Massachusetts Institute of Technology

SMSD SEMINAR SERIES

Soft Materials Structures and Devices

Thursday, February 20th 2020, 4pm, Room 3-370

Architected materials with adaptive energy absorption & bioinspired self-adaptable materials

Prof. Sung Hoon Kang, *Johns Hopkins University*

In my presentation, I will first briefly introduce research projects in my group and focus on two studies about how we can realize materials/structures that can adapt to loading conditions by changing their mechanical properties.

An architected material (or metamaterial) is a class of materials that provide new properties that are not observed in natural materials or from a bulk material that the "material" is made of. I will present adaptive energy-absorbing "materials" with extreme energy dissipation and improving energy absorption with increasing strain rate by the interplay of nonlinear behaviors of materials and structures. We utilize energy dissipation mechanisms across different length scales by utilizing architected liquid crystalline elastomers (LCEs). As a result, our energy-absorbing materials show about an order of magnitude higher specific energy dissipation at quasi-static condition compared with the previous studies and even higher energy dissipation at faster strain rates with power-law relation, whose exponent can be tuned by controlling the mesoscale alignment of molecules using a simple strain control-based approach. The findings from our study can contribute to realizing extremely lightweight and high energy dissipating materials, which will be beneficial for various applications, including automotive, aerospace, and personal protection.

Nature produces outstanding materials for structural applications such as bones and woods that can adapt to their surrounding environment. For instance, bone regulates mineral quantity proportional to the amount of stress. It becomes stronger in locations subjected to higher mechanical loads. This leads to the formation of mechanically efficient structures for optimal biomechanical and energy-efficient performance. However, it has been a challenge for synthetic materials to change and adapt their structures and properties to address the changes in loading conditions. To address the challenge, we are inspired by the findings that bones are formed by the mineralization of ions from blood onto scaffolds. I will present a material system that triggers mineral deposition from ionic solutions on organic scaffolds upon mechanical loadings so that it can self-adapt to mechanical loadings. For example, the mineralization rate within the material system could be modulated by controlling the loading condition and a 30-180% increase in the modulus of the material was observed upon cyclic loadings whose range and rate of the property change could be modulated by varying the loading condition. We envision that our findings can open new strategies for making synthetic materials with self-adaptable mechanical properties.

Sung Hoon Kang is an Assistant Professor in the Department of Mechanical Engineering and is an associate faculty of Hopkins Extreme Materials Institute and Institute for NanoBioTechnology. He earned a PhD degree in Applied Physics at Harvard University and MS and BS degrees in Materials Science and Engineering from MIT and Seoul National University, respectively. Sung Hoon has been investigating bioinspired solutions to address the current challenges in synthetic materials and mechanical systems with applications including safety, healthcare, sensing, and energy. His research has been supported by NSF, AFOSR, NIH, ARO, and ONR. Throughout his career, Sung Hoon has co-authored 42 papers, has given ~120 presentations (including over 70 invited talks) and has three patents. His honors include 2019 China-America Frontiers of Engineering Symposium Alumnus, 2019 Johns Hopkins University Whiting School of Engineering Research Lab Excellence Award, FY 2018 Air Force Office of Scientific Research Young Investigator Program Award, 2016 National Academy of Engineering US Frontiers of Engineering Symposium Alumnus, and 2011 Materials Research Society Graduate Students Gold Award. He has been co-organizing ~30 symposia on mechanical metamaterials, bioinspired materials, and 3D printing at international conferences. He is a member of the American Society of Mechanical Engineers (ASME), Society of Engineering Science (SES), American Physical Society (APS), and Materials Research Society (MRS). He serves as the Chair of the ASME Technical Committee on Mechanics of Soft Materials.

Seminar Host: *Xuanhe Zhao (zhaox@mit.edu)*

Please join us for refreshments beforehand, outside Room 3-370

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