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Microstructure-based approach for predicting low-cycle fatigue in metals

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Summary

Fatigue in engineering materials has been the subject of intense study for decades. There exists a large body of empirical knowledge and engineering models of fatigue. However, our understanding of the fundamental mechanisms, initiation, and early stages of fatigue, especially at the microstructural scale, is less mature.

This study examines the elasto-plastic response of materials microstructures under low-cycle fatigue conditions by directly combining computational and experimental methods. The microstructure morphology, crystallography and deformation behavior of nickel polycrystals were characterized using electron-backscattered diffraction (EBSD), and a finite element simulation of the deformation was performed using a crystal plasticity constitutive treatment. The agreement between experiment and simulation was good when viewed at a sufficiently coarse scale, but a closer examination of microstructure-scale behavior revealed significant discrepancies in the local mechanical response. In this sense, the degree of agreement between experiment and simulation differed depending upon the length scale of the comparison.

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