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TEM Characterization of Deformation and Failure Mechanisms in 40 nm and 5nm Cu/Nb Nanolayed Micro Compression Pillars

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Cu/Nb nanolayered composites have recently been shown to possess interfacial characteristics that render them resistant to ion irradiation damage. The ability of interfaces to act as sinks for defects such as dislocations also provides for enhanced mechanical behavior. In our recent work, Cu/Nb nanoscale multilayered composites have shown ultra-high strength as well as high ductility using a variety of mechanical test methods (nanoindentation, tensile testing, and micropillar compression). In this presentation, we will examine, via transmission electron microscopy (TEM), the post deformation microstructures of micropillars that have been created by focused ion beam (FIB) milling with individual layer thicknesses of 40 nm and 5 nm. Deformation microstructure of micropillars of both layer thicknesses with layer interfaces that are perpendicular, parallel, and at 45 degrees with respect to the cylinder axis and compression direction will be examined and compared.

Formation of shear bands, as well as homogeneous deformation of over 10% true strain, are evident at individual layer thicknesses as low as 5 nm. The microstructure within the shear band exhibits large plastic deformation and grain rotation relative to the compression axis, and the layered structure remains continuous even after local strains in excess of 70%. Plastic behavior of these materials at large plastic strains will be discussed in terms of interfacial effects on dislocation motion. Total plasticity to failure in nanoscale multilayered composites was limited only by the onset of instability due to mechanical testing geometry.

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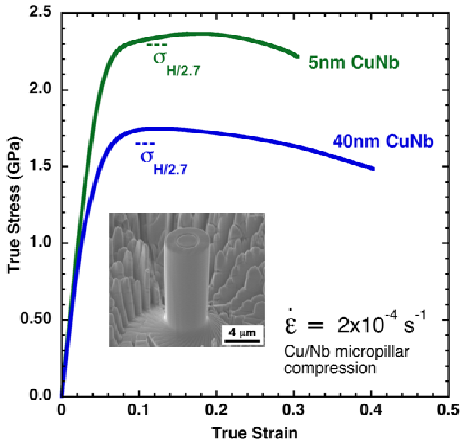
Figures:



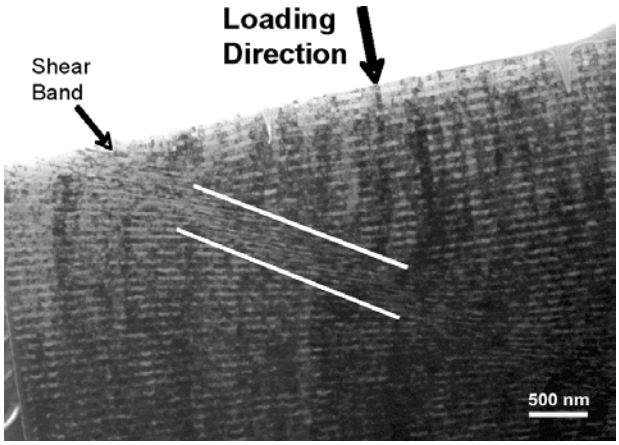


Figure 1 (left): Compression curves for 40 nm and 5 nm Cu/Nb multilayers. **Inset:** SEM micrograph of micropillar of 5 nm Cu/Nb multilayer in the as-prepared condition. Pillar height is 8 microns, and diameter is 4 microns. Layer interfaces are perpendicular to the long axis of the micropillar.
Figure 2 (right): Shear band in 40 nm CuNb multilayers. The layer interfaces are again perpendicular to long axis of the micropillar and the compression direction.

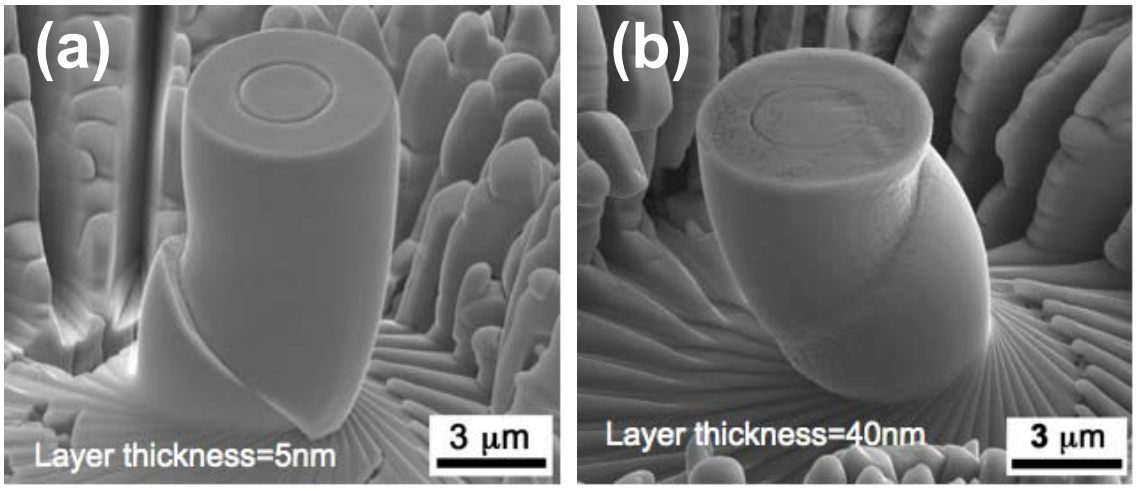


Figure 3: SEM micrographs of micropillars after compression. **(a) 5** nm Cu/Nb multilayer underwent 25% true strain before failing at the shear surface shown. **(b)** 40 nm multilayer deformed to 35% true compressive strain with failure in shear without fracture

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