Society of Engineering Science 51st Annual Technical Meeting

1–3 October 2014

Purdue University, West Lafayette, Indiana, USA

Lattice strain evolution in polycrystalline materials and comparison to advanced diffraction measurements

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ABSTRACT

Because of the inhomogeneity in the polycrystalline materials, the nontrivial grain-to-grain and phase-to-phase interaction effects change the deformation behavior of individual grain. By using slip-based crystal plasticity theory, the lattice strain evolution of specific orientation can be evaluated and compared with the experimental observation by advanced diffraction measurements. In a recent in-situ two-dimensional X-ray diffraction test of Ni-based super alloy, the distribution of lattice strain near a round edge notch has been mapped out in a fatigue test. A continuum model is developed to observe the stress distribution near the crack tip and provide a stress/strain distribution and history near the crack tip, which is used as the load input profile in the RVE polycrystalline model. By comparing the lattice strain evolution with diffraction measurements, the intergranular strain effects can be clearly indicated with the strain partition observed in the simulation results. Another simulation based on multiple phases high strength steel is performed to further evaluate the intergranular interaction effects. The multiple phases steel have been investigated to improve the stress-elongation balance and the lattice strain evolution under a tensile loading is tested by in-situ neutron diffraction measurements. The lattice strain partition in three stages is observed in both measurement and simulation and indicates an intergranular interaction existing in the multiple phases steel model.