Synthetic Three-Dimensional Polycrystals for Improved Ultrasonic Scattering Models

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Ultrasonic methods are increasingly used to characterize microstructures of polycrystalline materials. The robustness of such approaches relies on ultrasonic scattering models that include the measurement system parameters. More importantly, the interaction of the waves with microstructural features governs the scattering such that precise details of the microstructure are needed. Current diffuse ultrasonic backscatter models include several assumptions about the macroscopic and microscopic properties of the polycrystals. Recently, synthetic three-dimensional polycrystals, created using DREAM.3D, have been used to investigate the influence of microstructure on ultrasound propagation. These results are first reviewed with respect to grain size and the grain-size distribution. The results clearly show the importance of the two-point spatial correlation function and the limitations of this approach are reviewed. Then the use of synthetic microstructures is examined with respect to several different problems. First, grain morphology of synthetic polycrystals is discussed relative to the ultrasonic scattering predictions in order to understand the impact of different models. Then, synthetic volumes are discussed regarding their role to understand grain statistics that are measured from two-dimensional (2D) micrographs from optical or electron microscopy. An ensemble of synthetic polycrystals with equiaxed grains and six different distributions are created using the DREAM.3D to highlight the differences between the 2D and the 3D grain size statistics. A procedure is then presented to convert the 2D morphological and orientation information into their 3D counterparts. Finally, progress regarding two-phase polycrystals is described in terms of the modeling challenges in order to represent electron backscatter diffraction measurements. The use of digital microstructures is anticipated to accelerate the development of new measurement techniques for microstructure quantification. [This work was supported by the U.S. Air Force Research Laboratory and was completed utilizing the Holland Computing Center of the University of Nebraska, which receives support from the Nebraska Research Initiative.]