Influence of Grain Size Distribution on Ultrasonic Scattering

Andrea Arguelles and Joseph A. Turner. Mechanical and Materials Engineering, University of Nebraska-Lincoln, W342 Nebraska Hall, Lincoln, NE, 68588

Elastic wave scattering at grain boundaries in polycrystalline media can be quantified to determine microstructural properties. The amplitude drop observed for coherent wave propagation (attenuation) as well as diffuse-field scattering events (such as the single-scattering response) have been extensively studied. In all cases, the scattering shows a clear dependence on grain size, grain geometric morphology, and material texture (i.e., macroscale anisotropy). Scattering models used to quantify such scattering experiments are often developed under the assumption of a single effective grain diameter implying a very narrow distribution of grain size throughout the sample. However, several microscopy studies suggest that most metals have a log normal distribution of grain sizes with distribution widths as large as $\sigma = 0.75$, where $e^{\sigma}$ represents the standard deviation of the distribution. In this presentation grain size distribution is discussed within the context of previous attenuation and single scattering response models. Results are presented for several example metals using reported experimental values of distribution means and widths assuming spherically-shaped grains and no material texture. The longitudinal and shear attenuations are shown to vary with respect to their frequency dependence for varying distribution widths even when the mean grain size is held constant. A similar effect is observed for diffuse ultrasonic backscatter (DUB) predictions. These results suggest that grain size estimates based on DUB can have large errors if the distribution is neglected. A multi-frequency analysis approach is discussed based on a log normal distribution in order to reduce grain size estimate errors. This work is anticipated to play an important role in microstructural characterization research associated with ultrasonic scattering.