Phase Diagram Determination of the HfO$_2$-Ta$_2$O$_5$ Binary up to 3000 °C using In-situ X-ray Diffraction

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Ceramic equilibrium phase diagrams have proven to be difficult to produce for materials above 1500 °C. We demonstrate here that in-situ X-ray diffraction on laser-heated, levitated samples can be used to elucidate phase fields. In these experiments, solid spherical samples were suspended and rotated by a gas stream through a conical nozzle levitator, heated by a 400 W CO$_2$ laser at beamline 6-ID-D of the Advanced Photon Source at Argonne National Laboratory. X-ray diffraction patterns suitable for Rietveld refinement were collected at 100 °C temperature intervals and were used to determine the phase fraction of phases present. The temperature of each phase was determined based on thermal expansion data collected by powder diffraction in conjunction with the Quadrupole Lamp Furnace (QLF) at beamline 33-BM-C. Crystallographic and symmetry relations were determined and related to the stable phases and phase transformations observed. HfO$_2$-Ta$_2$O$_5$ was investigated as an example system due to its high melting points and application in refractories and electronics.