Abstract

Soft packaging materials are the key to ensure the stable operation of soft electronics, making it essential for human-machine interaction, advanced healthcare, and many other applications. Development of soft packaging materials is limited by the inextricably linked material properties, for example, stretchability and high water-vapor-barrier performance. Stretchability demands low density of chemical bonds, which unfavorably means the material at molecular level contains free volumes allowing water to penetrate. How to address the conflict between stretchability and barrier performance remains an open challenge. In this talk, I will present a liquid-solid hybrid soft packaging material with high water-vapor-barrier performance by introducing hydrophobic lubricant to seal free volumes and weaken surface polarizations in solid packaging. The hybrid design builds a self-adaptive chemical environment to prevent water diffusion and adsorption under various mechanical conditions. As a result, it well protects flexible halide perovskite thin films in water and concurrently offers multiple functions such as self-cleaning and self-healing.

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Li Zhang

Department of Mechanical and Automation Engineering, The Chinese University of Hong Kong (CUHK), Shatin NT, Hong Kong, China
Chow Yuk Ho Technology Centre for Innovative Medicine, CUHK, Hong Kong, China
CUHK T Stone Robotics Institute, CUHK, Hong Kong, China
Multi-scale Medical Robotics Center (MRC), InnoHK, Hong Kong Science Park, Hong Kong, China
Email: lizhang@cuhk.edu.hk

Bio-inspired Magnetic Microrobots: From Individual to Swarm

Abstract

People have envisioned tiny machines and robots that can explore the human body, find and treat diseases since Richard Feynman's famous speech, "There's plenty of room at the bottom," in which the idea of a "swallowable surgeon" was proposed in the 1950s. Even though we are at a state of infancy to achieve this vision, recent intense progress on nanotechnology, MEMS/NEMS technology and micro-/nanorobotics has accelerated the pace toward the goal. A number of research efforts have been recently published regarding the development of tiny swimming machines/robots from the basic principles and fabrication methods to practical applications.

I will first briefly show the development history of bio-inspired microrobotics, afterwards our recent research progress on bio-inspired magnetic swimming microrobots, from the individual to swarm, for biomedical applications will be presented. In particular, I will discuss the fundamental understanding on design, active generation and adaptive locomotion of the magnetic microrobotic swarm, and the perspective of using a large number of small robotic agents for in vivo applications, such as minimally invasive medicine.

Pingan Zhu

Department of Mechanical Engineering, City University of Hong Kong
83 Tat Chee Avenue, Kowloon Tong, Hong Kong, China
Email: pingazhu@cityu.edu.hk

When biomimetics meets microfluidics

Abstract

Nature has always been an open-source library for innovations. After millions-years of evolution for adaption and optimization, natural species are often endowed with rich morphologies and chemical compositions to fulfill specific functions, mimicking which allows us to invent splendid synthetic materials. However, faithfully replicating the sophisticated structures remains challenging with current manufacturing techniques that suffer from the long-standing trade-off between small-scale accuracy and large-scale production. In this talk, I will introduce our recent work of developing a versatile microfluidic platform for scalable and precise fabrication of bio-inspired materials with well-tailored morphology and composition. I will first provide fundamental insight into microfluidic droplet generation, based on which various emulsions (single, double, Janus, Pickering, and complex emulsions) are produced with precision. The emulsions are useful templates for functionalizing synthetic materials of different forms, including particles, fibers, and

membranes. I will then show bioinspired micromotors and microcapsules for cargo transport and drug delivery, bioinspired microfibers for fog harvesting and soft actuation, and bioinspired porous membranes for liquid repellency in diverse environments, including robust omniphobicity in the air, under-liquid super-repellency, super-repellency to hot water, and durable liquid-infused slippery state. The study will open a significant new venue for engineering bioinspired materials with scalability and precision for applications in various fields, such as biomedical engineering, energy, and environment.

Chenjie Xu

Department of Biomedical Engineering, City University of Hong Kong
Email: chenjie.xu@cityu.edu.hk

IceMicroneedles for intradermal delivery of vaccines

Abstract

Intradermal delivery of vaccines is an emerging route. As the outermost protective barrier, skin is highly immunogenetic by comprising abundant resident antigen-presenting cells in epidermis and dermis, such as Langerhans cells and dendritic cells. These cells can transfer antigen via lymphatic drainage to initiate antigen-specific adaptive immune response. Microneedles (MNs) have been regarded as a promising minimally invasive device for intradermal vaccine delivery. These miniaturized needles with length of 50-1000 um can physically break the stratum corneum and intradermally deliver therapeutic agents, including vaccines, to the viable dermis layer without touching blood vessels and nerve-endings5. MNs cause no pain and bleeding and are convenient to use, potentially allowing the self-administration. Many investigations have been conducted using dissolvable MNs for the delivery of vaccines. However, all the existing MNs are unsuitable for intradermal delivery of cell vaccines and mRNA vaccines.

To solve those limitations, our team have developed a new device that can package and stored living mammalian cells/mRNA for months. This ready-to-used device can circumvent complex and redundant procedures. In addition, the device is easy for transportation and deployment. Delivery of cells with this device is minimally invasive, generates no sharp hazard, and can be performed by end users with minimal expertise. As a proof-of-concept, the researchers explored the cancer immunotherapy through intradermal delivery of ovalbumin-pulsed dendritic cells. Vaccination with this device elicits robust antigen-specific immune responses and provides potent prophylactic protection against tumor in mice, which are superior to the therapeutic outcomes by conventional standard vaccination methods such as subcutaneous and intravenous injection.

Lei Xu

The Chinese University of Hong Kong
Email: xuleixu@cuhk.edu.hk

Achieving adjustable elasticity with non-affine to affine transition

Abstract

In various engineering and industrial applications, it is desirable to realize mechanical systems with an elasticity broadly adjustable in response to external environment change. In both 2D and 3D packing-derived networks, we discover a fundamental transition between affine and non-affine regimes in elasticity, which correlates to the change in network's topology. Based on this transition, we numerically design and experimentally realize multifunctional systems with adjustable elasticity. Within one system, we achieve the affine response like a typical solid, the non-affine response like a liquid, and a continuous tunability in between. Moreover, the system also exhibits a broadly tunable Poisson's ratio from positive to negative values, which is of practical interest for energy absorption and fracture resistant materials. Our study reveals a fundamental connection between elasticity and network topology, and demonstrates its practical potential in designing mechanical systems and metamaterials.

Xiya Yang

Institute of New Energy Technology, College of Information Science and Technology, Jinan University
Email: xiyayang@jnu.edu.cn

Triboelectric Nanogenerator towards Low-Frequency Hydrodynamic Energy Harvesting

Abstract

Triboelectric nanogenerators (TENGs) have received growing attentions to efficiently harvest waste micromechanical energy from ambient atmosphere such as hydrodynamic energy from raindrops and ocean waves. In addition, development of ocean energy conversion technique is strategic requirement to optimize the energy structure and expand the "blue economic" space, TENG provides a potential approach for efficiently capturing wave energy with its unique advantages. Comprehensive understanding of electrification mechanism and dynamic charging behavior at the liquid-solid interface are essential for multi-application scenarios of TENGs.

Herein, various types of TENGs are designed towards droplets and wave energy harvesting, including bi-electrode freestanding mode-TENG, water-tank TENG, enclosed nodding duck structured TENG, respectively. By placing the bi-electrode freestanding mode-TENG horizontally, intriguing cumulative charging behavior of successive water droplets is investigated, which expands the fundamental charging

mechanism for maximizing the surface charge storage capacity. Optimal configurations of inclination angle and drop height are further studied for improving the electrification charge density and power output. Through coupling of cumulative charging behavior and the optimal configurations, an instantaneous maximum power density of 1.838 W/m2 is achieved and 30 LEDs can be lighted up when spraying tap water on the bi-electrode freestanding mode-TENG.
For the enclosed nodding duck structured TENG, configuration parameters including track numbers, connection approach, oscillation frequency and swing amplitude on electrical output performances are systematically investigated and optimized, the maximum instantaneous power density of 4 W/m3 is obtained by one block TENG with 320 LEDs lighted up simultaneously. The nodding duck structured TENG is proved to be an efficient device for driving small electronics with excellent stability and durability in real water wave environment, and the power potential can be further magnified by combining more units in parallel to form a network towards large-scale blue energy harvesting.

