

Using finite element analysis and synchrotron x-ray diffraction to understand stress distributions in deforming polycrystals

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High energy x-ray sources combined with new sophisticated data reduction methodologies are enabling the measurement of complex deformation processes within metallic polycrystals. These experimental results, when coupled with multiscale modeling formulations, have the potential to build understanding of important micromechanical processes such as fatigue crack initiation, recrystallization and phase transformations. This talk describes such a hybrid approach created to understand deformation partitioning in sintered copper. The experiments employ synchrotron x-ray diffraction combined with in-situ mechanical loading to measure lattice Strain Pole Figures (SPFs) for an aggregate of crystals. Our group has developed a method, based on quantitative texture analysis, for inverting the SPFs for the lattice strain distribution function and crystal stress distribution within the aggregate. The simulation environment consists of a restricted slip polycrystal plasticity formulation with each crystal in the aggregate discretized using finite elements. Trends in the distribution of stress over orientation space measured in the experiment and calculated using the model are compared directly using spherical harmonic expansions of each stress component. Even though the macroscopic stress state is uniaxial, multiaxial stress states arise at many orientations within the aggregate with both magnitude and direction of stress varying significantly.