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Title: THE EFFECTS OF LENGTH SCALE ON THE DEFORMATION BEHAVIOR OF METALLIC MULTILAYERS-PART II: MODELING

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The Effect of Length Scale on the Deformation Behavior of Metallic Multilayers--Part II: Modeling

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Abstract Body:
The experimental observations described in a companion presentation of the same title by Misra et al. highlight that unique, non-bulk rolling textures are achieved in nanoscale multilayered thin films. Specifically, Cu/Nb multilayers deposited with an initial Kudjumov-Sachs orientation relation between Cu and Nb grains and with an initial individual layer thickness of 75nm preserve that relation during rolling. In contrast, samples with micron-scale individual layer thickness do not. To help understand this layer-dependent response, a crystal plasticity model is presented in which the Cu and Nb phases respond by slip on {111}/<110> systems in the fcc Cu case, and {110}/<111> systems in the bcc Nb phase. Grains within each layered phase are required to plastically deform by a reduction in thickness and corresponding elongation in the rolling direction, with zero plastic strain along the transverse axis. The model also adopts the observation for nano-scale multilayers that the Kudjumov-Sachs orientation relation is preserved; in particular, the <111> Cu and <110> Nb directions remain parallel to the interface normal during rolling. The crystal plasticity model then furnishes the minimum plastic work to deform a grain, as a function of grain orientation. For Cu grains, the plastic work is invariant of grain orientation, provided the critical resolved shear stress is uniform on all fcc slip systems. However, the corresponding plastic work in Nb grains is very dependent on grain orientation and has a strong minimum. This large anisotropy serves as a driving force for Nb grains to rotate around their <110> interface normal, toward the minimum. The resulting prediction for rolling texture in Nb layers agrees well with experimental observations in nanoscale Cu/Nb multilayers.