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# High energy diffraction microscopy studies of fatigue and failure in superalloys

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## ABSTRACT

High Energy X-ray Diffraction Microscopy (HEDM) is a suite of synchrotron-based measurement techniques that probe structural responses in bulk polycrystals on the grain and subgrain length scales and do so nondestructively. Near-field HEDM yields three-dimensional maps of crystal lattice orientations including intragranular variations with a spatial resolution of ~2 micron and orientation resolution of 0.1 degree. Far-field HEDM adds strain sensitivity with <1e–4 resolution, grain center-of-mass positions, and minority phase detection. Absorption or phase contrast computed tomography yields density contrast that can be used to detect voids, cracks, and micron scale sample deformation. With advanced instrumentation, these measurements can all be performed essentially simultaneously and during in-situ loading. This discussion will illustrate, through studies of fatigue fracture surfaces and crack formation in nickel superalloys, the power as well as limitations of multimodal high energy X-ray measurements. As a case study, measurements have been performed on two pins extracted from overlapping regions of the two fracture surfaces of a failed specimen. We have reassembled the two pieces (virtually) so that microstructural characteristics of the fracture surface can be studied. Inter- and transgranular regions of the fracture are identified and characterized. Deformation levels in grains, sensed through orientation variations, are compared as a function of distance from the fracture; the grain-to-grain dispersion is found to be large compared to any trend in the average. This study motivates proposed new measurements using in-situ loading and using both nf- and ff-HEDM combined with tomography.