Zhengbao Yang

Department of Mechanical Engineering, City University of Hong Kong
Email: zb.yang@cityu.edu.hk

Vibration Energy Harvesting and Flexible Piezoelectric Devices

Abstract

The Smart Transducers and Vibration Laboratory (STVL) at the City University of Hong Kong focus on smart materials and structures for energy harvesters, sensors, and transducers. In today's presentation, I will introduce two works from our group completed in 2020. One is about the new compressive operation mode for piezoelectric energy harvesters (PEHs); the other is about flexible piezoceramic composites. How to improve the power output of PEHs? This is one of the most critical questions in the research field. It is known that most existing PEHs generate less than 1 mW power and cannot meet the constant operation of most potential sensor applications. From the perspective of material strength, we proposed a new compressive operation mode where piezoelectric materials only experience periodic compressive stress. The compressive mode is 10 times stronger than the commonly used bending mode such as cantilever or other modified bending-beam modes. We experimental demonstrate the superiority of compressive mode and achieved 78 mW power output under 1 g excitation. Based on that, we further developed a self-powered wireless sensor system for jet engine condition monitoring. Another big problem is that piezoceramics are too brittle and fragile. We thus developed flexible piezoceramic composites and demonstrated them for energy harvesting and skin sensors.

Student Oral Presentations

Abstract ID No.13

Design and Analysis of a New Type of Twisting Pneumatic Artificial Muscle

Wei Xiao[1,2], Dean Hu[1,2*]

1.State Key Laboratory of Advanced Design and Manufacturing for Vehicle Body, College of Mechanical and Vehicle Engineering, Hunan University, Changsha 410082, P. R. China
2.Key Laboratory of Advanced Design and Simulation Techniques for Special Equipments, Ministry of Education, Hunan University, Changsha 410082, P. R. China
Email: hudean@hnu.edu.cn

Abstract

Inspired by natural biology, pneumatic artificial muscles (PAMs) that can achieve various motions like elongation, bending, twisting, etc. are developed successively. The twisting pneumatic artificial muscle as a promising flexible actuator can enhance the flexibility and mobility of soft robotics. However, fewer attempts have been done in twisting PAMs compared with bending PAMs. The existing twisting PAMs also face challenges such as overpressure risk and small torsion angle. Inspired by the tendril-climber, a new type of twisting PAM with helical chambers is designed. Due to the unique structure, the twisting PAM can convert the cooperative collapse of silicone rubber to twisting motions. The twisting performance is investigated experimentally and numerically. The experimental results show that the twisting PAM can generate a torsion angle of up to 2.59 °/mm and an output torque of 18.85 N.mm as the negative pressure of 60 kPa is applied to the chambers. We also establish the finite element model of the twisting PAM with the software ABAQUS. The numerical results match well with the experimental results, which demonstrates the validity of the finite element model. Furthermore, a surrogate model is developed to investigate the influence of structure parameters on the torsion performance effectively. Based on the developed surrogate model, we can easily find that the torsion angle can be improved by increasing the height and relative rotation angle, and the output torque also can be enhanced with the bigger relative rotation angle. In conclusion, the developed twisting PAM can extend the researches on pneumatic artificial muscles and providing a high-performance actuator for soft robotics.

Abstract ID No.14

Modulating Neural Subtype Specification with Employing cSAPs Substrates for Neural Direct Conversion of Human Fibroblast

Javad Harati[1,2], Xuelian Tao[1], Ping Du[1], Kun Liu[1], Hossein Shahsavarani[1], Shahin Bonakdar[2], Behrouz Aflatoonian[3], Mohammad Ali Shokrgozar [2*], Peng-Yuan Wang [1*]

1.Shenzhen Key Laboratory of Biomimetic Materials and Cellular Immunomodulation, Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences, Shenzhen, Guangdong 518055, China
2.National Cell Bank, Pasteur Institute of Iran, Tehran, Iran
3.Stem Cell Biology Research Center Yazd Reproductive Sciences Institute Shahid Sadoughi University of Medical Sciences, Yazd, Iran
Corresponding authors: py.wang@siat.ac.cn, mashokrgozar@pasteur.ac.ir

Abstract

Neural direct reprogramming has been recently developed with the horizon of application in regenerative medicine and drug discovery. One important technical challenge that remained is about the specification of

Abstract ID No.26

Multi-material additive manufacturing of a bionic layered ceramic/metal structure: Formation mechanisms, gradient interface and mechanical properties

Rui Wang, Kaijie Lin, Dongdong Gu*

Nanjing University of Aeronautics and Astronautics
Jiangsu Provincial Engineering Laboratory for Laser Additive Manufacturing of High-Performance Metallic Components, College of Materials Science and Technology, Nanjing University of Aeronautics and Astronautics, Yudao Street 29, Nanjing 210016, China
Email: wr79@live.com

Abstract

After million years of evolution and selection, the structures of biomaterials have experienced unprecedented optimizations and presented delicate microstructures. As a special deep-sea creature, the hydrothermal vent Crysomallon squamiferum is not only resistant to high temperature, high pressure and strong acid, but also able to resist the hunting of natural enemies. This is mainly because of the multilayered structure of unique shell with excellent comprehensive mechanical properties, which have been widely utilized in biomedical, aerospace, military, and other industries by bionic technology. In this presentation, a layered ceramic/metal structure inspired by the bionic structure of the shell of Crysomallon squamiferum were designed and prepared by multi-material selective laser melting (SLM). Firstly, a processing window was determined by examining the type of ceramic molten pools and continuity of ceramic tracks. Based on our experimental analysis and numerical simulations, a range of laser energy density from 0.67 J/mm to 1.50 J/ mm at laser powers of 400–450 W was found to be a feasible scope of processing parameters to fabricate stable tracks of TiB2 on Ti6Al4V alloy by SLM. Then, fully dense multi-material samples without discernible interfacial cracks and pores were successfully fabricated. The results showed that TiB whiskers were generated by the in-situ reaction between TiB2 and Ti matrix, yielding a good metallurgical bonding. Moreover, gradient elements and microstructures induced the gradually changed microhardness at the gradient interface. Finally, it has been revealed that the flexural strength and ductility of SLM-fabricated TiB2/Ti6Al4V multi-material parts were enhanced by the dual effects of bioinspired layered composite and whiskers composite. This study will pave the way for manufacturing and strengthening the layered ceramic/metal structure using multi-material SLM technique.

Abstract ID No.29

Mechanically efficient corrugated structures inspired by mantis shrimp: optimization, mechanism, and laser 3D printing

Jiankai Yang, Kaijie Lin, Dongdong Gu*

Affiliation: Jiangsu Provincial Engineering Laboratory for Laser Additive Manufacturing of High-Performance Metallic Components, College of Materials Science and Technology, Nanjing University of Aeronautics and Astronautics
Address: Yudao Street 29, Nanjing 210016, China
Email: yangjiankai@nuaa.edu.cn

Abstract

Over millions of years, nature has developed many biological materials that have superior mechanical properties than traditional ones. The exoskeleton of arthropods is generally mechanically robust and multifunctional, providing mechanical protection for arthropods from the surrounding environment and potential predators. Mimicking the structural features of arthropod exoskeletons may open new avenues for the design of next-generation structural materials, which are in great demand for a wide range of applications including aerospace, vehicle, bone tissue engineering, and human body armors. In particular, the telson of Stomatopods, more colloquially referred to as mantis shrimp, can be used for self-protection during ritualized fighting and defense against enemies from behind. The potential mechanical benefits of the macro-scale configuration of mantis shrimp telson are worth investigating. Here, a series of bi-directionally corrugated panel (DCP) structures inspired by the telson of mantis shrimp was designed and manufactured by laser powder bed fusion (LPBF). The structural parameters of DCP structures, namely wavelength (∧) and amplitude (A), were optimized and the failure mechanism of DCP structures under compression was revealed by a combination of finite element simulations and experiment methods. The results show that the influence of wavelength of DCP structure on the energy absorption (EA) and specific energy absorption (SEA) capability was greater than that of the amplitude, and the DCP structure with A=8mm and ∧=6mm possessed the best impact resistance performance. With the increase of wave number (N), the structural expansion effect became more obvious, which led to the disappearance of the plateau region on the compressive force-displacement curve, the decrease of SEA growth rate and the energy absorption per periodicity cell. Three deformation modes were observed, namely full-folded mode (N=4), transitional mode (N=5), and global-buckling mode (N=6). The fracture morphologies elucidated that the fracture mechanism changed from ductile fracture to brittle fracture with the increase of wave number. Furthermore, a novel superimposed sine-wave (SSW) structure was designed and fabricated by LPBF based on the DCP structure. The energy absorption performance, deformation modes, and fracture mechanism were studied. Experimental results indicated that the SSW components exhibited a maximum crush force efficiency (CFE) of 73.06%, which was higher than most reported energy absorption structures. As the height of sinusoid 1 (H1) increased, the EA and SEA gradually increased to 37.73 J and 8.45 J/g, respectively. Simulation results revealed that the secondary trough had a large deformation during the compression process, which greatly enhanced the load uniformity of the structure. Fracture mode of SSW components was ductile fracture due to the post heat treatment. This study represents an effective approach for the design and engineering of high-performance corrugated structures through bio-inspired 3D printing.

