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Quantitative Characterization of Particle Rotations During Plastic Deformation of Two Wrought Aluminum Alloys

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Particle fracture is an important void nucleation mode in numerous alloys where fracture is governed by void nucleation and growth processes. The rotations of brittle phase inclusions/particles can facilitate particle cracking (and therefore, void nucleation) by bringing the inclusions/particles in favorable orientations with respect to the applied/induced tensile load, thereby increasing the void nucleation rate. Experimental evidence is presented to show that significant rotations of brittle phase inclusions of a Fe-rich intermetallic phase occur during plastic deformation of 6061 (T6) and 5086(O) wrought Al-alloys. The particle rotations are quantitatively characterized, for uniaxial tension, compression, torsion, and notch-tension test specimens strained to different strain levels. The particle rotations are monitored by measuring the morphological orientation distribution function of the particles. Significant particle rotations occur under all loading conditions. The morphological orientation distribution function evolves with plastic strain under uniaxial tension, compression, and torsion. The particles tend to align themselves in the direction parallel to applied (or induced) tensile stress for deformation under tension and compression, and they tend to align at an angle of 45 degrees to torsion axis for deformation under torsion. The particle rotations can be rationalized on the basis of crystal plasticity theory. Although particle rotations are observed in 5086(O) and 6061(T6), the extent of particle cracking damage is different in the two alloys. These differences are explained on the basis of the microstructure and constitutive behavior of the two alloys

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