COLLEGE OF ENGINEERING
MECHANICAL ENGINEERING
UNIVERSITY OF MICHIGAN

ME Department Seminar

Folded and Crumpled Two -Dimensional Materials -Where Shape Enables New Functions

SungWoo Nam

Mechanical Science and Engineering,
University of Illinois at Urbana-Champaign

Tuesday, December 13, 2016
4:00 p.m.
1200 EECS

Abstract:

Meta-material, a synthetic material with a structure such that it exhibits properties not usually found in natural materials, enables innovations in various research fields, including optics, mechanics and electronics. This innovative concept can be extended to the thinnest materials system in the world, i.e., two-dimensional (2D) materials, to enable new materials properties and device functions. Here I present our work on folded and crumpled 2D materials for meta-materials and advanced sensors and actuators. First, I will introduce two unique fabrication approaches to enable folded and crumpled 2D materials: (1) a rapid and scalable method of creating crumpled graphene and MoS_2 monolayer surfaces by soft-matter transformation of shape-memory polymers, and (2) swelling/shrinking-induced crumpling process. Second, I will introduce a new class of meta-materials that are fabricated using these novel approaches, which exhibit a wide range of new material properties. I will present surface plasmonics enabled by crumpled topographies of graphene and will further discuss shape reconfigurability which opens the door to tunable plasmonic resonance of crumpled graphene. Furthermore, I will share our ongoing research efforts on strained superlattice for the modulation of electronic properties in 2D materials as well as strain gradient-induced flexoelectricity of crumpled 2D materials. Finally, I will present our work on strain-tunable, stretchable optoelectronics based on crumpled graphene. Our optoelectronic sensor is based exclusively on graphene and transforms the two dimensional material into three dimensional (3D) crumpled structures. This added dimensionality enhances the photoabsorption of graphene by increasing its areal density with a buckled 3D structure, which simultaneously improves device stretchability to 200% strain. Furthermore, we demonstrate a new concept of strain-tunable photoresponsivity where a 200% applied tensile strain results in 100% modulation in photoresponsivity. Our approach to forming folded and crumpled 2D materials offers a unique avenue for enabling new materials properties and engineering of advanced device functions.

Bio:

Dr. SungWoo Nam is an Assistant Professor in the Department of Mechanical Science and Engineering at University of Illinois at Urbana-Champaign (UIUC). He received a B.S. degree in Materials Science and Engineering from Seoul National University, South Korea, where he graduated summa cum laude with the Valedictorian Prize. Following 3 years of industry experience in carbon nanotube (CNT) manufacturing at ILJIN Nanotech Co., Ltd., he obtained his M.A. in Physics (2007) and Ph.D. in Applied Physics (2011) from Harvard University. Following the completion of his Ph.D., he worked as a postdoctoral scholar at the Department of Bioengineering at University of California, Berkeley. His current research program includes (i) investigating mechanically-driven self-assembly of 2D materials for advanced micro- and meso-scale meta-materials and structures, and (ii) exploring micro-/meso-scale structures for stretchable/flexible sensors and actuators. Dr. Nam is the recipient of the NSF CAREER Award, AFOSR Young Investigator Research Program (YIP) Award, NASA Early Career Faculty (ECF) Award, American Chemical Society (ACS) Petroleum Research Fund Doctoral New Investigator Award, and the UIUC Engineering Council Award for Excellence in Advising.