2017 June 28-30

Personalized Intelligent Living: Human, Robot and Nature

Penn Wharton China Center

Penn Wharton China Center, Beijing, China

Day 1 - Monday June 28, 2017

Session 1: Geometry, mechanics, bioinspired materials, robotics (Chair: Shu Yang)

8:30 - 9:15	Randall Kamien (Univ. Pennsylvania): The Mathematics of Paper
9:15 - 10:00	Cynthia Sung (Univ. Pennsylvania): Origami robotics
10:00 - 10:15	Break
10:15 - 11:00	Tutorial: Shu Yang (Univ. Pennsylvania): Analyzing Biological Structures for Advanced Materials
11:00 - 11:30	Shutao Wang (王树涛, Tech. Inst. Phys. Chem. CAS): Engineering Biointerface
11:30 - 12:00	Ji Yan (吉岩，Tsinghua Univ.): Reconfigurable liquid crystalline elastomers for soft robots
12:00 - 13:00	Lunch

Session 2: Flexible electronics & Mechanics (Chair, Milin Zhang)

13:30 - 14:15	Yonggang Huang (Northwestern Univ.): Universal Kirigami
14:15 - 14:45	Milin Zhang (张沕琳, Tsinghua Univ.): Bioinspired sensors
14:45-15:15	Ting Zhang (张婷, Tsinghua Univ.): Biomanufacturing
15:15-15:45	Break
15:45-16:30	Panel discussion

Abstracts & Biosketches

The Mathematics of Paper
Randall D. Kamien
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I will not be talking about doing math problems on paper. I will not be talking about the economics of selling newspapers in the internet age. I will talk, instead, about how there is some profound mathematics behind our everyday trouble with wrapping oddly-shaped gifts and making maps. The solution? A cousin of *origami* called *kirigami* allows us to solve these problems and more.

Randall D. Kamien received his Ph.D. in Physics from Harvard University in 1992. From 1992-1995 he was a Member in the School of Natural Sciences at the Institute for Advanced Study. He was hired as a postdoc at Penn in 1995 and has stayed there since where he is now the Vicki and William Abrams Professor in the Natural Sciences. He uses geometry and topology to study the organization of soft materials. He is currently a Simons Investigator in Theoretical Physics.

Origami robotics
Cynthia Sung
Gabel Family Term Assistant Professor
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Origami is an ancient art that allows us to fold flat sheets into complex, three-dimensional structures. In the last few decades, we have developed the mathematics to design and analyze new fold patterns, transforming origami from a form of recreation into a powerful engineering tool. In this talk, I will discuss some of these models in the context of action origami, origami structures that can continue to move after folding. We will look at how we can model these fold patterns as linkage mechanisms and combine them into new origami robot designs that can self-assemble, walk, and transform.

Cynthia Sung is a Gabel Family Term Assistant Professor in the Department of Mechanical Engineering and Applied Mechanics (MEAM) at the University of Pennsylvania. Her research group focuses on computational methods for design automation of robotic systems with the aim of providing designers with intuitive computer-aided design tools for creating customized robots and behaviors. Their work involves developing techniques for representing, modeling, simulating, and fabricating these designs. Sung's research lies at the intersection of computational geometry, data driven methods, and rapid fabrication techniques such as 3D printing and origami-inspired assembly. She received a Ph.D. in Electrical Engineering and Computer Science from MIT in 2016 and a B.S. in Mechanical Engineering from Rice University in 2011.

Analyzing Biological Structures for Advanced Materials

Shu Yang
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Bio-organisms with exquisite array of hierarchical organization with multiscale structures provides us fascinating examples with remarkable optical, mechanical, and surface effects as part of their evolved strategies to optimize water, heat, and light management in cope with their local habitat. Here, I will analyze several examples, including butterfly wings with dazzling iridescence and/or brilliant whiteness for camouflage and signaling depending on lighting, Cephalopod skins that change from transparency to red upon exposure to UV light for dynamic underwater camouflage, Tridacnid giant clams in the west Pacific presents the first geometric solution to utilize 100% of the solar energy for biofuel production, gecko foot hairs that can reversibly engage and release from a surface, and Namib desert beetle using bump shell for frog harvesting. Taking the cues from nature, I will discuss how materials scientists attempt to fabricate hierarchical structures via combination of top-down and bottom up approaches to mimic the functions observed from nature for advanced materials.

