Spatially Resolved Acoustic Spectroscopy (SRAS): from Surface Acoustic Waves Velocities to Crystallographic Orientation

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The microstructure and properties of a material determine its characteristics such as strength and stiffness. The laser ultrasonic technique spatially resolved acoustic spectroscopy (SRAS), which generates surface acoustic waves (SAW) thermoelastically, is a robust and rapid method to quantitatively measure the velocity of SAW propagating on the material's surface. The topographic map of velocity is obtained and shows the contrast of grains. We developed a forward model which predicts the SAW velocity for all the combinations of plane and SAW propagation direction of a material based on its elastic constants. The purpose of the work presented is to determine the orientation of the crystal or grain according to the measured SAW velocities in a limited number of directions. A search algorithm, termed the overlap function, solves this inverse problem and is tuned for SRAS results which present data as a velocity surface spectrum. The orientation results of a range of industrial materials, such as nickel-based alloys, titanium-based alloys and stainless steels, have been presented with comparison with electron back-scattered diffraction technique. We discuss the influence of number of directions in the SAW velocity measurements which affect the accurate determination of the planes. The implementation of this technique utilizes the triangular relation of three elements – elastic constants, crystallographic orientation and SAW velocities – by knowing any of the two, the third one can be achieved. However, it is possible to determine the elastic constants by SAW velocities on multigrain materials without knowing the orientation of grains. The feasibility study of cubic structure materials are demonstrated.