Abstract ID No.37

Self-righting strategies of ladybirds Coccinella septempunctata under variable roughness

Jie Zhang, Zhigang Wu, Jianing Wu*

Affiliation: Sun Yat-Sen University
Address: School of Aeronautics and Astronautics
Email: wujn27@mail.sysu.edu.cn

Abstract

Insects such as cockroaches and locusts can self-right swiftly to protect themselves from predators. Compared to these insects, self-righting is of great challenge for ladybirds, as the smaller ratio of foreleg length to the body height makes it difficult to catch up the ground firmly. Additionally, ladybirds living in an over-ground environment with clusters of vegetation also need to be able to self-right from various natural substrates, such as soil, bark, and leaves. However, self-righting strategies under such a complicated environment packed with multiple substrates remain elusive. In this combined experimental and theoretical study, we not only examined self-righting behaviors of ladybirds on surfaces with varying roughness but quantified the probability of these behaviors occurring. Most ladybirds could use either legged or winged strategies to self-right in a quarter of a minute within 3 attempts (success rate of ~ 100.00%). When righting on a coarser board (Ra = 124.62 μm), the ladybirds self-righted by swinging their legs to attach and hook the protrusions on the surface. By contrast, if self-righting occurred on a smooth surface (Ra = 6.69 μm), both the elytra and hind wings were deployed to alter the body orientation to roll over. For the discrepancy in strategy selection, a mathematical model considering the effect of surface roughness was used to analyze the self-righting mechanism of the ladybirds. Based on this, we uncovered that the contact status between the claw and surface microstructures could affect the arm of force required to self-right, which

neuron subtype. Employing biophysical cues through substrate engineering is an amenable mean to improve cellular modulation in different approaches of regenerative medicine.
Here, we have investigated the potential of a new family of substrates called Colloidal Self Assembled Patterns (cSAPs) for the generation of chemical-induced human neurons (cihNs). A combination of Silica and Polystyrene particles was used to generate our basic cSAP; afterward by employing Polydimethylsiloxane (PDMS) in an imprinting process another type of substrate was fabricated to incorporate manageable stiffness property. Generation of iNs was carried out by two different combination of small molecules for the induction and maturation of iNs based on the previous reports.
We observed changes in cells' morphology and behavior including a decrease in proliferation rate, delay in cell cycle progression in the S phase, and faster migration on the cSAPs than the control. Furthermore, vinculin expression analysis showed that the cells on the substrates have smaller focal adhesion points. Then our data proved that during neural conversion, the cSAP substrates alter signaling pathways and patterns of transcription factors. Eventually, concerning the ciNs characterization on RNA, protein and epigenetic levels, the promotion of neural subtype specification was confirmed through using cSAPs as the substrate for neural reprogramming.
Taken together, our findings uncover the importance of the biophysical characteristics of the niche as the key factor in the fate determination during direct reprogramming and subsequently the great potential of cSAPs for further cell reprogramming application.

Abstract ID No.24

A novel high toughness cementitious structural material via biomimetic design

Hao Pan, Wei She*

School of Materials Science and Engineering, Southeast University
Materials building A Southeast University, Dongnandaxue road No. 2, Jiangning, Nanjing, 211189
Email: weishe@seu.edu.cn

Abstract

Concrete remains to be the most widely consumed construction material in the world, but possesses the inherent quasi-brittleness and heterogeneity. Thus, matrix-directed toughening of concrete and cement composites is the key target and huge challenge for concrete science and technology. Since concrete and cement composites are ubiquitous structural materials but highly brittle, the bioinspired structural characteristics and multiscale toughening mechanisms provide new design concepts and principles for their toughness enhancement. Herein, inspired by natural nacre and other biological materials, a facile and efficient approach is developed to fabricate novel biomimetic cementitious composites. This method combines with a three-dimensional (3D) "brick-bridge-mortar" (BBM) structure design strategy and synchronously the intrinsic and extrinsic toughening concepts. The proposed fabrication process implements the assembly of a multiscale BBM structure induced by pre-prilling and compaction. Such an approach shows the remarkable maximum toughness enhancement of 27-fold with 71% increase in flexural strength via cooperation with only 4 wt.% organic matter. More attractively, it alters the traditional brittle-fracture of cementitious materials to a distinct ductile-fracture. In addition, such a biomimetic composite demonstrates the long-term ever-increasing strength and toughness, performing the excellent ductile-fracture retention ability. The hierarchical toughening mechanisms are further revealed with the synergy of microscopic characterizations and simulation methods. Furthermore, this method can be scaled up easily and further extended to other cementitious systems universally. This work paves a new way for the development of high performance cementitious structural materials through bio-inspired design strategies, for potential applications in construction field.

directly led to the binary strategic selection. Our quantification of self-righting on diverse surfaces not only deepens understanding of ladybird's self-righting but may inspire new means of evaluating its environmental adaptability.

Abstract ID No.40

How to make a hairy biological surface both flexible and rigid: material stiffness variation in honey bee tongue facilitates multifunctions

Yu Sun[1], Jianing Wu[1*]

1. School of Aeronautics and Astronautics, Sun Yat-Sen University, Guangzhou, China
*. E-mail: wujn27@mail.sysu.edu.cn

Abstract

Flexibility and rigidity are sometimes the contradictive demands for biological structures. The honey bee's segmented tongue, structured by compliant intersegmental membranes coated in bushy hairs, is an elaborate probe and micropump that can not only interact with different corolla shapes but transport viscous nectars across three orders of viscosities at an ultra-high dipping frequency over 3 Hz. The tongue extends into the viscous nectar with hairs flattening and retracts with hairs erecting to lap up nectar. Coordinated with hair erection, the intersegmental membranes exhibit a large extendibility of 20% in length when the tongue retracts to load nectar, implying the high compliance in membranes, which might be incapable of resisting the ultra-high torque transmitted by viscous drag on glossal hairs. However, high-speed films uncover that the brushy configuration of the tongue remains stable with a negligible deflection in hairs during the tongue retraction phase, the mechanism of which remains unknown. Here we combine modern imaging techniques and mathematical models, to elucidate integrated effects of morphology and material properties on the correlative deformability and structural stability in a honey bee tongue. We find the tongue is composed of resilin dominated intersegmental membranes and highly-sclerotized continuum cricoid bases, the combination of which exhibits both high flexibility tongue and load-bearing during dipping nectar. These observations provide a better understanding of the functional variability in a honey bee tongue and enlighten deployable structures with correlative functional components.

Abstract ID No.52

How an elastic rod strengthens honey bee versatile tongue

Jiangkun Wei[1], Zhigang Wu[1,#], Jianing Wu[1,#]

1. School of Aeronautics and Astronautics, Sun Yat-Sen University, Guangzhou, 510006, People's Republic of China
#. Author to whom correspondence should be addressed. E-mail: wuzhigang@mail.sysu.edu.cn; wujn27@mail.sysu.edu.cn (J. Wu)

Abstract

The honey bee tongue is a versatile tool that can well adapt to various surfaces for foraging nectar. Their back-and-forth licking movements of tongue, with a reciprocating frequency around 5 cycles per second, may lead to huge times of deformation during entire life. The flexibility and durability of tongue are

essentially ascribed to an elastic rod internally reinforcing the entire tongue, of which the material composition and the structural merits have been poorly understood. Here, we aim to characterize the spatial morphology, surface wettability, material composition and the active function of tongue rod of honey bee (Apis mellifera), via a combination of several imaging techniques. Together with further mechanical experiments, we provide evidence that the internal canal of the rod has high performance at water retaining, which could be a strategy activating the resilin inside. The resilin, an elastomeric protein dominated the entire rod, seems to be the key factor for the compliance and the robustness of the tongue, and only functions when it has high water content. Our numerical simulation further suggests that the canal with an opening may facilitate larger deformation at twisting, providing greater flexibility to the rod. Together with the structural and materials analysis, our study may help to better understand, from a mechanical aspect, how honey bee tongue is endowed with multiple functions.

