Observation of Dislocation Dynamics in a Nickel-Base Superalloy using Transmission Scanning Electron Microscopy

P.G. Callahan\textsuperscript{1}, J.C. Stinville\textsuperscript{1}, E.R. Yao\textsuperscript{1}, J. Shin\textsuperscript{1}, F. Wang\textsuperscript{1}, M.P. Echlin\textsuperscript{1}, M De Graef\textsuperscript{2}, D.S. Gianola\textsuperscript{1}, T.M. Pollock\textsuperscript{1}

\textsuperscript{1}University of California Santa Barbara, Santa Barbara, CA
\textsuperscript{2}Carnegie Mellon University, Pittsburgh, PA

First we will consider the capabilities of transmission scanning electron microscopy (TSEM), which is transmission imaging in a FEG scanning electron microscope (SEM) equipped with a scanning transmission electron microscopy (STEM) detector. Imaging modes that are similar to conventional TEM (CTEM) bright field (BF) and dark field (DF) and STEM are explored, and some of the differences due to the lower accelerating voltages used in an SEM are highlighted. Defect images for the TSEM configuration were simulated using a scattering matrix formulation to study the diffraction contrast in the SEM and compare it to diffraction contrast in the TEM.

Then we will show how we have used TSEM to observe dislocation evolution during in-situ mechanical tests on micro-tensile specimens of a polycrystalline nickel-base superalloy. We will focus on how oligocrystals were extracted from targeted regions of a bulk sample and prepared for microscale mechanical testing, all of which is enable by the use of a FIB-SEM. The observations were correlated with intermittencies measured during plastic flow and recorded with high load- and temporal-resolution sensors. This investigation focused on the dislocation behavior near twin boundaries with certain slip configurations. Several deformation mechanisms at the dislocation scale were observed within individual slip bands, including precipitate shearing, dislocation decorrelation, and APB-coupled shearing. These processes affect strain localization near twin boundaries and can provide new defect-level insights on strain localization and fatigue crack initiation in these alloys.