Multi-scale structures, anisotropy, and thermal constraints at Earth's core-mantle boundary

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The large chemical, density, and dynamical contrast associated with the juxtaposition of a liquid iron-dominant alloy and an intimate mixture of silicates and oxides at Earth's core–mantle boundary is associated with a wide range of complex seismological features. Interpretation of these multi-scale features and the dynamic processes that formed them requires, in part, knowledge of the thermoelasticity and melting properties of candidate phases. We will present recent inelastic x-ray scattering and x-ray diffraction measurements on iron-bearing phases and the application of these results to our understanding of Earth's core-mantle boundary region [1-5]. Specifically, we will present nuclear resonant and non-resonant inelastic x-ray scattering and x-ray diffraction measurements to over 100 GPa and temperatures around 4500 K. The nuclear resonant inelastic x-ray scattering method provides specific vibrational information, e.g., the partial projected phonon density of states. The high statistical quality of the data in combination with a small x-ray focus size and in-situ x-ray diffraction permits accurate evaluation of the vibrational-related parameters of iron-bearing materials, such as the sound velocities, vibrational entropy and free energy, Grüneisen parameter, thermal pressure, and iron isotope fractionation quantities. Using non-resonant inelastic x-ray scattering, we determine the acoustic phonon dispersions (thus, the elastic tensor) of (Mg,Fe)O magnesiowüstite and constrain its elastic anisotropy. Finally, we will present constraints on the temperature of the core-mantle boundary using new methods of melt-detection: synchrotron Mössbauer spectroscopy and a fast temperature readout spectrometer. Our approach is unique because the dynamics of the atoms are monitored prior to melting, while temperatures are determined accurately and precisely. I will briefly discuss the implications of our results as they relate to the composition and dynamics of various structures near Earth's core-mantle boundary.

Select References

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