Manipulation of dimensionality and strain in transition metal dichalcogenide nanocrystals

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Two-dimensional (2D) transition metal dichalcogenide (TMD) crystals exhibit electronic, magnetic, and optical properties which can be tailored through control of crystal dimensionality, edge character, and strain state. We recently introduced a rational chemical synthesis strategy, based on gas-phase growth of TMD crystals on designer surfaces, that substantially improves control over the dimensions, morphology, and crystalline edges of 2D TMDs. TMD nanoribbons prepared through this approach exhibit atomically uniform edges, readily controllable dimensions, and anomalous photoluminescence features. This talk will focus on these recent results and highlight our progress towards expanding the capabilities of this chemical strategy for low-dimensional materials synthesis. This talk will also discuss our recent efforts to introduce precise nanoscale strain fields in 2D materials through the use of non-planar structured assemblies comprised of 2D TMDs interfaced with Si nanowires. Detailed structural and optical characterization of these assemblies reveals unique strain-mediated photoluminescence that is highly localized and significantly red-shifted with respect to known exciton emission lines. Our results emphasize that rational chemical design of low-dimensional materials can open new opportunities in optoelectronic, energy conversion, and quantum metrology studies.