Shu Yang is a Professor in the Departments of Materials Science & Engineering, and Chemical & Biomolecular Engineering at University of Pennsylvania, and Director of Center for Analyzing Evolved Structures as Optimized Products (AESOP): Science and Engineering for the Human Habitat. Her group is interested in synthesis, fabrication and assembly of polymers, liquid crystals, and colloids with precisely controlled size, shape, and geometry; investigating the dynamic tuning of their sizes and structures, and the resulting unique optical, mechanical and surface/interface properties. Yang received her BS degree from Fudan University, China in 1992, and Ph. D. degree from Cornell University in 1999. She worked at Bell Laboratories, Lucent Technologies as a Member of Technical Staff before joining Penn in 2004. She received George H. Heilmeier Faculty Award for Excellence in Research from Penn Engineering (2015-2016). She is elected as Fellow of the Royal Society of Chemistry (FRSC) (2017), Fellow of National Academy of Inventors (2014), and TR100 as one of the world's top 100 young innovators under age of 35 by MIT's Technology Review (2004).

Engineering Biointerface with Controlled Cell Adhesion towards Cancer Diagnostics

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Learning from nature and based on lotus leaves and fish scale, we developed super-wettability system: superhydrophobic, superoleophobic, superhydrophilic, superoleophilic surfaces in air and superoleophobic, superareophobic, superoleophilic, superareophilic surfaces under water. Further, we fabricated artificial materials with smart switchable super-wettability. The smart super-wettability system has great applications in various fields, such as self-cleaning glasses, water/oil separation, anti-biofouling interfaces, and water collection system. Also, we discovered the spider silk's and cactus's amazing water collection and transportation capability, and based on these nature systems, artificial water collection fibers and oil/water separation system have been designed successfully.

Circulating tumor cells (CTCs) have become an emerging “biomarker” for monitoring cancer metastasis and prognosis. We here proposed that nanoscaled local topographic interactions besides biomolecular recognitions inspired by natural immuno-recognizing system. This cooperative effect of physical and chemical issues between CTCs and substrate leads to increased binding of CTCs, which significantly enhance capture efficiency. We have also developed a 3D cell capture/release system triggered by enzyme, electrical potential and temperature as well as magnetic field, which is effective and of “free damage" to capture and release cancer cells. In addition, immune cells have also been employed as living template for greatly improving the limitation of traditional immunomagnetic beads. Therefore, these bio-inspired interfaces open up a light from cell-based disease diagnostics to subsequent safety treatment of biomedical waste.

Shutao Wang is currently a professor and director of Division of Science and Technology at Technical Institute of Physics and Chemistry, and vice director of Key Lab of Bio-inspired Materials and Interfacial Science, Chinese Academy of Sciences. His research interests include the design and synthesis of bioinspired interfacial materials and devices with special adhesion and their applications. He received his PhD degree in 2007 from Institute of Chemistry Chinese Academy of Sciences (ICCAS) under the supervision of Prof. Lei Jiang. Then he worked in the Department of Molecular & Medical Pharmacology and California NanoSystem Institute at the University of California at Los Angeles as a postdoctoral researcher (2007–2010). He was appointed as a full Professor of Chemistry in 2010–2014 at ICCAS. He was elected as the Ministry of education of Yangtze River Scholar Professor (2016), Youth Science and Technology Innovation Leader (2016), the Top-Notch Young Talents Program of China (2014), National Science Fund for Distinguished Young Scholars (2014). He received Youth Distinguished Awards of Chinese Chemical Society (2013). He is associate editor of NPG Asia Materials.

Reconfigurable liquid crystalline elastomers for soft robots

Yan Ji
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http://www.chem.tsinghua.edu.cn/publish/chemen/2141/2012/20120408162111682408327/20120408162111682408327_.html

In contrast to traditional industry robots, soft robots employ deformable non-rigid materials to perform bending, twisting, extension, and other movements. Consequently, they offer safer human-robot interaction. The design of soft robots are often inspired by the behavior of animals including octopus arms, elephant trunks, etc. Despite of the rapid progress achieved in the past decade, none of the present soft robots is able to change their 3D structures, which can mimic the flexible morphing ofTerminator-1000 in the sci-fic movie Terminator 2&5. To achieve this, we believe that the first step is to achieve soft actuators which are able to change their shapes freely. In this talk, I will show our efforts towards the reconfigurable soft actuators built of liquid crystalline elastomers with dynamic covalent bonds.

Yan Ji is an Associate Professor at the Department of Chemistry, Tsinghua University, China. She received her Bachelor's and Master's degrees from Tianjin University (China) in 1998 and 2001 respectively. In 2006, she received her Ph.D. degree from Peking University (China). After 5 years in Cambridge University (UK) as a Research Associate, she joined Tsinghua University by the end of 2011. Her main research interests are polymers containing dynamic covalent bonds, stimuli-responsive polymers and polymeric nanocomposites.

