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Ultrasonic characterization of material morphology in additively manufactured AlSi10Mg

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Laser powder bed fusion (LPBF), a form of metal additive manufacturing (AM), creates components by selectively melting metal powder layer-by-layer. The cyclical heating and cooling process generates grains that possess nominally elliptical morphology which is often symmetric about the build axis due to the melt pool formation. Such morphology affects the mechanical behavior, including strength, ductility, and fatigue life. Microstructures are often characterized using imaging methods that require the sample to be cut and polished such that the sample can no longer be used. A method to characterize microstructures nondestructively would have high value, especially for metal AM. For this presentation, LPBF was used to create samples of the aluminum alloy AlSi10Mg. Ultrasonic measurements were used to characterize the sample in terms of the velocity and diffuse scattering in multiple directions. For comparison, the samples were inspected using electron backscatter diffraction (EBSD) and spatially resolved acoustic spectroscopy (SRAS) to gain insight into the morphology of the sample microstructures. The EBSD, SRAS and experimental ultrasound measurements, are compared with theoretical models which predict ultrasonic velocity and diffuse scattering. Two models are used for comparison. An analytical model based on ellipsoidal grains will provide information about the aspect ratios necessary to match the experimental backscatter data. The other model incorporates synthetic polycrystals using DREAM.3D which also have nominal ellipsoidal geometry, but also include a distribution of grain sizes. The morphology from the models will be quantified with respect to the EBSD and SRAS data which will show the true multiscale nature of the microstructures. These results will show the capability of simple models to provide overall microstructures of AM parts, such as melt pool shape, that are needed for part certifications. This research will allow for better control over AM process optimization because ultrasound is an efficient and nondestructive method for part inspection.

To be presented as an invited presentation for the Ultrasonics NDE Methods – UT in Materials with Complex Microstructures section during the ASNT research symposium meeting in Pittsburgh, Pennsylvania June, 2024.