ABSTRACT

The Role of Surface and Interface Diffusion in Nanoscale Plasticity

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Defect-free metal nanoparticles of sub-micometer dimension represent convenient model system for studying the nucleation-controlled plastic deformation. They deform elastically up to the critical stress comparable to the theoretical strength of respective metal, followed by an abrupt plastic collapse. We illustrate the ultrahigh strength of Ag, Ag-Au, and Pt nanoparticles by performing in-situ microcompression tests on the particles fabricated by solid state dewetting [1–3]. The activation volume associated with dislocation nucleation is only a fraction of atomic volume, pointing on the role of vacancies and surface diffusion in nucleation of dislocations [2]. Furthermore, we proposed a model based on stress-induced surface/interface diffusion and demonstrated that diffusion-cotrolled room temperature plasticity is only possible in the nanoparticles smaller than about 10 nm in size [1]. By performing a mass compression of Pt particles we demonstrated that their lattice rotates during the deformation [4]. This rotation cannot be caused by dislocation slip alone. We developed a model based on a combination of dislocation slip and interface diffusion demonstrating that room temperature short circuit diffusion is an important factor in plasticity of supported metal particles of micrometer dimensions.

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