The Department of Mechanical Engineering/College of Engineering and Applied Sciences
Stony Brook University

Mechanical Engineering Seminar

M. Zubaer Hossain
Division of Engineering and Applied Science
California Institute of Technology

Lecture Title: Multiscale implications of heterogeneity in solids

Friday, April 11, 2014 at 2 PM, Room 173 Light Engineering Building

Abstract

Heterogeneity is ubiquitous in almost all solids at some length scales. Both in classical and quantum mechanical regimes, it is however a challenging task to determine its macroscopic effect on fundamental material properties and processes, mainly due to the involvement of multiple phenomena and length scales. Consequently, mechanisms that arise solely from careful consideration of the minute details of heterogeneities remain indeterminable under traditional single scale analyses. To transcend such limitations, this talk will discuss two multiscale modeling efforts (one in the classical regime and another in the quantum regime) and demonstrate the implications of heterogeneities on macroscopic behavior of solids that are intractable under simplifying approximations. The first part of the talk will describe a computational approach to determine macroscopic toughness of heterogeneous solids containing arbitrary sources of singularities and inhomogeneity. Using the fundamental description of energy-momentum tensor and a *surfing boundary condition*, the study reveals that macroscopic toughness is different from the weighted surface area of the crack set in heterogeneous media. It also indicates that elastic heterogeneity alone can have a profound influence on enhancing macroscopic toughness and creating toughening asymmetry. The findings provide critical insights for designing tougher materials with applications in energy and military products. The second part of the talk will demonstrate a multiscale approach in the quantum regime (combining density functional theory and finite element calculations) to examine the influence of material and strain heterogeneity on energy absorption ability of alloy quantum dot (QD) solar cells. This investigation unveils a new variable in the design space for providing low-cost solution to solar cells with improved absorption efficiency using mismatch-induced strain, applied at the QD-substrate heterointerface.

Biography

M. Zubaer Hossain is currently a Postdoctoral Scholar in the Division of Engineering and Applied Science at California Institute of Technology. He also worked as a Visiting Scientist in the Physical & Life Sciences Directorate at Lawrence Livermore National Laboratory in 2012. He obtained his Ph.D. degree in mechanical engineering in 2011 from the University of Illinois at Urbana-Champaign (UIUC), and his research interests involve understanding the mechanics of energy transport and failure in heterogeneous solids and nanostructured materials. He is the recipient of multiple awards and fellowships including an APS-Energy Travel Grant Award in 2013, an AVS Travel Fellowship in 2012, an NSF Travel Fellowship Award in 2010, the UIUC ExxonMobil Fellowship in 2010, and the UIUC MechSE Teaching Fellowship in 2007. He is a member of ASME, MRS, APS, TMS and SES.

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