High-Entropy Materials under Extremes of Pressure, Temperature, and Strain Rates

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High entropy materials contain a mixture of five or more elements in near equal proportion and demonstrate enhanced physical and mechanical properties and thermal stability as compared to their constituent elements due to their high configurational entropy. This talk will cover several high-entropy ceramics and high-entropy alloys that have been studied at HPCAT in the last few years and at Laser-Shock compression facilities in Japan. I will describe research with Paris-Edinburgh Cell that has played a key role in not only in synthesis of high-entropy borides (HEB), e.g., $(Ti, Zr, Hf, Ta, Mo)B_{10}$ but also measurements of thermal equation of state these materials to 10 GPa and 2300 K. Radial x-ray diffraction studies have provided unique insights in to high shear strength of these materials and x-ray microdiffraction studies have established their equation of state to pressures exceeding 300 GPa in a diamond anvil cell. In high-entropy alloys (HEA), using additively manufacturing techniques, simultaneously high strength and ductility under tensile loading have been achieved in eutectic high entropy alloys e.g., $AlCoCrFeNi_{2.1}$. These alloys are comprising of alternating body- centered cubic (BCC) and face-centered cubic (FCC) nano-lamellae which share a common melting temperature. The shock experiments to 515 GPa were performed by using GEKKO XII lasers at the Institute of Laser Engineering, Osaka University, and further dynamic x-ray diffraction experiments were performed at EH5-BL3 of SACLA-XFEL. The BCC-FCC phase transformation shows different behavior under high-strain rate shock compression versus static compression in high-entropy alloys. Future research opportunities in high-entropy materials at HPCAT (APS-U) will be discussed.