Correlating dislocation behavior with macroscopic mechanical properties directly in the TEM through use of a novel tensile test device

Ian Robertson, Taher Saif, Khalid Hattar and J. Han
Department of Materials Science and Engineering,
University of Illinois at Urbana-Champaign

Dislocations and their interactions with other microstructural features, such as impurity atoms, precipitates, dislocations, and grain boundaries are known to determine the mechanical properties of metallic systems. However, no clear methodology exists to transfer this information from the atomic scale and the mesoscale into a constitutive model that can predict the macroscopic mechanical response especially in the transition region between elastic and plastic behavior. The ideal model should incorporate the behavior at different length and time scales within one grand multi-scale scheme. Such a scheme is, however, impractical and lower length scale models are used to provide fundamental information to serve as the foundation for the development of the next higher length scale. What is needed is identification of the controlling deformation processes at different length and time scales. *In situ* TEM straining experiments can in part address this need.

In this talk, I will describe recent advances in straining stage designs that for the first time permit observation of the microscopic processes and simultaneous measurement of the macroscopic stress strain response. The sample used in this device has a uniform thickness and cross-sectional area and, through the inclusion of u-springs, loads the specimen in uniaxial tension. I will illustrate how *in situ* TEM straining can be combined with large-scale molecular dynamics simulations to provide a fundamental understanding of the interactions between glissile dislocations and obstacles, and how this information has been used to develop macroscale constitutive models that predict the mechanical response of materials.