# Modeling micron-scale compression molding

Christian F. Niordson[1], Kim L. Nielsen[1], Bin Zhang[2], Wen J. Meng[2], John W. Hutchinson[3]

[1] Department of Mechanical Engineering, Technical University of Denmark
[2] Department of Mechanical and Industrial Engineering, Louisiana State University
[3] School of Engineering and Applied Sciences, Harvard University

Micron-scale metal forming is highly influenced by material size effects due to plastic strain gradients. While compression molding with characteristic feature sizes above about 100 microns exhibits intrinsic size-effects mainly through the Hall-Petch relation, molding with smaller feature sizes is explicitly affected by hardening due to plastic strain gradients and related geometrically necessary dislocations. Recent experimental studies have shown how the characteristic molding pressure increases with decreasing feature size. While this effect is well modelled using strain gradient plasticity theory, capturing the details of the imprinted features in terms of their sharpness has proven challenging. The present study demonstrates how a finite strain version of Gudmundson's strain gradient plasticity theory can capture the size effects in compression molding of copper in terms of the characteristic pressure. However, the feature geometry is poorly represented by the plastic flow model alone, leading for example to difficulties in accurately assessing the contact pressure between the punch and the molded material. It is argued that plastic damage and the creation of new surface is essential in compression molding of sharp features on the micron-scale, and a simple shear cohesive zone model is proposed in order to improve modeling capabilities.