Mechanical Engineering Doctoral Defense

Investigating the mechanical behavior and deformation mechanisms of ultrafine-grained metal films using ex-situ and in-situ TEM techniques

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abstract

Nanocrystalline (NC) and Ultrafine-grained (UFG) thin films exhibit a wide range of enhanced mechanical properties compared to their coarse-grained counterparts. These properties, such as very high strength, primarily arise from the change in the underlying deformation mechanisms. Experimental and simulation studies have shown that because of the small grain size conventional dislocation plasticity is curtailed in these materials and grain boundary mediated mechanisms become more important. Although the deformation behavior and the underlying mechanisms in these materials have been investigated in depth, relatively little attention has been focused on the inhomogeneous nature of their microstructure (originating from the texture of the film) and its influence on their macroscopic response. Furthermore, the rate dependency of mechanical response in NC/UFG metal films with different textures has not been systematically investigated. The objectives of this dissertation can be divided into two distinct parts. The unifying thread between these goals is to expand the understanding of the deformation behavior of NC/UFG metals and to enhance the characterization techniques to investigate the behavior of thin metal films. The first objective is to carry out a systematic investigation into mechanical behavior of the NC/UFG thin films with different textures under different loading rates. This includes a novel approach to study the effect of texture-induced plastic anisotropy on mechanical behavior of the films. Efforts will be made to correlate the behavior of UFG metal films and the underlying deformation mechanism. The second objective is to understand the deformation mechanisms of UFG aluminum films using in situ TEM experiments with Automated Crystal Orientation Mapping. This technique enables us to investigate grain rotations in the UFG Al films and to monitor the microstructural changes in these films during deformation. This will help reveal detailed information about the deformation mechanisms prevalent in UFG metal films.

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