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Twinning-Mediated Plastic Deformation in Au Nanowhiskers

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We have tested Au nanowires with diameters between 30 and 500 nm in tension inside a dual beam SEM/FIB. The nanowires are single crystal with [110]-orientation, and virtually free of defects. The stress-strain data show strengths exceeding 1 GPa and plastic strains of about 10% without a strong size dependence in the regime investigated. The in situ SEM and subsequent TEM observations reveal that the deformation is governed by twinning. This is in contrast to bulk fcc metals, where twinning is only observed at very low temperatures or at very high strain rates. These observations are compared to molecular dynamics simulations, which identified two different modes of twin propagation. The propensity for twinning depends critically on the orientation of the loading axis, whereas the mode of twinning depends on the ease of partial dislocation nucleation at the surfaces as well as obstacles to twin propagation. It is argued that the statistical distribution of small flaws at the surface can influence these mechanisms and thus lead to the experimentally observed large scatter in strength.

Keywords: twinning;nanowires;theoretical strength;molecular dynamics;

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