Size Effect in Contact Compression of Nano- and Micro-scale Pyramid Structures

J. Wang[1], J. Lian[1], J.R. Greer[2], W. D. Nix[2], K.-S. Kim[3]

[1] Department of Mechanical Engineering
University of California
Riverside, CA 92521
wang@engr.ucr.edu

[2] Department of Materials Science and Engineering
Stanford University
Stanford, CA 94305

[3] Division of Engineering
Brown University
Providence, RI 02912

Advances in microelectronics and nanotechnology enabled the development of ever-smaller micro and nanoelectromechanical systems. When materials and structures are scaled down from tens of micron to a fraction of a micron, many of their properties become size-dependent. This phenomenon has motivated a large effort in the science community to develop both experiments and theories to investigate the material behavior at micron and nanometer scales. In this work, an electro-chemical etching induced self-assembly was used to produce micron and nanometer scale pyramid structures on (100) surfaces of gold. Using the unique characteristics of self-similar pyramid structures, contact compression experiments on the pyramids were carried out to study the size effect in the contact pressure of the plastically deformed pyramids. The pressure-displacement data obtained from experiments clearly demonstrate a characteristic length scale. The self-similar nature of the pyramids and the resulting size-dependent compression behavior provide valuable experimental evidence for exploring size-dependent material behavior at small length scales. They can also be used to test the validity of various plasticity theories which can be utilized to address this phenomenon.