**Nonuniqueness Analysis of Ultrasonic Grain Size Inversion of Polycrystalline Materials**

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Polycrystalline materials are composed of a group of grains of various sizes. Studies have shown that the size distribution of these grains controls material properties such as ductility, corrosion resistance, yield strength, and hardness. Conventionally, acquiring this information has often relied on destructive methods, including optical and electron microscopy techniques. However, it is far more desirable to interrogate the sample without compromising its integrity, as seen in ultrasonic nondestructive techniques. Studies have demonstrated the sensitivity of ultrasound to both the mean and standard deviation of grain sizes. Leveraging this phenomenon, this work investigates the potential of utilizing ultrasound to estimate the mean and standard deviation of grain diameters. This study approaches the problem from both an analytical and numerical standpoint. To initiate the inversion process, a target distribution characterized by a predetermined mean and standard deviation is considered. Subsequently, a grid of input statistics is considered to identify volumes that closely match the target distribution. The relative difference between the ultrasonic attenuation of the grid and the target is used as the measure of comparison. All attenuation values are calculated analytically using the ultrasonic models developed by Arguelles and Turner [1], and Sha [2]. Additionally, attenuation values are also found numerically [3] using synthetic three-dimensional (3D) microstructures generated by DREAM.3D. The analysis explores how different factors, including frequency regimes (Rayleigh and stochastic) and scattering modes (longitudinal and transverse), impact the effectiveness of the inversion process. Finally, the role of the two-point statistics is analyzed. Within the current ultrasonic scattering framework, two volumes having identical orientation and two-point spatial correlation function (TPSC) exhibit consistent scattering responses. The results show how volumes with various distributions may have similar TPSC functions, resulting in comparable ultrasonic behavior. This study evaluates the capacity of ultrasonic techniques to accurately characterize grain size distributions in polycrystalline materials.

**References:**

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