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Ion Cutting of Large Samples for Brillouin Scattering: Elastic Anisotropy of Antigorite at High-Pressures

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Brillouin spectroscopy has become a major technique for the determination of elastic properties of both single-crystals and polycrystalline materials at high-pressures and also high-temperatures. Sample preparation is a crucial point for this technique, as for optical spectroscopy in general. Brillouin scattering at extreme conditions is usually carried out in symmetric platelet forward scattering geometry, which allows for a straight-forward evaluation of shear and compressional velocities. However, well-polished platelet samples with parallel faces are required. Unfortunately, mechanical polishing is restricted to materials of sufficient size and mechanical stability. This precludes the preparation of a number of compounds with significant geophysical relevance, including both natural samples (i.e. serpentine minerals) and candidate Earth materials that are synthesised at high-pressure/high-temperature conditions (i.e. ferropericlase, perovskite).
Sample preparation using a focused beam of ions (FIB) has become a standard procedure for the preparation of electron transparent foils to be used in transmission electron microscopy (TEM). Consequently, FIB facilities can be found in many research laboratories around the globe. Here, we show that ion cutting and polishing is a very elegant approach to prepare μm-sized samples of well-defined thickness with high surface quality. It does not expose the samples to mechanical forces, thus allows for preparing materials that are brittle, meta-stable, or show a strong cleavage. In addition, it offers the chance to cut more than one sample from a piece of material, for instance two platelets with different orientation from one single-crystal. Also, a TEM foil can be produced simultaneously. This allows for a detailed characterization, including chemical composition, crystallographic orientation, defect structure and secondary phases, of the same sample material, i.e. the same single-crystal, that is later used for optical spectroscopy.
In this contribution, we chose natural antigorite to demonstrate the feasibility and the capabilities of this approach. A sample platelet was cut parallel to the b-c-plane, i.e. the plane of maximum elastic anisotropy, from an antigorite single-crystal. The sample platelet was loaded in a symmetric diamond anvil cell to test the performance in high pressure Brillouin scattering experiments. Simultaneously, a thin ($\sim$100 nm) lamella was cut parallel to the platelet from the same single-crystal for characterisation with transmission electron microscopy (TEM).