Abstract ID No.57

Nature-inspired nacre-like composites combining human tooth-matching elasticity and hardness with notable damage tolerance and fatigue properties

Guoqi Tan[1,2], Zengqian Liu[1,2,*], Zhefeng Zhang[1,2,*]

1. Shi-Changxu Innovation Center for Advanced Materials, Institute of Metal Research, Chinese Academy of Sciences, Shenyang 110016, China
2. School of Materials Science and Engineering, University of Science and Technology of China, Hefei 230026, China
72 Wenhua Road, Shenyang, China
gqtan16s@imr.ac.cn

Abstract

Making replacements for the human body similar to natural tissue offers significant advantages but remains a key challenge. This is pertinent for synthetic dental materials, which rarely reproduce the actual properties of human teeth and generally demonstrate relatively poor damage tolerance. Here new bioinspired ceramic–polymer composites with nacre-mimetic lamellar and brick-and-mortar architectures are reported, which resemble, respectively, human dentin and enamel in hardness, stiffness, and strength and exhibit exceptional fracture toughness. These composites are additionally distinguished by outstanding machinability, energy-dissipating capability under cyclic loading, and diminished abrasion to antagonist teeth. The underlying design principles and toughening mechanisms of these materials are elucidated in terms of their distinct architectures. Moreover, fatigue properties are critical, but usually a major limitation for the applications of new bioinspired materials. The fatigue behavior and damage mechanisms of the nacre-like composite with brick-and-mortar structure are investigated under cyclic compression, which imitates the actual service conditions of human teeth. The composite exhibits a staircase-like fracture mechanism, and as a result demonstrate notable fatigue endurance. The brick-and-mortar structure plays an effective role in shielding the crack tip from applied stress by means of including crack deflection, promoting roughness-induced crack closure, and bridging the crack by mineral bricks. It is demonstrated that the notable fatigue properties, combined with the human tooth-matching Young's modulus and hardness along with the exceptional fracture toughness and machinability, endow the nacre-like composite with a good potential for dental application.

Abstract ID No.95

Deciphering the role of perinuclear actin cap (pnAC) in nanocarrier trafficking and gene transfection in skeletal myoblasts on nanopillars

Ray Chang[a], Peng-Yuan Wang[a,b,*]

a. Shenzhen Key Laboratory of Biomimetic Materials and Cellular Immunomodulation, Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences, Shenzhen, Guangdong 518055, China
b. ARC Training Centre for Surface Engineering for Advanced Materials (SEAM), Swinburne University of Technology, Hawthorn, Victoria 3122, Australia
Email: py.wang@siat.ac.cn

Abstract

Gene transfection is vital in biotechnology to modify suspensive or adhesive cells. Several factors, including nanocarrier and cell division processes, will affect the transfection efficiency. Anchor-dependent cells are sensitive to the attached substrate and adapt their behavior accordingly, such as plasmid trafficking during gene transfection. Our group has shown that the cytoskeleton is essential in gene transfection in skeletal myoblasts via cell culturing on nanogrooves. Herein, the role of the cytoskeleton on the transfection was examined using different nanopillars and two kinds of nanocarriers. Nanopillars with various diameters and depths were prepared using colloidal self-assembly and reactive ion etching. All surfaces treated with polydopamine or oxygen plasma for manipulation of cell morphology. Plasmid DNA was conveyed into cells through nanocarriers: jetPRIME or Lipofectamine 3000. After examining numbers images, two different F-actin distributions were observed; cells with or without a perinuclear actin cap (pnAC). Cells on deep pillars had a smaller spreading area, shorter F-actin, more 3D-like cell nuclei, and a lower percentage of pnAC, which results in a higher transfection efficiency using jetPRIME. In contrast, cells on shallow pillars or flat surfaces had a larger spreading area, longer F-actin, more 2D-like cell nuclei, which exhibits a higher percentage of pnAC facilitating gene transfection via Lipofectamine. Moreover, the effects of cell density, cytoskeleton, and focal adhesions on gene transfection were investigated, which compatible with our hypothesis that filament actin distribution is one of the essential factors during the transfection process. Therefore, this study has revealed that pnAC plays an essential role in intracellular trafficking, providing new insights into transfection in adherent cells.

Abstract ID No.96

Earthworm-inspired Capacitive Strain Sensor based on Liquid Microfluidic with Stress-insensitivity

Jie Zhang[1], Jiayi Yang[2], Dongguang Zhang[*1]

1. College of Mechanical and Vehicle Engineering, Taiyuan University of Technology, Taiyuan 030024, China
2. College of Computer Science and Technology, Xi'an University of Science Technology, Xi'an 710054, China
Email: zhangdongguang@tyut.edu.cn

Abstract

Soft strain sensors with high stretchability have attracted tremendous interest in the fields of human-machine interfaces, soft robots, and skins. However, soft strain sensors are difficult to distinguish strain from stress. To solve this problem, an earthworm-inspired capacitive strain sensor based on liquid metal microfluidic with stress-insensitivity is introduced. The sensor contains two liquid metal interdigital electrodes prepared by the lithography and vacuum. The capacitance is generated by the fringing effect of liquid metal electrodes and decreases with increasing strain. The sensor exhibits high stretchability (100%), stability (at ε of 30% for 300 cycles), and sensitivity (-0.36). Due to earthworm-inspired liquid metal

microfluidic, the sensor has no hysteresis behavior and cross-talk between strain and stress sensing. The sensor can be used to monitor gas safety in hydrogen fuel cells or to monitor human movement.

Abstract ID No.104

Study on the energy absorption of sandwich plate inspired by the seagull feather rachis

Jianfei Zhou, Meng Zou*

Key Lab of Bionic Engineering, Ministry of Education, Jilin University, Changchun, 130025, China
Email: jfzhou20@mails.jlu.edu.cn zoumeng@jlu.edu.cn

Abstract

In order to reduce the mass and improve the energy absorption of sandwich plate, a novel sandwich plate inspired by the cross-section shape of seagull feather rachis was proposed and studied. Firstly, the macro and microstructure of feather rachis was observed and analyzed in the paper. The quasi-static compression test was used to investigate its mechanical properties. Then, finite element software was used to simulate the loading conditions of feather shafts with different cross-section shapes. Based on the relationship between the cross-section shape and the mechanical properties, a sandwich plate with the variable cross section tubular sandwich inspired by the cross-section of feather rachis was designed. And then, finite element software was used to compare the energy absorption capacity between the bionic sandwich plate and the ordinary sandwich plate under the axial impact loads. The result shows that the specific energy absorption of the bionic sandwich plate is 25.10 % and 20.97 % higher than that of the square and round tube sandwich plates, respectively. Then the parameterization was studied by numerical simulation. It is found that the height of the bionic sandwich and the thickness of the upper and lower panels have important effects on the energy absorption characteristics. Finally, five kinds of bionic sandwich plates were evaluated and compared with the Complex Proportional Assessment (COPRAS), and the conclusion was drawn that the energy absorption characteristics of BSP-3 were better than other sandwich plates.

Abstract ID No.110

Inspiration for MAV design from aerodynamic benefits of flexible deformation of insect wings

Liansong Peng, Qiushi Li, Mengzong Zheng*

School of Energy and Power Engineering, Beihang University, Beijing 100191, China
Email: zhengmengzong@buaa.edu.cn

Abstract

We present a fluid–structure interactions (FSI) model of insect flapping flight with flexible wings. This FSI-based model is established by coupling the finite element method (FEM)-based computational structural dynamic (CSD) solver (Abaqus) and the computational fluid dynamic (CFD)-based dynamic solver (Xflow). Based on the kinematics of wings of wandering glider dragonfly when producing maximum aerodynamic force measured by our research group, an FSI analysis of flapping flexible wings of dragonfly is carried out and discussed with a specific focus on the flexible deformation of the dragonfly wings and aerodynamic performances with the flexible and rigid wings.
Insects can control their wings with direct musculature at each wing base. During flapping, the wings are affected by inertia and aerodynamic force, resulting in obvious passive deformation. The wing properties are anisotropic because of the membrane–vein structures. The values of elastic flexural rigidity in span-wise or chord-wise directions depend on wing materials and structure, such as vein arrangement, folding lines, and flexion lines. The computational structural dynamic (CSD) model in this study is developed specifically for insect flapping flight, which is capable of modelling the membrane–vein structures of insect flexible wings by considering the distribution and anisotropy in both wing morphology and wing material properties.
The results show that the chordwise bending and spanwise torsion of dragonfly wings simulated by the FSI model are consistent with the deformation of dragonfly wings observed in experiment. The aerodynamic force generated by the flexible wing is about four times the body weight, which is increased by 15% compared with the flapping of the rigid wing, and agrees with the experimental observation results. Under the influence of flexible deformation, flapping wing efficiency increases by 10%. The chordwise bending is beneficial to increase the strength of the leading-edge vortex (LEV), which is conducive to the generation of aerodynamic force. Spanwise torsion is beneficial to the stability of flow field at high angle of attack, which can maintain the wing without stall and thus generate aerodynamic force steadily and continuously.
The results show that wing flexibility is beneficial to the aerodynamic performance of insect flapping wings. This conclusion can provide guidance for the design and optimization of the wings of micro air vehicle (MAV).

