Inelastic Deformation Polycrystalline Thin Films and Lines

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We have characterized inelastic deformation of polycrystalline metallic films using *in-situ* Transmission Electron Microscopy (TEM), and *ex-situ* substrate curvature measurements during heating, cooling, and isothermal anneals. In-situ TEM studies were made possible through the use of micromachined silicon membranes. We have demonstrated that uncapped Ag and Cu films undergo rapid diffusional creep at temperatures as low as $0.25T_m$, where T_m is the melting temperature in degrees Kelvin. The temperature at which creep is rapid, decreases with decreasing film thickness. This can lead to a decrease in the flow stress observed at room temperature as the film thickness is decreased. We have also demonstrated that dislocation-mediated plasticity dominates in capped films, or in uncapped films that are thicker or deformed at lower temperatures. We have shown that dislocation-mediated plasticity is thermally activated, and is controlled by pinning due to obstacles whose spacing is small compared to the film thickness and the grain size. This leads to the high flow stresses often observed in capped thin films. We have seen similar effects to those described above, in Cu films patterned into lines through a damascene process. This work demonstrates that the inelastic properties of polycrystalline metallic films depend strongly on the film dimension, the surface condition of the film, and temperature.

We are currently investigating the use of micromachined cantilevers for isothermal study of deformation of thin films and films patterned into dots.