“Using High Pressure Diffraction to Understand Elastic and Plastic Behaviors in Superhard Transition Metal Borides”

By Shanlin Hu
Profs. Tolbert & Kaner Group

ABSTRACT: The motivation of this research is to find alternatives to traditional superhard materials, such as diamond, with much lower costs and great mechanical properties. Inspired by diamond’s 3D network of strong, short carbon-carbon covalent bonds, we have designed a family of transition metal borides by combining incompressible transition metals with a rigid boron network. We specifically focus on the design novel superhard transition metal borides, considering both intrinsic effects, like chemical bond strength, and extrinsic effects, like dissipation of energy at grain boundaries. We then study the microscopic deformation mechanisms controlling the plastic behavior of the material through in-situ high-pressure radial X-ray diffraction experiment. Specific projects include examining intrinsic hardening through solid solution formation in WB2, ReB2, WB4 and MB12 (M=metal) systems and investigating the size dependence of extrinsic hardness in nano-ReB2 system through Rietveld refinement and texture analysis. By understanding the elastic and plastic deformation mechanisms in different transition metal systems under high pressure, we can develop a comprehensive understanding of the fundamental physics that contributes to their high hardness and design new approaches to synthesizing next generation superhard materials.