Grain boundary network evolution studies: 3D parameterization from 2D sections

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Abstract

Microstructure evolution during the life-cycle of a material impacts the structural stability and performance of many modern materials. Critically grain boundaries are most sensitive to changing conditions and are arguably the initiation sites of microstructure evolution. Furthermore, they influence material properties not only through grain size but also through the expression in their 5 macroscopic degrees of freedom because they can exist in multiple stable/metastable structures or complexions. Grain boundary network characterization of textured poly-crystalline samples requires derivation from 3 dimensional (3D) microstructural data such as 3D synchrotron-based or X-ray tomography methods. Yet a 2D method, accessible in most laboratories would facilitate wider and less expensive access to 3D microstructural characterization. Consequently, we test the applicability of stereological approaches to a textured poly-crystalline sample synthetically generated using Dream3D. The simulated microstructure serves as the ground truth and is subsequently analyzed on 3 orthogonal sides as if using EBSD orientation mapping. We observe that combining grain morphology information from 3 orthogonal sides provides the average 3D GBPD for textured samples. We present a grain boundary character distribution study evaluating the evolution of grain boundaries during normal grain growth and compare this to the grain boundary evolution during experimentally induced dislocation-assisted grain boundary sliding (disGBS). Our results suggest that the rate of deformation is controlled by the assimilation of dislocations into grain boundaries and that the dislocation types interacting with grain boundaries govern which specific type of grain boundaries form, we will place this in context with our simulation-based study.

Keywords: Grain boundary character, grain boundary plane, Dream3D, microstructure evolution, grain morphology

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