Abstract ID No.116

Mimicking Schooling Fishes to Construct a 3D Reconfigurable Microswarm for On-Demand Reaction-Rate Control

Fengtong Ji, Dongdong Jin, Ben Wang, and Li Zhang*

Department of Mechanical and Automation Engineering,
The Chinese University of Hong Kong, Sha Tin, Hong Kong, China
Email: lizhang@mae.cuhk.edu.hk

Abstract

Swarm behaviors are natural strategies for performing cooperative work, and extensive research has been aimed at emulating these strategies in engineering systems. From living bacteria colonies [1] to abiotic particles [2], various swarm behaviors have been majorly implemented in 2D spaces, i.e., solid substrate or liquid-air interface, for presenting directional motion [3] and reconfigurable patterns [4]. While such a dependence on boundaries may limit the wall-bound motion and performance of swarming agents, e.g., 3D motion control [5] and enhancing catalysis [6]. Moreover, because of the less dependence, maintaining a large number of particles as a dynamically stable swarming entity in 3D and managing its reconfigurable collective behaviors remain the central problem.
Herein, a tornado-shaped microswarm [7] is established in an aqueous environment under a hybrid source of magnetic actuation and laser irradiation, mimicking schooling fishes. The magnetic field initiates the in-plane rotation of a 2D microswarm, and the light irradiation transforms the 2D microswarm into a 3D microswarm tornado. This microswarm tornado (MST) performs reversible vertical mass transportation during its reconfigurable generation. The reconfiguration of the MST consists of rising, hovering, oscillation, and landing stages (Figure 1). Moreover, this 3D tornado-like microswarm can manage on-demand control of reaction rate, e.g., the degradation of methylene blue (MB) in this study. In experiments, the MST accelerates the global reaction, while holds the local reactants owing to the flow difference in different regions. Subsequently, by reprogramming the precessing field as an oscillating magnetic field, the previously trapped MB is degraded on demand. The MST is investigated to serve as a model for 3D collective transportation and mimicking natural swarm behaviors on collective anti-gravity reconfiguration, aiming at taking effects in catalytic and nanoengineering applications.

Abstract ID No.120

Fabrication of flexible ionic hydrogel battery inspired by electric eels

Pei He[1,2], Jiankang He[1,2*], Ziyao Huo[1,2] and Dichen Li[1,2]

1. State Key Laboratory for Manufacturing Systems Engineering, Xi'an Jiaotong University
2. Rapid manufacturing research center of Shaanxi Province, Xi'an Jiaotong University, Xi'an 710049, People's Republic of China

Email: jiankanghe@mail.xjtu.edu.cn

Abstract

Biomimetic power-generating systems inspired by electric eels has recently gained extensive attentions due to their potential as efficient, sustainable and renewable power sources. However, the existing fabrication strategies for biomimetic power-generating systems such as microfabrication and surface printing are time-consuming and complex, and the rigid assembly strategy is unsuitable for their applications in wearable electronics, soft implantable devices and soft robotics since their working conditions are usually under large deformation. Here we developed a microfluidic strategy for the fabrication of hydrogel-based ionic battery by mimicking the ion-concentration gradients inspired by electric eels. A flexible assembly approach based on negative pressure was further established to ensure the stable assembly of the ionic battery to function under large deformation. It was found that the ionic battery pack which total contains 801 gel particles can be rapidly fabricated via the designed perfusion systems in less than 1.6 minutes. The voltage output and current output reached 10.66±0.59 V for the battery pack assembled by the present flexible assemble strategy, which were the same as those of the traditional rigid assembled ones. The bionic voltage output of flexible assembled ionic battery increased linearly with the increase of battery unit number, and a maximum voltage as high as 70 V was realized by connecting eight ionic hydrogel battery packs in series. Additionally, the flexible assembled ionic hydrogel battery maintained its electrical performance under large deformation working conditions such as bending, folding and rolling up. The results showed the great potential of the flexible assembly ionic battery to be used as next-generation soft power source for soft robotics.

Abstract ID No.123

Plasma electrolytic oxidation coating of magnesium alloy with corrosion resistance and durability

Qianqian Cai, Jinkai Xu*, Zhongxu Lian*, Zhanjiang Yu, Huadong Yu, Shen Yang, Jian Li

Ministry of Education Key Laboratory for Cross-Scale Micro and Nano Manufacturing
Changchun University of Science and Technology, Changchun 130022, China
Email: xujinkai2000@163.com (J. Xu), lianzhongxv@126.com (Z. Lian)

Abstract

Plasma electrolytic oxidation technology (PEO) is an excellent surface treatment technology, which can produce a layer of oxidation coating with wear resistance and corrosion resistance on the metal surface, and has a good protective effect on the metal. Magnesium is a kind of metal material with low density, and has good thermal and electrical conductivity. In addition, magnesium alloy has excellent vibration and impact absorption properties, which has been widely used in automotive and aviation fields. The poor corrosion resistance of magnesium alloy seriously restricts its application in more fields. Plasma electrolytic oxidation technology is used to prepare an oxide ceramic film on the surface of the magnesium alloy, and a superhydrophobic surface is prepared after fluorination treatment. Through electrochemical test and durability test research, it is found that compared with magnesium alloy substrate and plasma electrolytic oxidation surface, the corrosion current density of superhydrophobic surface is the lowest, showing better corrosion resistance. After the durability test, the superhydrophobic surface still has good superhydrophobic properties.

Abstract ID No.126

Independent Pattern Formation and Parallel Locomotion of Two Microrobotic Swarms under a Global Input

Xingzhou Du[1,2,3], Jiangfan Yu[4,5], Dongdong Jin[1], Qianqian Wang[2], Li Zhang[1,3,6*]

1. Department of Biomedical Engineering, The Chinese University of Hong Kong, Shatin,N.T., Hong Kong, China.
2. Department of Mechanical and Automation Engineering, The Chinese University of Hong Kong, Shatin,N.T., Hong Kong, China.
3. Chow Yuk Ho Technology Centre for Innovative Medicine, The Chinese University of Hong Kong, Shatin,N.T., Hong Kong, China.
4. School of Science and Engineering, The Chinese University of Hong Kong, ShenZhen, China.
5. Shenzhen Institute of Artificial Intelligence and Robotics for Society (AIRS), Shenzhen, China.
6. CUHK T Stone Robotics Institute, The Chinese University of Hong Kong, Shatin NT, Hong Kong, China.

Email: lizhang@mae.cuhk.edu.hk

Abstract

Various creatures can form natural swarms to maximize the living chance of an individual. For example, birds fly in flocks to save energy, and fish swim in schools for anti-predator and feeding. In robotics, swarms of robots consisting of many individuals can extend the capabilities of each single one, such as forming patterns to adapt to the environments, conducting cooperation for targeted actuation, etc. At micro/nanoscale, making agents form swarm behaviour is a challenge, as devices or circuits cannot be integrated into the small-sized structures, and therefore only physical or chemical interactions among the agents can be employed. Through parallel operations, multiple swarms will further enhance overall capability for task solving. In this work, independent pattern formation and actuation of two microrobotic swarms in a global magnetic field is accomplished. We proposed a swarm consisting of millions of nickel nanorods actuated by a customized oscillating magnetic field. Different behaviours emerge in pattern formation and moving speed, compared with swarms formed by Fe_3O_4 nanoparticle. The oscillating field is the sum of an alternating field and a static field, and the ratio between the magnitudes of these two elements is denoted as γ. The nanorod swarm has a nonmonotonic pattern-changing sequence when adjusting the γ value of the fields, while the sequence of the nanoparticle swarm is monotonic. Thus, pattern changing of the nanorod swarm can be conducted in the decreasing region of its sequence while the nanoparticle swarm remains unchanged, and synchronous pattern changing of the two swarms can be completed in the increasing region. Furthermore, the magnetic anisotropy of the nanorods leads to different moving speeds with the nanoparticle swarm. Therefore, individual position control of the two swarms can be completed using this feature, and actuating the swarms towards opposite directions was achieved on a tilted substrate. In this work, the fundamental principles of the microrobotic swarms are investigated, proposing a solution for the independent control of multiple microrobotic swarms.

