MAR12-2011-020065

Abstract for an Invited Paper
for the MAR12 Meeting of
the American Physical Society

Failure of molecules, bones, and the Earth itself

SINAN KETEN, Northwestern University

Materials fail by recurring rupture and shearing of interatomic bonds at microscopic, molecular scales, leading to disintegration of matter at macroscale, and a loss of function. In this talk, the state-of-the-art of investigations on failure mechanisms in materials will be presented, in particular focusing on atomistic origin of deformation and fracture, and the relationships between molecular mechanics and macroscale behavior. Simple examples of fracture phenomena are used to illustrate the significance and impact of material failure on our daily lives. Based on case studies, mechanisms of failure of a wide range of materials are discussed, ranging from tectonic plates to rupture of single molecules, and an explanation on how atomistic simulation can be used to complement experimental studies and theory to provide a novel viewpoint in the analysis of complex systems is provided. Biological protein materials are used to illustrate how extraordinary properties are achieved through the utilization of intricate structures where the interplay of weak and strong chemical bonds, size and confinement effects, and hierarchical features play a fundamental role. This leads to a discussion of how even the most robust biological material systems fail, leading to diseases that arise from structural and mechanical alterations at molecular, cellular, and tissue levels. New research directions in the field of materials failure and materials science are discussed and the impact of improving the current understanding of materials failure for applications in nanotechnology, biotechnology, medicine as well as the built environment.