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SRAS++ for single-crystal elasticity measurements in polycrystalline materials

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The elastic constants (C_{ijkl}) provide vital insights into the behaviour of a material, allowing calculation of various critical mechanical properties, along with the ultrasonic velocities often necessary for inverse problems, and facilitating simulation of microstructure evolution during materials processing. However, elasticity measurements are challenging to undertake, usually requiring a single crystal of known crystallographic orientation. The bulk wave velocities or the resonant frequencies of the material are then used to determine the elastic constants inversely. Unfortunately, most engineering metals appear as polycrystalline aggregates, preventing the measurement of their elastic constants by these methods.

Spatially resolved acoustic spectroscopy (SRAS) is an acoustic microscopy technique, that can image the microstructure and measure the crystallographic orientation of grains or crystals in the material. It works by measuring the velocity of surface acoustic waves (SAWs) via the acoustic spectrum. In the usual configuration, the SAWs are generated by laser using a pattern of lines and detected by laser at a point close to this grating-like source. The use of the acoustic spectrum to measure the velocity has a number of practical advantages, which makes the technique robust and fast and gives an excellent spatial resolution. This makes the measurement suitable for imaging and gives it many advantages over traditional laser UT and microstructural measurement techniques.

In this talk, we will demonstrate that by combining the measurement of the acoustic velocity spectrums from multiple grains, as measured by SRAS, it is possible to determine both the elastic constants of the sample and the crystallographic orientation of each grain. This provides a viable method to measure the elastic constants in 'real-world' polycrystalline samples. The talk will review the experimental instrument, inversion procedure (for calculating both crystallographic orientation elastic constants), and present recent experimental results. The talk will conclude by outlining the ongoing challenges and contemporary developments to address them, both experimental and numerical, in the pursuit of extremely high precision elasticity measurements in near real-time.

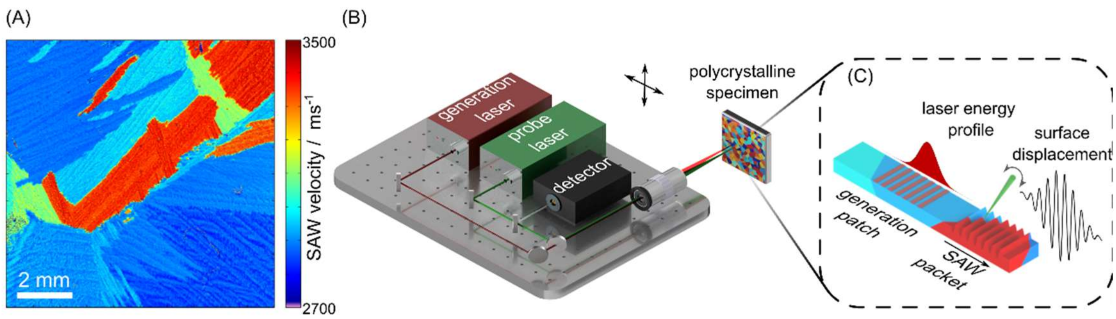

Figure 1: (A) SRAS SAW velocity map in polycrystalline titanium alloy. (B) basic SRAS system layout, and (C) working principle.