Physics-based and Experimentally Supported Plasticity of Very Thin Metallic Films

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Abstract

The lecture summarizes some of the recent advances in experimentally-based dislocation models of slip-induced plasticity of fcc and bcc crystals, including rate and temperature effects, showing that the length scales emerge as integral parts of such physics-based model, while the sample-size effect, observed in thin metallic films, is a problem-dependent issue that may or may not relate to the dislocations-based length scales. I will show by illustrative examples that the experimentally observed increase in the yield stress of very thin metallic membranes most likely is due to the variation of grain orientations through the thickness of the membrane, which effect is generally insignificant when there is a sufficient number of interior crystals through the membrane thickness. I will suggest that the dislocations-based crystal plasticity models can account for such size effects and I will support this suggestion by comparing the results of my calculations with experimental data on very thin films published by others. In addition, I will show by illustrative examples that, using the physics-based model of crystal plasticity, one can directly and unambiguously calculate all simultaneously active slip systems in a crystal, e.g., as many as up to 24 active slip systems in tantalum (a bcc crystal), and 8 in copper (an fcc crystal).