Abstract ID No.128

Preparation of corrosion resistant coating on magnesium alloy by hydrothermal method

Jian Li, Yiquan Li*, Jinkai Xu*, Zhanjiang Yu, Huadong Yu, Qianqian Cai, Shen Yang

Ministry of Education Key Laboratory for Cross-Scale Micro and Nano Manufacturing
Changchun University of Science and Technology, Changchun 130022, China
Email: liyiquan@cust.edu.cn (Y. Li), xujinkai2000@163.com (J. Xu)

Abstract

With the research and development of metals, magnesium alloy appears in the field of vision of researchers gradually, and it has been widely used in various fields because of its excellent properties. However, in the actual working environment, the oxide film produced on the surface of magnesium alloy is too fragile to protect the metal surface. The corrosion of magnesium alloy has become the biggest obstacle in its development. In this paper, the surface energy of magnesium alloy is reduced by fluorination treatment. The superhydrophobic corrosion resistant surface of magnesium alloy is prepared. The surface of magnesium alloy modified by hydrothermal method has good hydrophobic property, and the air layer between the substrate and the corrosive medium prevents the direct contact between the two, which effectively improves the corrosion resistance of the material. The corrosion resistance of the modified magnesium alloy was tested by electrochemical workstation. The results showed that the superhydrophobic surface had better corrosion resistance, mechanical properties and self-cleaning than the substrate surface. This method is of great significance to expand the application of magnesium alloy in practical life.

Abstract ID No.141

Robust scalable reversible strong adhesion by gecko-inspired composite design

Xiaosong Li, Xinxin Li, Yu Tian*

Affiliation: Tsinghua University
Address: Department of Mechanical Engineering, Tsinghua University, Beijing 100084, China.
Email: tianyu@mail.tsinghua.edu.cn

Abstract

Bio-inspired reversible adhesion has significant potential in many fields requiring flexible grasping and manipulation, such as precision manufacturing, flexible electronics, and intelligent robotics. Despite extensive efforts for adhesive synthesis with a high adhesion strength at the interface, an effective strategy to actively tune the adhesion capacity between a strong attachment and an easy detachment spanning a wide range of scales has been lagging. Herein, we report a novel soft-hard-soft sandwiched composite design to achieve a stable, repeatable, and reversible strong adhesion with an easily scalable performance for a large area ranging from ~1.5 to 150 cm2 and a high load ranging from ~20 to 700 N. Theoretical studies indicate that this design can enhance the uniform loading for attachment by restraining the lateral shrinkage in the natural state, while facilitate a flexible peeling for detachment by causing stress concentration in the bending state, yielding an adhesion switching ratio of ~54 and a switching time of less than ~0.2 s. This design is further integrated into versatile grippers, climbing robots, and human climbing grippers, demonstrating its robust scalability for a reversible strong adhesion. This biomimetic design bridges microscopic interfacial interactions with macroscopic controllable applications, providing a universal and feasible paradigm for adhesion design and control.

Abstract ID No.145

Underwater Impact Hammer Inspired by Mantis Shrimp

Xinxin Li[1], Yu Tian[1*]

1. Department of Mechanical Engineering, State Key Laboratory of Tribology, Tsinghua University, Beijing 100084, China
Email: lixinxin17@mails.tsinghua.edu.cn
(Type should be 12 points for the Title and 10 points for the author and body sections. Times New Roman is the only font for English letters.)

Abstract

Inspired by the linkage mechanics and ultrafast power-amplified systems of the mantis shrimp's strike, an impact hammer mechanism called Mantisbot was built to strike hard objects automatically and circularly. Driven by a DC motor, Mantisbot integrated springs and latches to store energy slowly and release energy

instantaneously. A four-bar linkage mechanism was adapted to amplify output rotation, with a rotational amplification approximately 2.2 times the input rotation, exceeding the previously reported kinematic transmission below 2 of mantis shrimp. Attributed to the synthetical biomimetic design, Mantisbot reached speeds over 12 ms-1, at accelerations of 2×103 ms-2, which were closed to the mantis shrimp. The impact forces of Mantisbot were more than 1200N underwater. More importantly, cavitation bubbles were observed when the hammer impacted the wall for the first time in this study, while similar phenomena occurred when mantis shrimp's appendages smashed hard-shelled prey. The shape of the Mantisbot's hammer was optimized to reduce the drag resistance of water by CFD simulation. And cavitation forces by the collapse of cavitation bubbles were calculated. Mantisbot reproduces the mantis shrimp's cavitation generation technique, which is conducive to comprehend the mechanical principles and fluid dynamics of ultrafast power-amplified systems of mantis shrimp.

Abstract ID No.148

Research on the Mechanical Durability and Corrosion Resistance of Oil-water Separation of Stainless Steel Mesh Developed by Waterjet-assisted Laser Ablation

Jiaqi Wang, Jinkai Xu, Guangjun Chen, Zhongxu Lian, Jingdong Wang and Huadong Yu*

Ministry of Education Key Laboratory for Cross-Scale Micro and Nano Manufacturing, Changchun University of Science and Technology, Changchun, Jilin Province, China
Corresponding author: yuhuadong@cust.edu.cn *

Abstract

With the increase of offshore oil exploration, oil transportation accidents and urban sewage discharge, the treatment of oily wastewater has become a worldwide challenge. The mechanical durability and corrosion resistance of oil-water separation materials are even more important. This research proposes a new method, water jet-assisted laser ablation, preparing microstructure on stainless steel mesh to make it have special wetting performance, which is used to separate oil-water mixtures. Compared with the mechanical durability and corrosion resistance of the filter screen obtained by laser dry processing and waterjet-assisted laser ablation, the results show that the surface prepared by the novel technology has stronger mechanical durability and corrosion resistance, it can be used in extreme environments and the wettability can still be maintained. In addition, complicated liquid-oil mixtures in complex environments have also been successfully separated with high separation efficiency. Therefore, the oil-water separation filter obtained in this study has excellent application prospects.
Keywords: Oil-water Separation, Durability, Corrosion Resistance, Waterjet-assisted Laser Ablation

Abstract ID No.157

Research in kinematics of jerboa hopping on sand and the jerboa-like robot model

Rui Zhang*, Hao Pang, Yupei Du, Yu Han and Jianqiao Li

Key Laboratory of Bionic Engineering, Ministry of Education Jilin University, 5988 The People's Street, Changchun, AL 130022
Email: zhangrui@jlu.edu.cn

Abstract

The Jerboa (Dipodidae) is a small rodent that lives and is good at hopping on two legs in the desert. The long and developed hind limbs of the jerboa are used for efficient and steady hopping. It is an excellent bionic prototype for developing a jumping robot on soft ground. Firstly, the hopping process of jerboa on flat sand, sloping sand and obstacle crossing on the sand were analyzed. It was found that jerboa could not only hop easily on the slope of the sand but also cross obstacles two to three times its standing height in the soft sand environment. It can take off and land smoothly without slipping. Then, to accurately capture the joint position and analyze the toe posture of the jerboa when kicking off sand, the hind limbs of jerboa

were gross dissection, and the hopping behavior of jerboa in loose media was captured by a 3D dynamic X-ray motion capture system. Through the study of jerboa, this paper elucidates the biological structure and locomotion mechanism of jerboa hind limbs adapted to efficient and robust hopping in the desert. Finally, based on the study of jerboa kinematics, the rigid-body model of a jerboa-like robot in the touchdown phase was established. This study provides a new research idea and method for the structural design of the jumping robot on soft ground.

Abstract ID No.20

Metal-ceramic composites with biomimetic structures fabricated by freeze casting and pressure infiltration

Meng-Qi Sun, Ping Shen [*]

Keywords: Freeze casting; Composites; Biomimetic structures

Abstract

By mimicking the sophisticated structures and mechanical design principles of natural materials, we can design and synthesize man-made structural materials with excellent properties. For example, despite being composed of > 95% brittle aragonite, nacre achieves orders-of-magnitude increase in toughness than pure aragonite; honeycombs, built by bees, achieve high strength with minimal materials. These examples provide inspiration for the design and fabrication of synthetic materials with high strength and toughness. In this work, aluminum/alumina composites imitating the nacre and honeycomb structures were prepared by a combination of freeze casting and pressure infiltration. The biomimetic structures could be tailored by controlling solvent concentration and freezing parameters. The lamellar-structure composites exhibited ceramic pull-out behavior and multiple cracking mechanisms, significantly improving the toughness. The composites with lamellar and honeycomb configurations showed high strength and considerable toughness. The fracture modes of these composites were characterized and discussed. This work provides new ideas and solutions for the design and fabrication of high-performance metal-ceramic composites.

