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A Deeper View of Materials: Coupling electrostatic levitation and high energy x-ray diffraction

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The ability to measure changes in the atomic scale structure, associated with novel thermophysical properties, will lead to tremendous advances in our understanding of the underlying physics of materials. This talk will focus on the integration of electrostatic levitation (ESL) techniques and high energy x-ray diffraction. The use of high energy x-rays ($E > 100$ keV) offers several distinct advantages over conventional x-ray methods. First and foremost, high energy x-rays are required for full penetration of the levitated samples, which are typically 2-3 millimeters in diameter. This ensures that the bulk, rather than near-surface, structures are sampled in the measurement. A second important benefit of high energy x-rays lies in the fact that diffraction patterns can be collected over a relatively wide momentum transfer range for a small range of angles. The relatively small range of scattering angles required for most measurements allows the use of area detectors for fast data acquisition while the sample is either held at a constant temperature or during continuous heating/cooling cycles. The latter method is particularly suitable for continuous studies of phase transformations as the sample is heated from room temperature to the liquidus temperature and above, or cooled from high temperatures. This is, perhaps, best illustrated by recent work on the atomic scale structure of deeply undercooled liquid metals and semiconductors, such as silicon, where time resolved (100ms/frame) data have shown that, in contrast to previous structural measurements and several theoretical treatments, there is no evidence for a liquid-liquid phase transition in the undercooled regime.