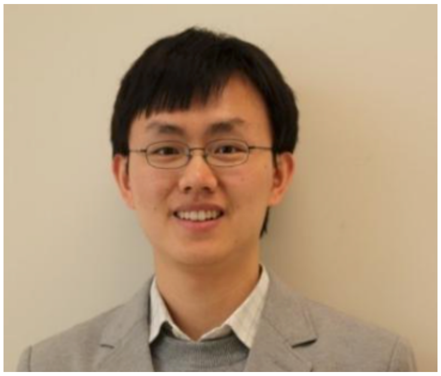
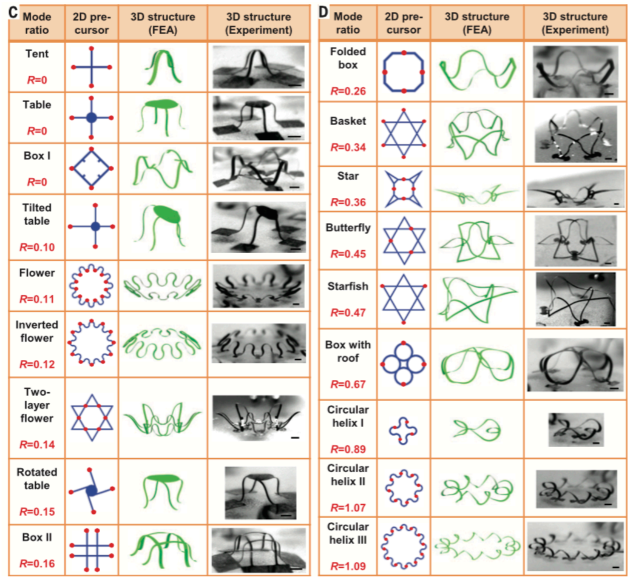


Dr. Sheng Xu



Two-dimensional structures that buckle into 3-D structures

(from: "Assembly of micro/nanomaterials into complex, three-dimensional architectures by compressive buckling", Science, Vol. 347, No. 6218, 9 January 2015)

See:
http://publish.illinois.edu/shengxu/about/
http://www.researchgate.net/profile/Sheng_Xu8

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Biography:

Dr. Sheng Xu is currently a Postdoctoral Research Associate at the University of Illinois Urbana-Champaign, where he is working with Dr. John Rogers on stretchable electronics, including ultra-stretchable micro/nanostructures, energy storage devices and mobile healthcare systems. He received his Ph.D. in Materials Science and Engineering from Georgia Institute of Technology in 2010, where his research focused on rational oxide nanowire synthesis, nanowire array based light emitting diodes and mechanical energy harvesters with Dr. Zhong Lin (Z.L.) Wang. He received his B.S. in inorganic chemistry from Peking University, China in 2006.

Research Interests:

Wearable devices that match the soft, curvilinear, and time-dynamic nature of the human body is an important trend for bio-integration, redefining not only the appearance, but also the design and fabrication of microelectronics. The search for pliable materials with superb electronic properties calls for strategies to bridge the gap between hard and soft – among which advanced engineering of the geometry and architecture of materials presents unique opportunities. A prominent example of geometry engineering is that nanowires of hard and brittle piezoelectric oxides such as ZnO and PZT can be used as a flexible energy source; their synthesis, properties and integration into an energy harvesting device will be discussed. For architecture engineering, the compressive straining of an elastic substrate can be used to fabricate previously inaccessible classes of 3D structures in monocrystalline materials. Conversely, rationally designed 2D geometries can buckle to form 3D layouts to accommodate tensile strain, resulting in unprecedented stretchability. This enables a series of device possibilities in stretchable electronics with mechanical properties similar to that of human skin. Combined strategies in materials processing, mechanical design and device and circuit construction for architecturally engineered stretchable electronics will be discussed. Demonstrations include a wirelessly rechargeable lithium ion battery with a record reversible biaxial stretchability up to 300%, and a skin-mounted soft health monitoring system with multifunctional physiological signal sensing and wireless power and data transmission.

Selected Publications:

Sheng Xu,[1] Zheng Yan,[1] Kyung-In Jang,[1] Wen Huang,[2] Haoran Fu,[3,4] Jeonghyun Kim,[1,5] Zijun Wei,[1] Matthew Flavin,[1] Joselle McCracken,[6] Renhan Wang,[1] Adina Badea,[6] Yuhao Liu,[1] Dongqing Xiao,[6] Guoyan Zhou,[3,7] Jungwoo Lee,[1,5] Ha Uk Chung,[1] Huanyu Cheng,[1,3] Wen Ren,[6] Anthony Banks,[1] Xiuling Li,[2] Ungyu Paik,[5] Ralph G. Nuzzo,[1,6] Yonggang Huang,[3] Yihui Zhang,[3,8] John A. Rogers[1,2,6,9]

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"Assembly of micro/nanomaterials into complex, three-dimensional architectures by compressive buckling", Science, Vol. 347, No. 6218, 9 January 2015

ABSTRACT: 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. We report routes to previously inaccessible classes of 3D constructs in advanced materials, including device-grade silicon. 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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"Lateral buckling and mechanical stretchability of fractal interconnects partially bonded onto an elastomeric substrate", Applied Physics Letters, Vol. 106, 091902, 2015, http://dx.doi.org/10.1063/1.4913848
ABSTRACT: Fractal-inspired designs for interconnects that join rigid, functional devices can ensure mechanical integrity in stretchable electronic systems under extreme deformations. The bonding configuration of such interconnects with the elastomer substrate is crucial to the resulting deformation modes, and therefore the stretchability of the entire system. In this study, both theoretical and experimental analyses are performed for postbuckling of fractal serpentine interconnects partially bonded to the substrate. The deformation behaviors and the elastic stretchability of such systems are systematically explored, and compared to counterparts that are not bonded at all to the substrate.

Kyung-In Jang, Ha Uk Chung, Sheng Xu, Chi Hwan Lee, Haiwen Luan, Jaewoong Jeong, Huanyu Cheng, Gwang-Tae Kim, Sang Youn Han, Jung Woo Lee, [...], Jeahoon Chung, Byunggik Kim, Jean Won Kwak, Myoung Hee Yun, Jin Young Kim, Young Min Song, Ungyu Paik, Yihui Zhang, Yonggang Huang, John A Rogers , "Soft network composite materials with deterministic and bio-inspired designs", Nature Communications, 03/2015; 6:6566. DOI: 10.1038/ncomms7566
ABSTRACT: Hard and soft structural composites found in biology provide inspiration for the design of advanced synthetic materials. Many examples of bio-inspired hard materials can be found in the literature; far less attention has been devoted to soft systems. Here we introduce deterministic routes to low-modulus thin film materials with stress/strain responses that can be tailored precisely to match the non-linear properties of biological tissues, with application opportunities that range from soft biomedical devices to constructs for tissue engineering. The approach combines a low-modulus matrix with an open, stretchable network as a structural reinforcement that can yield classes of composites with a wide range of desired mechanical responses, including anisotropic, spatially heterogeneous, hierarchical and self-similar designs. Demonstrative application examples in thin, skin-mounted electrophysiological sensors with mechanics precisely matched to the human epidermis and in soft, hydrogel-based vehicles for triggered drug release suggest their broad potential uses in biomedical devices.