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Generalized inverse problems in resonant ultrasound spectroscopy

Resonant ultrasound spectroscopy (RUS) is one of the most precise and versatile methods used for the determination of elastic coefficients. The method is based on measurement of mechanical resonances of a solid body. However, determination of the elastic constants by RUS is an inverse problem so the experimentally obtained resonant frequencies cannot be directly recalculated into the elastic constants. Instead, an approximate spectrum is calculated from the known dimensions of the sample, its mass, and a set of 'guessed' elastic constants. Our main goal is to show the ability of the resonant ultrasound spectroscopy to precisely identify the anisotropy class, crystallographic orientations, and dimensions of the sample, in addition to elastic coefficient determination.

The reliability and robustness of our extended algorithm was tested on three differently oriented samples of Si-doped iron single crystal. Precision of the algorithm is discussed with respect to the number of resonances utilized during the procedure, and calculated crystallographic orientations are compared with the measurements obtained by Laue diffraction experiment. Our optimization procedure was then applied on room temperature measurements of 2 types of metastable β-Ti alloys (Ti15Mo and LCB) with an increased amount of secondary phase particles after additional heat treatment. The aim was to observe potential change of the symmetry of the material after the phase transformation. This procedure was performed by comparing the best possible inversion assuming cubic symmetry with full triclinic calculations.

Our results show no significant change of the symmetry of the material on macroscopic scale, which means that the material retained its cubic symmetry after the phase transformation. To further confirm our findings a transient grating spectroscopy (TGS) measurements are compared with the measurements obtained by RUS, showing a good agreement.

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