Quantitative in-situ nanoindentation in the TEM

Eric A. Stach,[1] A.M. Minor,[2] Z. Shan,2 S.A. Syed Asif,[3] E. Cyrankowski,[3] T.J. Wyrobek,[3] and O.L. Warren[3]

[1]School of Materials Engineering, Purdue University, West Lafayette, IN 47906
[2]National Center for Electron Microscopy, Lawrence Berkeley National Laboratory, Berkeley, CA 94720
[3]Hysitron Incorporated, Minneapolis, MN, 55344

Nanoindentation is widely accepted as the preferred technique to study localized mechanical deformation phenomena in materials. However, the mechanisms of deformation can only be inferred from the load-displacement data obtained during a typical instrumented nanoindentation test. In order to elucidate the underlying physics of these processes, we have spent the past several years developing and exploiting the technique of in-situ nanoindentation in a transmission electron microscope (TEM). In this technique, a voltage-actuated piezoceramic tube is used to position a sharp diamond in plane with the edge of an electron transparent sample. The tip is driven into the material in order to induce deformation and the corresponding deformation is observed in real time and at high spatial resolution. Recently, we have incorporated a miniature capacitive transducer into the system, thereby permitting high-resolution measurements of the load-displacement response (resolution of $< 0.5\mu N$ in load, < 1 nm in displacement) to be directly correlated with real-time diffraction contrast images obtained during indentation. I will report on initial results from this quantitative system, with a specific emphasis on the new physics that it reveals, as well as the ways that it has forced us to re-evaluate some of our prior conclusions based solely on qualitative studies.