SRAS: A Laser Ultrasonic Technique to Determine Crystallographic Orientation

Wenqi Li [S], Steve Sharples [C], Matt Clark and Michael Somekh
University of Nottingham, Electrical Systems of Optics Research Division, Faculty of Engineering, Nottingham, United Kingdom
steve.sharples@nottingham.ac.uk

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. 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. This function is able to detect the presence of a systematic experimental velocity scaling error, and take this into account when solving the inverse problem. We have measured the orientation of 12 single crystal nickel samples using this technique, these are compared with X-ray Laue back reflection (LBR) measurements. We express the orientation in terms of θ—defined as the deviation, regardless of direction, from the reference direction to the <001> direction—and α, which is essentially the rotation of the plane. The root mean square difference between SRAS and LBR measurements are less than 3° for θ and less than 4° for α. We discuss the influence of systematic errors in the SAW velocity determination due to instrument miscalibration—which predominantly affect the accurate determination of θ—and the likely causes of errors in α. Overall, SRAS has great potential for complimentary measurements or even for replacing established orientation determination and imaging techniques.