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New diamond anvil cells for gigahertz ultrasonic interferometry and X-ray diffraction

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ABSTRACT

Two new diamond anvil cells have been designed for ultrasonic and X-ray diffraction measurements on a single crystal sample up to 6 GPa and 250 °C. Advances in the generation and transmission of coherent GHz ultrasonic signals with wavelengths of the order of micrometers now make it practical to measure elastic properties of samples small enough to be subjected to pressure and temperature in diamond anvil cells. The signal is carried from a thin transducer through a sapphire buffer rod coupled to one of the diamond anvils by means of force. The signal traverses the diamond anvil and enters the single crystal sample which is coupled to the anvil face by cement, adhesion, or by a normal force. Interference of superimposed waves reflected from the near and far faces of the single crystal is used to measure travel time of the sound waves in the sample. One of the diamond anvil cells employs the conventional geometry in which access for the X-rays is through the diamond anvils. The other provides access for X-rays at high angles to the load axis so that they do not need to pass through the diamond anvils and can therefore have access to the sample while the buffer rod is in place. Both diamond anvil cells make it possible to measure d-spacings at several different orientations using a four-circle goniometer. This capability is used for detecting and correcting displacement of the sample from the center of the goniometer. Measurement of travel times and lattice parameters at the same pressure-temperature conditions allows conversion of travel times to velocities and can provide simultaneous equations of state, which EOS can then be used to make an independent determination of pressure vs. lattice parameter. This provides a primary pressure scale.