Structural Mechanics Seminar Series

Rethinking Plasticity Theory for Crystalline Solids

John. L. Bassani
Department of Mechanical Engineering and Applied Mechanics
University of Pennsylvania
Friday, March 30 at 2:00PM
MRDC Building, Room 4211

Host: Jianmin Qu, ME

http://www.me.gatech.edu/SMSS

ABSTRACT

The structure of classical plasticity theory, whether applied to single crystals or to the effective behavior of polycrystals, is generally assumed to be *associative* in the sense that the flow potential is taken to be the yield function. As Hill noted in 1950, to a large extent this choice is a matter of convenience, particularly as it gives rise to certain variational principles and uniqueness theorems, and perhaps at that time justified by a lack of contradictory evidence. But not quite, as G. I. Taylor recognized as early as 1926 that BCC iron and brass behave quite differently than FCC aluminum and copper. The root of these differences also arises in granular materials, which also do not follow an associative flow rule. Ample experimental evidence now exists, but not until atomistic simulations became sufficiently refined have we been in a position to rigorously addresses the issue of non-associated flow in crystals undergoing plastic deformation by the mechanism of dislocation glide. In 1985 A. Cottrell remarked: "... for too long we have taken the FCC dislocation as the paradigm of all dislocation behavior; but, as the studies of BCC screw dislocations have shown, the *FCC structures and properties are the exception rather than the norm*." Issues that arise at various scales are discussed in this lecture. Atomistic simulations are used to construct multislip models of plastic flow in single crystals, and then polycrystal behavior is estimated using simple homogenization techniques. Even for random polycrystals, the effective behavior is generally of the *non-associated flow* type, and this is shown to significantly affect macroscopic deformations and failure mechanisms. In addition, we discovered that intermittent bursts of strain can arise as a consequence of non-associated flow, and there is experimental evidence for such behavior.

BIO-SKETCH

Dr. John L. Bassani is the Richard H. and S. L. Gabel Professor of Mechanical Engineering at University of Pennsylvania. He received a B.S. in Mechanical Engineering (1973) from Lehigh University, a M.S. in Applied Mechanics (1975) from Lehigh University and Ph.D. in Engineering (1978) from Harvard University. He also holds appointments in Materials Science and Engineering, the Laboratory for Research on the Structure of Matter, and the Institute of Medicine and Engineering at Penn. He is the recipient of the Presidential Young Investigator Award (1984-1989), Fellow of the American Society of Mechanical Engineers, Midwest Mechanics Lecturer (2001-2002), and on the Board of Directors of the Society of Engineering Science (2002-2009) and Chair Elect of SES (2008). He has served on the editorial boards of

Modelling and Simulation in Materials Science and Engineering (1992-2000), *Interface Science* (since 1993), *Journal of Applied Mechanics* (Assoc. Tech. Ed., 1996-2000), and *Mechanics of Materials*, Elsevier (Honorary Scientific Advisory Board). Professor Bassani's research interests include: the relationship between properties of discrete and continuous media; interfacial mechanics; formation and properties of nanostructures; mechanics of living cells; plastic deformation of crystals; non-local plasticity theory; mechanics of fracture and fatigue; and material stability and localized deformation.

If you are interested in meeting Dr. Bassani, please contact Jianmin Qu at jianmin.qu@me.gatech.edu or Cecelia Jones at cecelia.jones@me.gatech.edu