Stretchable Electronics and Deterministic 3D Assembly

Yonggang Huang
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Biology is soft, elastic, and curved; silicon wafers are not. An electronics technology that overcomes this fundamental mismatch in mechanics and form will enable applications that are impossible to achieve with hard, planar integrated circuits that exist today. Examples range from surgical and diagnostic implements that naturally integrate with the human body to provide advanced therapeutic capabilities, to cameras that use biologically inspired designs to achieve superior performance. Sensory skins for robotics, structural health monitors, wearable communication devices, and other systems that require lightweight, rugged construction in thin, conformal formats will also be possible. Establishing the foundations for this future in electronics represents an emerging direction for research, much different from the one dictated by the ongoing push toward smaller and faster devices that are still confined to the planar surfaces of silicon wafers.

Recent advances in mechanics and materials provide routes to integrated circuits that can offer the electrical properties of conventional, rigid wafer-based technologies but with the ability to be stretched, compressed, twisted, bent and deformed into arbitrary shapes. Inorganic electronic materials in micro/nanostructured forms, intimately integrated with elastomeric substrates offer particularly attractive characteristics in such systems, with realistic pathways to sophisticated embodiments. Mechanics plays a key role in this development of stretchable electronics by identifying the underlying mechanism and guiding design and fabrication. I will present our research on stretchable silicon [1] and its applications to stretchable and foldable circuits [2], electronic-eye camera [3,4], semi-transparent and flexible LED [5], epidermal electronics [6], dissolvable electronics [7,8],injectable, cellular-scale optoelectronics [9], and soft, microfluidic assemblies of sensors, circuits and radios [10]. Review of stretchable electronics has been published [11].

Mechanics also plays a key role in deterministic 3D assembly. Complex three-dimensional (3D) structures in biology (e.g., cytoskeletal webs, neural circuits, and vasculature networks) form naturally to provide essential functions in even the most basic forms of life. Compelling opportunities exist for analogous 3D architectures in human-made devices, but design options are constrained by existing capabilities in materials growth and assembly. I report routes to previously inaccessible classes of 3D constructs in advanced materials, including device-grade silicon [12]. The schemes involve geometric transformation of 2D micro/nanostructures into extended 3D layouts by compressive buckling. Demonstrations include experimental and theoretical studies of more than 40 representative geometries, from single and multiple helices, toroids, and conical spirals to structures that resemble spherical baskets, cuboid cages, starbursts, flowers, scaffolds, fences, and frameworks, each with single- and/or multiple-level configurations.

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Yonggang Huang is a Professor in the McCormick School of Engineering at Northwestern University. His group is interested in stretchable electronics; and mechanic-guided, deterministic 3D assembly. Huang received his BS degree from Peking University, China in 1984, and S.M. (1987) and Ph. D. (1990) degree from Harvard University. She worked several universities before, including University of Illinois at Urbana-Champaign before joining Northwestern University in 2007. He is a member of the US National Academy of Engineering.

Bio-3D printing — Design and Fabrication of Living Constructs with 3D Printing Techniques

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As an emerging field, various approaches have been established to create three-dimensional (3D) living constructs, which closely mimic native organs and tissues, for further biological applications. Rapid-prototyping techniques, also named 3D printing, which are capable of fabricating individualized, complex 3D construct, have become the most potential technique in this interdisciplinary field. The macro-, micro-, and gradient architecture of the scaffolds/constructs, as well as micro/macro environment, greatly influence cell proliferation, migration, and differentiation, and are also capable of directing functional tissue formation. Here, I will report some newly developed approaches for the design and fabrication of living constructs with our self-developed indirect/direct bio-3D printing techniques, with the application of tissue engineering and tissue-on-chips. Challenges, opportunities and future trend of the techniques will also be shared at the end of presentation.

Ting ZHANG is an Associate Professor in the Department of Mechanical Engineering at Tsinghua University, and Vice Director of Bio-manufacturing Center. Her group is interested in developing manufacturing techniques for the fabrication of three-dimensional living constructs or living systems with complex structure and functions, with the application to tissue engineering and regenerative medicine, biology and disease pathogeneses study, drug testing and tissue/organ-on-chips. ZHANG received her BS degree from Tsinghua University, China in 2004, Engineer Diploma (M.S.) from Ecole Centrale de Lyon, France in 2004 and Ph. D. degree from Tsinghua University in 2009. She worked as a visiting scholar in the laboratory for stem cells and tissue engineering in the Department of Biomedical Engineering at Columbia University (2008). She is now a core member of Biomanufacturing and Rapid Forming Technology Key Laboratory in Beijing, and 111 “Biomanufacturing and Engineering Living Systems”Innovation International Talents Base in China.