Generalized Expressions for Ultrasonic Scattering from Polycrystals with Transversely Isotropic Material Texture

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Metals are often subjected to rapid cooling, such as during welding or laser-based additive manufacturing (AM), and the resulting microstructures often have material texture. In many cases, the texture is uniaxial (i.e., transversely isotropic) such that one symmetry axis defines the material response. Therefore, ultrasonic inspection methods that exploit the scattering from the microstructure are complicated by the resulting texture which affects the wave velocity, attenuation, and diffuse backscatter. In this presentation, a generalized approach is described in which the covariance of the elastic modulus tensor for a uniaxial ensemble of cubic crystals is expressed in terms of a fundamental set of constants. These constants are determined for an arbitrary texture from synthetic polycrystals created using DREAM.3D. With this information, calculations for wave velocity, ultrasonic attenuation, and diffuse scattering can be made efficiently for any propagation direction relative to the material symmetry axis. The results include all combinations of longitudinal and transverse waves. Results are first compared with previous analytical expressions for simplified cases. Then, more generalized textures are examined in terms of the ultrasonic scattering with respect to the strength of the texture. Finally, prospects for characterization of components created using metal AM are discussed especially within the context of input data from electron backscatter diffraction (EBSD) measurements. The results of this work are expected to provide additional insight regarding the inversion of measurement data for texture characterization.