Materials Science & Engineering Seminar Series

Carnegie Mellon University
Materials Science & Engineering

presents

Mechanical Instability-driven Architecturing of Atomically-thin Materials – Where Shape Enables New Functions

SungWoo Nam, Ph.D.
Materials Science an Engineering, University of Illinois at Urbana-Champaign

ABSTRACT:
Mechanical deformations, such as buckling, crumpling, wrinkling, collapsing, and delamination, are usually considered threats to mechanical integrity which are to be avoided or reduced in the design of materials and structures. However, if materials systems and applied stresses are carefully controlled, such mechanical instabilities can be tailored to deterministically create functional morphologies that can enable powerful new functions. In particular, in atomically-thin material systems with ultralow bending stiffness, such as graphene, mechanical deformations enable new structural properties and device-level functionalities which surpass the limits of bulk material systems. In this talk, I will present our work on controlled deformation and straining of atomically-thin materials, and the emergent materials properties and applications of such deformed and strained atomically-thin materials. First, I will introduce two unique fabrication approaches to enable controlled deformation of atomically-thin materials. Second, I will introduce a wide range of new material properties enabled by the new class of 'architectured atomically-thin materials'. I will discuss the 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. In addition, I will share our ongoing research efforts on strained superlattice for the modulation of electronic properties. Third and last, I will present our work on adaptive/conformal and multifunctional electronics based on mechanically deformed atomically-thin materials. 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 and furthermore enables strain-tunable photoresponsivity. Our approach to forming architectured atomically-thin materials offers a unique avenue for enabling new materials properties and engineering of advanced device functions.

BIOGRAPHY:

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 mechanical instability-driven self-assembly and patterning 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, UIUC Engineering Dean's Award for Excellence in Research, and UIUC Engineering Council Award for Excellence in Advising.

Doherty Hall 2315, 11:30AM
Friday, April 7, 2017