LENGTH-SCALE DEPENDENT DEFORMATION BEHAVIOR OF NANOLAYERED CU-BASED MICROPILLARS

Gang Liu, Jin-Yu Zhang, Jun Sun
State Key Laboratory for Mechanical Behavior of Materials, Xi’an Jiaotong University, Xi’an 710049, People’s Republic of China

By using microcompression methodology, deformation of nanolayered crystal/crystal (C/C) Cu/Zr and Cu/ Cr, and crystal/amorphous (C/A) Cu/CuZr micropillars was systematically investigated within wide ranges of intrinsic layer thickness (5 – 150 nm) and extrinsic sample diameter (300 – 1500 nm). The intrinsic size effect, extrinsic size effect and their interplay were respectively revealed. Competition between the intrinsic and extrinsic size effects leads to a common experimental observation of a critical layer thickness of about 20 nm, above which the deformation is predominantly intrinsic-size-related and insensitive to sample size, while below which the two size effects are comparable. The underlying deformation mechanisms are proposed to transform from bulk-like to small-volume materials behavior. Deformation mode is correspondingly transited from homogeneous extrusion/barreling to inhomogeneous shear banding, and the two competing modes coexist in the layer thickness range from about 50 to 20 nm. Besides these generalities, specific deformation features of the C/C and C/A micropillars are respectively discussed. In particular, deformation-induced devitrification in the amorphous layers promotes an extraordinary plasticity in the C/A micropillars, which provides a viable route to enhance the controllability of plastic deformation in metallic glassy composites. A deformation mode map is further developed to clearly elucidate the coupling intrinsic and extrinsic size effects on the deformation mode of nanolayered micropillars.