Abstract ID No.30

Fabrication of Transparent and Robust Superhydrophilic Anti-fogging Coating by Polymer and Inorganic nanoparticles Hybridization

Weilin Deng, Wei Wang, Jing Liu, Lili Xu, Xinquan Yu[*], and Youfa Zhang[*]

Jiangsu Key Laboratory of Advanced Metallic Materials, School of Materials Science and Engineering, Southeast University, Nanjing 211189, PR China

Abstract

Anti-fogging coatings are often required to have high transparence, excellent robust properties, water resistance and acid-alkali resistance. Here, we report a water-borne anti-fogging coating were deposited by the dipping method in mixed solution mainly consisting of sodium vinylsulfonate, epoxide resin, silica and alumina nanoparticles. Such a low-cost hybrid coating with high transparence (>93.5% transmittance) exhibits outstanding anti-abrasion resistance up to 100 continuous Taber abrasion cycles, maintaining superhydrophilic water contact angles. Furthermore, the resulting coating demonstrates noted water resistance, preserving the initial superhydrophilic performance after immersing in boiling water for 0.5h. The presence of silica and alumina nanoparticles allows the coating to have excellent mechanical properties. The effect of composition and structure on the mechanical properties, water resistance and acid-alkali resistance are investigated.

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Poster Presentations

Abstract ID No.22

Superwetting Membranes fabricated by colloidal nanoparticle self-assembly for efficient oil/water separation

Chaolang Chen

State Key Laboratory of Tribology, Tsinghua University, Beijing, China

clchen100@163.com, ccl16@mails.tsinghua.edu.cn

Abstract ID No.33

Bionic Design of Energy-absorbing Structure of Bean Goose (Anser fabalis) Feather Shaft Based on Lightweight

C. Liu[1,2], L. H. Xu[1], M. Zou[1], J. Y. Sun[1*]

1. Key Laboratory for Bionics Engineering of Education Ministry, Jilin University, Changchun, 130022, China

2. Faculty of Science and Engineering, University of Groningen, 9747 AG Groningen, The Netherlands

*Corresponding author: Jiyu Sun (sjy@jlu.edu.cn)

Abstract ID No.41

Cleaning without being contaminated: Antenna cleaner of a honey bee is a catapult

Wei Zhang[1, a], Zheyu Xu[1, a], Ji Wang1, Zhigang Wu[1], Jianing Wu[1,*]

1. School of Aeronautics and Astronautics, Sun Yat-Sen University, Guangzhou, 510006, People's Republic of China

a. These authors contributed equally.

Email:317377580@qq.com

Abstract ID No.49

Study on the structural characteristics of the goose's neck and its motion features in the sagittal plane

Jiajia Wang[1*], Wenfeng Jia[1], Zhaomei Qiu[1]

1.College of Agricultural Equipment Engineering, Henan University of Science and Technology, Luoyang 471003, Henan, China

Email:1016722007@qq.com

Abstract ID No.58

An ultra-sensitive and wide-range pressure sensor with multiscale hierarchical structure based on carbon nanotube film

Chao Wang[1], Jun Cai[1,*]

1. *School of Mechanical Engineering and Automation, Beihang University, Beijing 100191, China

Address: 37 Xueyuan Road, Haidian District, Beijing, China

Email: wangchao_charles@126.com, jun_cai@buaa.edu.cn

Abstract ID No.87

A soft biocompatible bacterial cellulose-based actuator enhanced by multi-walled carbon nanotubes

Yaofeng Wang, Yang Kong, Fan Wang*
Faculty of Mechanical Engineering and Automation
Zhejiang Sci-Tech University, Hangzhou 310018, China
Email: fwang@zstu.edu.cn

Abstract ID No.89

An economical and reproducible soft biocompatible actuator based on microfibrillated cellulose

Yang Kong, Yaofeng Wang, Fan Wang*
Faculty of Mechanical Engineering and Automation
Zhejiang Sci-Tech University, Hangzhou 310018, China
Email: fwang@zstu.edu.cn

Abstract ID No.100

A novel polar organic gas soft actuator based on the MIL-53-Cr composite film

Danhong Yang[1], Tengfei Zheng[2] and Chaohui Wang[3*]
State Key Laboratory for Manufacturing Systems Engineering
Xi'an Jiaotong University, Xi'an 710049, China.
Email: ydh5495666@stu.xjtu.edu.cn

Abstract ID No.102

Effect of Additive Manufacturing Biomimetic Gradient Ceramic Coating on Impact Performance of 40Cr

Xi Wang[1,3], Ti Zhou[2,3,*]
1. Yancheng institute of technology,Yancheng 224051,China
2. School of Mechanical and Aerospace Engineering, Jilin University,Changchun 130025,China
3. Weihai Institute for Bionics, Jilin University, Weihai 264200,China
Email: wangxi2020@ycit.edu.cn

Abstract ID No.105

Synergistic interplay between human BMSCs and HUVECs in 3D spheroids laden in gelatin/hyaluronan hydrogels for simultaneously enhancing osteogenesis and vascularization

Zhen Zhang[1,2], Xue-lian Tao[1], Ping Du[1], Javad Harati[1], Peng-yuan Wang[1,2*]
1. Institute of Biomedicine and Biotechnology, Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences, Shenzhen, Guangdong, China
2. University of Chinese Academy of Sciences, Beijing, China
Email: zhen.zhang@siat.ac.cn, py.wang@siat.ac.cn*

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Abstract ID No.107

Selection and Enrichment of Cancer Stem Cells Utilizing Surface Structure Modification

Yung-Chiang Liu[1, 2], Peng-Yuan Wang[1, 2, *]
1. Shenzhen Key Laboratory of Biomimetic Materials and Cellular Immunomodulation, Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences, Shenzhen, Guangdong 518055, China
2. Institute of Biomedicine and Biotechnology, Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences, Shenzhen, Guangdong 518055, China
1068 Xueyuan Avenue, Shenzhen University Town, Shenzhen, P.R.China
Email: py.wang@siat.ac.cn
(Type should be 12 points for the Title and 10 points for the author and body sections. Times New Roman is the only font for English letters.)

Abstract ID No.113

Design of small manned lunar rover with high folding ratio bionic structure

Hongtao Cao, Meng Zou*
Key Lab of Bionic Engineering, Ministry of Education, Jilin University, Changchun, 130025, China
Email: htcao20@mails.jlu.edu.cn, zoumeng@jlu.edu.cn

Abstract ID No.117

Generation of Multicellular Liver Tumor Spheroids and its Application in Drug Screening

Xing-Jian Liu[1,2], Peng-Yuan Wang[1,2,*]
1. Shenzhen Key Laboratory of Biomimetic Materials and Cellular Immunomodulation, Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences, Shenzhen, Guangdong 518055, China
2. Institute of Biomedicine and Biotechnology, Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences, Shenzhen, Guangdong 518055, China
1068 Xueyuan Avenue, Shenzhen University Town, Shenzhen, P.R.China
Email: py.wang@siat.ac.cn

Abstract ID No.121

Harnessing colloidal self-assembled patterns (cSAPs) to modulate inflammatory phenotypes of mouse and human macrophages

Kun Liu, Jiao Lin, Yue shi, Xuelian Tao, Ping Du, Javad Harati, Peng-Yuan Wang*
Shenzhen Key Laboratory of Biomimetic Materials and Cellular Immunomodulation, Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, Shenzhen, Guangdong 518055, China
1068 Xueyuan Avenue, Shenzhen University Town, Shenzhen, China
Email: kun.liu1@siat.ac.cn, py.wang@siat.ac.cn

Abstract ID No.125

Cell squeezing of cancer cells and its application

Jhe-Wei Jhang[1, 2] **, Peng-Yuan Wang**[1, 2, *]
Shenzhen Key Laboratory of Biomimetic Materials and Cellular Immunomodulation,
Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences
1068 Xueyuan Avenue, Shenzhen University Town, Shenzhen, China
Email: zw.zhang2@siat.ac.cn, py.wang@siat.ac.cn

Abstract ID No.133

A Multi-bioinspired Superhydrophobic Coating for Daytime Radiative Cooling

Chaohua Xue[1,2*]**, Bingying Liu**[2]**, Shuntian Jia**[1]
1. College of Bioresources Chemical and Materials Engineering, Shaanxi University of Science & Technology, Xi'an 710021, China
2. College of Environmental Science and Engineering, Shaanxi University of Science & Technology, Xi' an 710021, China
Email: xuechaohua@126.com

Abstract ID No.136

Development of a Humanoid Robotic Leg with Foot Tactile Feedback for Intelligent Cognition and Control

