Laser Interactions to Understand the Synthesis and Optoelectronic Functionality of Atomically-Thin Nanostructures at the CNMS

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Nanostructures like quantum dots (0D), nanotubes (1D), and atomically-thin two-dimensional (2D) materials (e.g., monolayers or few-layers of graphene or the transition metal chalcogenides) have unique properties different from the bulk that result from both quantum confinement due to their structure, and heterogeneity caused by defects, dopants, and surface interactions. Understanding and controlling their structure and properties toward optoelectronic applications requires controllable synthesis, atomistic characterization of structure, and functional testing. Laser interactions are central to this effort, from their use (e.g., pulsed laser plasmas) to create non-equilibrium conditions for synthesis, to fundamental laser spectroscopy used to understand their electronic and vibrational properties. Here we will describe our recent work in the synthesis of nanostructures and the characterization of their atomistic structure and optoelectronic properties, with a focus on atomically-thin 2D materials for electronics, photodetectors, and photovoltaics. In addition, we will describe the development of time-resolved, *in situ* spectroscopic and imaging diagnostics which are used to develop growth models and to control nanostructure synthesis in real time. These real-time diagnostic measurements are correlated with predictive theoretical methods and post-growth characterization by imaging, spectroscopy, and atomic-resolution analytical electron microscopy, to develop a framework for the deterministic synthesis of nanomaterials with desired properties. These capabilities and others available to users at the Center for Nanophase Materials Sciences (CNMS), one of five Dept. of Energy Nanoscale Science Research Centers, will be described.

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