**Cantilevered Resonators for Determining Single Crystal Elastic Properties by Resonant Ultrasound Spectroscopy**

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ABSTRACT

Single crystal elastic properties are critical to modeling material system performance. Resonant ultrasound spectroscopy (RUS) is a measurement technique that uses the natural resonance behavior of a specimen to determine elastic properties. Typically, RUS employs analytic methods to predict the resonance behavior for a particular material with a well-characterized canonical geometry and density. Optimization is then used to determine elastic properties from experimentally measured resonance. However, determining single crystal properties with RUS generally requires measurement of centimeter-scale single crystal samples [1]. These are difficult, time consuming, and expensive to produce. As such, improved techniques are needed to measure single crystal elastic properties without the need for growing large single crystals.

In this work, we propose an alternative specimen geometry for single crystals elastic property measurement at the scale of the typical grain size found in fine-grained aerospace alloys. Standard material preparation techniques are employed to obtain a thin slice of a material of interest and generate cantilevered resonators contained within specific grains of a known orientation, as determined by electron backscatter diffraction measurement. Resonance measurements are then performed to determine single crystal properties. A damping material is applied to the surface of the cantilever and substrate to minimize the presence of wave modes not related to the resonator itself. The finite element method is used to solve the forward problem and a hybrid Gauss-Newton/grid search method is used for optimization [2, 3]. The viability of the technique is demonstrated by performing a millimeter-scale experimental demonstration using a sample of galfenol, an iron-gallium alloy. Relevant theory and modeling results will also be presented.

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REFERENCES

[1] – A. Migliori and J. L. Sarrao. *Resonant Ultrasound Spectroscopy*. Wiley, New York, 1996.

[2] – C. T. Kelly. *Implicit Filtering*. Society for Industrial and Applied Mathematics, Philadelphia, 2011.

[3] – T. J. Lesthaeghe, R. A. Adebisi, S. Sathish, M. R. Cherry, and P. A. Shade. Toward Characterization of Single Crystal Elastic Properties in Polycrystalline Materials using Resonant Ultrasound Spectroscopy. *Materials Evaluation.* 75(7): 930-940, 2017.

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