Funing Hou[1]**, Jixiao Liu2**[*]**, Dicai Chen**[2]**, Shijie Guo**[1]
1. Academy for Engineering and Technology, Fudan University, Shanghai, 200433, China
2. School of Mechanical Engineering, Hebei University of Technology, Tianjin 300401, China
fnhou19@fudan.edu.cn, liujixiao@hebut.edu.cn, 201931204026@stu.hebut.edu.cn, guoshijie@fudan.edu.cn

Abstract ID No.137

Bionic Anisotropic Hydrophobic-Coating Hydrogels for Organs-on-a-Chip

Jun Liu[1,*]**, Zhongze Gu**[1]
1. School of Biological Science & Medical Engineering, Southeast University, SiPaiLou #2, Nanjing, Jiangsu 210096
Email: junliu2019@outlook.com

Abstract ID No.139

Vascularization and Immune Response within Multi-Cellular Lung Tumor Spheroids

Yan-Shan Xu[1,2]**, Peng-Yuan WANG**[1,2*]
1. Shenzhen Key Laboratory of Biomimetic Materials and Cellular Immunomodulation, Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences, Shenzhen, Guangdong 518055, China
2. Institute of Biomedicine and Biotechnology, Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences, Shenzhen, Guangdong 518055, China
1068 Xueyuan Avenue, Shenzhen University Town, Shenzhen, P.R.China
Email: py.wang@siat.ac.cn

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Abstract ID No.140

Integrated Sensing-Control-Drive Robotic Hand Based on Tactile Information

Kuo Liu[2]**, Jixiao Liu**[2*]**, Dicai Chen**[2]**, Shijie Guo**[1]
1. Academy for Engineering and Technology, Fudan University, Shanghai, 200433, China
2. School of Mechanical Engineering, Hebei University of Technology, Tianjin 300401, China
202021202121@stu.hebut.edu.cn, liujixiao@hebut.edu.cn, 201931204026@stu.hebut.edu.cn, guoshijie@fudan.edu.cn

Abstract ID No.149

Facile fabrication of transparent superamphiphobic coating by spraying template methods for micropatterns

Haojun Li, Haibo Li, Hua Tong, Qingqing Jin, Keke wang, Yanan Li[*]
School of Chemical Engineering and Technology, Sun Yat-sen University, Zhuhai,519082, China.
E-mail: liyn75@mail.sysu.edu.cn

Abstract ID No.151

Self-assembly of impinging ferrofluid droplet under magnetic field

Zhaoyi Wang, Ran Tao, Chonglei Hao[*]
School of Mechanical Engineering and Automation, Harbin Institute of Technology, Shenzhen
Address: University Town of Shenzhen, Shenzhen 518055, China
Email: haochonglei@hit.edu.cn

Abstract ID No.153

Bionic superamphiphobic surfaces for controllable oil droplet transportation

Faze Chen[*]**, Jiaqi Chao, Zexin Cai**
School of Mechanical Engineering, Tianjin University
No.135 Yaguan Road, Haihe Education Park, Tianjin, 300350
Email: faze.chen@tju.edu.cn

Abstract ID No.162

Low Melting Point Alloy Based Structure-Designable Triboelectric Nanogenerators for Energy Harvesting and Sensing

Liang Zhou, Shichao Niu[*]**, Lili Ren**
Key Laboratory of Bionic Engineering, Ministry of Education, Jilin University, 130022, People's Republic of China.
5988 Renmin Street, Changchun,130022, China
Email: niushichao@jlu.edu.cn

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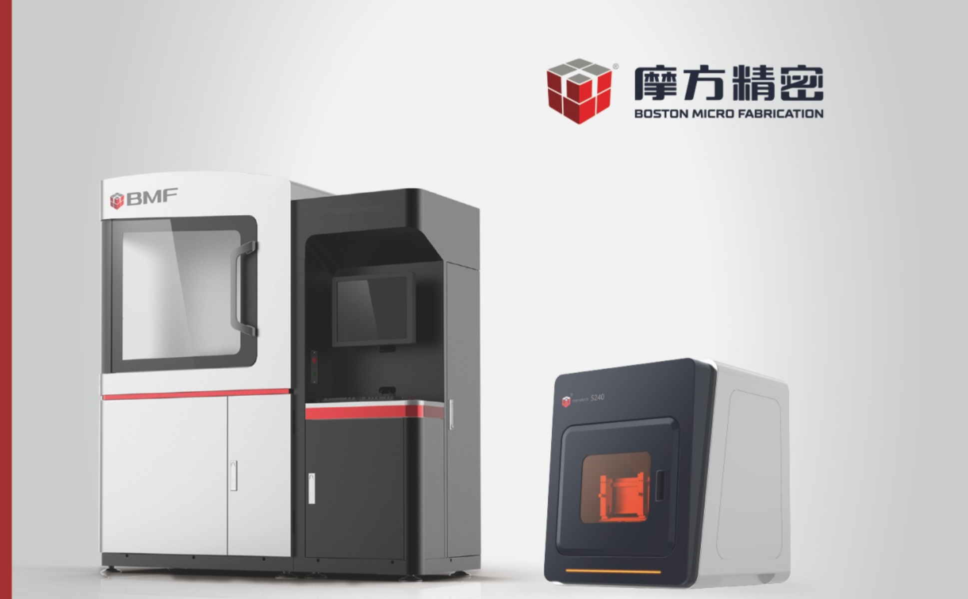

2μm 打印设备

10μm 打印设备

2μm 打印设备	10μm 打印设备
光学精度： 2μm	**光学精度：** 10μm
最大打印尺寸： 50mm(L)×50mm(W)×10mm(H)	**最大打印尺寸：** 100mm(L)×100mm(W)×75mm(H)

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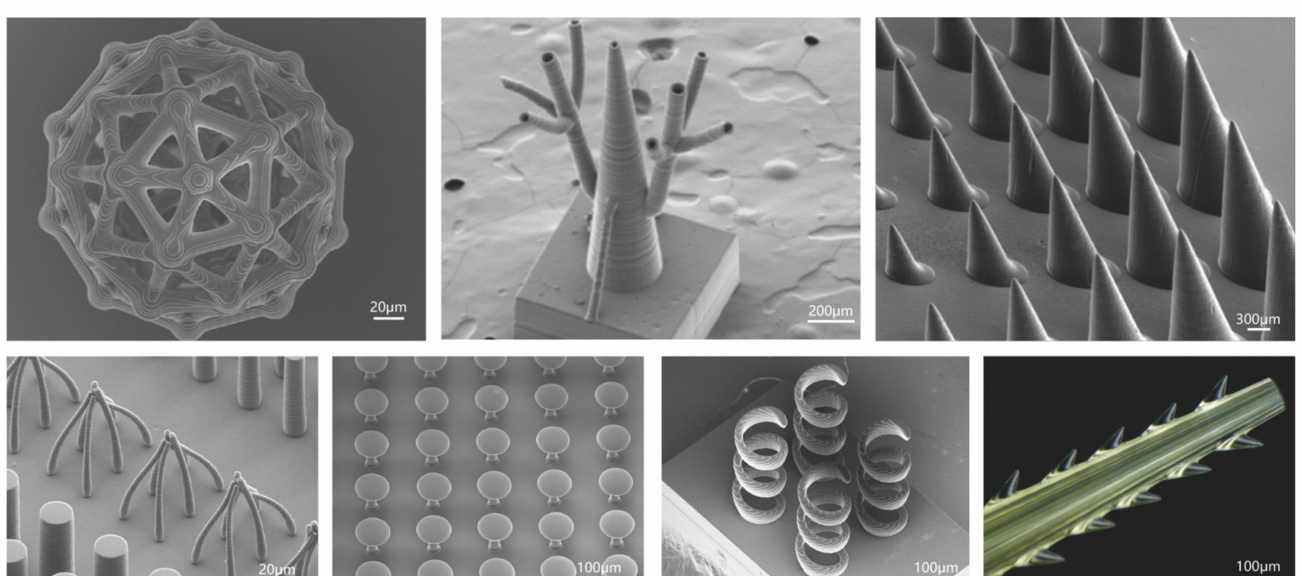

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4. 在海外知名高校和科研机构工作者应获得副教授以上或相当职位；
5. 主持过国家级科研项目，近5年内在国际顶级学术期刊上以第一作者/通讯作者发表至少10篇SCI论文。
6. 有重大原创性研究成果者，对年龄和论文要求可适当放宽。

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2. 在海内外知名高校取得博士学位本研究领域青年拔尖人才，或已在海内外科研院校工作，并做出突出成果者；
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4. 具有独立带领团队开展研究的能力以及成长为相关领域学术带头人的潜力；
5. 近5年内在国际顶级学术期刊上以第一作者/通讯作者发表至少5篇SCI论文。

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