Engineering Quantum Confinement in Metal-Organic Chalcogenide Assemblies (MOCHA)

J. Nathan Hohman, Staff Scientist

The Molecular Foundry, Lawrence Berkeley National Laboratory, California, USA

Abstract

When 2D monolayers are abstracted from layered materials, new properties—and opportunities—emerge. In the archetypical example of the layered transition metal dichalcogenide MoS­2, there is a change from an indirect band gap in the bulk to a direct band gap in the monolayer. This change in the light-matter interaction has been the source of much attention for luminescent, photovoltaic, catalytic, spintronic, and other applications utilizing 2D materials. However, building devices out of such ultrathin materials poses a variety of technical challenges: considerable effort must be expended to ensure isolation of stable monolayers, post-synthetic modification and doping is challenging, and integration into devices can alter the unique properties enabled by the ultrathin structure. As a route towards solving these challenges, we employ a hybrid chemical approach that combines organic and inorganic constituents in a single material: metal-organic chalcogenide assemblies (MOCHA). By employing organic ligands as a structural and functional elements of a hybrid coordination polymer, we are able to achieve 3D crystalline assemblies of 2D monolayers that are quantum confined in their as-synthesized bulk state. Here, we will demonstrate the synthetic flexibility of the MOCHA system, show how ligand identity controls the transition between 1D, 2D, and 3D coordination polymer systems, and introduce how new techniques in crystal growth and design can be employed to achieve new opportunities for manipulating the optoelectronic properties of low-dimensional material systems.