Contribution ID: **31** Type: **not specified**

A Tale of Melting at high Pressures: X-ray diffraction meets Phase-Contrast Imaging

High pressure is a fascinating variable as the phase-space is heavily extended and one can, in general, observe a range of phase transitions with increasing pressure. Some phases may be metastable and some will be the most stable structure. High pressures can be easily generated using the diamond anvil cell (DAC), which can reach Mbar pressures (100's of GPa). Combine this with lasers and temperatures above 4000 K can be reached. This relatively simple device can be used to explore high pressure and temperature space where new phases can be found and high-pressure melting can be constrained. In addition, often times, a unique interplay exists between the phase transitions of the compound and the way the pressure is applied. Here, we are interested in how the compression rate can influence phase transitions. Under dynamic compression new phases have been observed (maybe only metastable) and phases that have been observed under static compression are sometimes skipped entirely. In this work we use a dynamic DAC which uses a piezoelectric actuator to apply a force to the sample. This setup can rapidly compress the DAC in the microseconds time range and can generate compression rates over 100 TPa/s.
In addition to the conventional approach in this extreme condition field, which is angle-resolved powder X-ray diffraction, we also collect propagation-based phase contrast imaging. This allows us to directly image melting and crystallization of opaque metallic systems and we attempt to extract kinetic information from these experiments. These studies have been conducted on platinum and gallium, respectively. Results from both studies will be presented, which includes the use of principal component analysis and machine-learning assisted segmentation of images.

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Session Classification: Poster Session & Fingerfood