On the relationship between microstructure and resonant ultrasonic spectroscopy: from single crystals to additively manufactured polycristals

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Abstract

In this talk, we report our recent progress regarding the development of a resonant ultrasound spectroscopy (RUS) probing system and associated tools at CEA List. These tools allow to accurately characterize the full elastic tensor for metallic materials of various shapes and microstructures. We first present the forward models used to compute the resonance frequencies, and two inversion algorithms with their properties, convergence behavior and error modeling: gradient-based descent and MCMC Bayesian modelling.
We then present applications of our setup to use-cases where RUS measurements can provide several types of information. We first discuss two case studies on single crystals: a silicon crystal of 110 alignment with respect to sample frame and a 316L crystal with a non-canonical geometry.
We then discuss some applications to elastic property characterization, anisotropy quantification, detection of cracks, recrystallization. The samples will come from various additive manufacturing techniques, including laser powder-bed fusion, wire arc additive manufacturing and metal binder jetting.
Finally, we will review the models linking microstructure and effective elastic constants measured by RUS and point out a number of interesting research directions at the intersection of resonant ultrasound and classical metallic characterization techniques such as EBSD, XRD, SEM and so on.

Keywords: RUS, ultrasound, resonance, nondestructive testing, additive manufacturing, elasticity tensor, characterization, microstructure, anisotropy

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