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Incorporating Crystallographic Orientation in the Development of Resonant Ultrasound Spectroscopy

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Resonant ultrasound spectroscopy (RUS) measures the mechanical resonance frequencies of solids and uses computational algorithm to extract a complete set of elastic constants. One of the advantages of the RUS method is its applicability to small single crystals. In the past two decades, the RUS technique has gained more acceptance as a nondestructive method to measure elastic properties. The goal of this project is to measure elastic properties of micro pillars without free-free boundary conditions and arbitrary crystallographic orientations. To achieve this goal we need a capability to measure elastic constants of single crystals with arbitrary crystal orientation relative to sample geometry. The inherent assumptions in conventional RUS algorithm include free boundary condition on the specimen faces and the faces of the specimens are normal/parallel to the principal crystallographic axes. To meet these requirements, a time consuming sample preparation, involving multiple inspections of x-ray Laue back reflection to check the crystallographic orientation, is followed. Such an intensive method is not suitable for many samples in engineering applications. To estimate the elastic constants of such samples, a new RUS algorithm has been developed that incorporates the sample crystallographic orientation expressed in terms of Euler angles. The power of the modified RUS algorithm is demonstrated by applying it to estimate the elastic constants of cubic and hexagonal crystal structure samples with known orientation. The results are compared with literature values. Potential application of the method include estimation of elastic constants and their use as input parameters in models that predicts the mechanical behavior of materials for engineering applications is discussed.