Texture Determination from Ultrasonic Wave Speeds for Hexagonal Close Pack and Cubic Materials

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Crystalllographic texture in polycrystalline hexagonal close pack (HCP) and cubic materials, often developed during thermomechanical deformations, has profound effects on properties at the macroscopic or component level. In this talk, a novel theoretical convolution model is presented, which couples the single crystal wave speed (the kernel function) with the polycrystal crystallographic orientation distribution function to give the resultant polycrystal wave speed function. Firstly developed on HCP [1] and then successfully extended to general anisotropic materials [2], the theoretical model expresses the three functions as harmonic expansions, thus enabling the calculation of any one of them when the other two are known. Hence, the forward problem of determination of polycrystal wave speed is solved for all crystal systems. Verifications are provided on various textures, showing near-perfect representation of the sensitivity of wave speed to texture as well as quantitative predictions of polycrystal wave speed. More importantly, the model also presents a solution to the long-standing inverse problem of detecting texture using ultrasound, with proof of principle established where the wave velocities propagating in groups of HCP and cubic polycrystals with different known textures are computationally calculated, and then the texture information is recovered solely from simulated velocities through the model, and the results show good agreements with the original textures.

With possibilities of developing a powerful tool for bulk texture measurement and wave propagation studies in general for HCP, cubic materials now shown, further experimental validations of the proposed model are then conducted. A series of samples cut from typical HCP and cubic materials, including commercially pure (CP) Ti, copper, Ti-6Al-4V, are examined by carefully designed experimental setup for the measurement of the angular variations of ultrasonic wave velocities. Texture information of the samples are extracted out from these measured velocities using the model, for the comparison and calibration against the set of information of the same samples measured independently by the well-established neutron diffraction technique. This part of the research is still ongoing and we hope to be able to show results soon.

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References: