

Tailoring fundamental interactions at nanoscale to create a menu card of materials, properties and applications in energy and biology

Nanoscaled materials and spectroscopic techniques offer unprecedented opportunities to measure and tailor fundamental interactions at atomic and molecular length scales. For example silicon, which is arguably the most important electronic semiconductor material, has poor optoelectronic properties which leads to inefficiencies in solar cell, photodetectors, and LEDs made from silicon. However, using nanoscaled silicon, and recent discovery of pseudo-direct bandgap transitions in silicon, highly efficient LEDs and energy conversion devices can be fabricated. In this talk, I will highlight some of the recent advances made in my group in taking conventional materials, and giving them desired properties tailored for specific applications, like novel 2D semiconductor nanosheets made from solar relevant materials (copper, lead cadmium and silver chalcogenides), formation of novel exciton-shelves for simultaneous charge or long-range energy transport from bandedge and higher energy “hot-carriers” in quantum-confined semiconductors, or new wavelength-selective photocatalysts to make desired solar fuels from water splitting and artificial photosynthetic reactions, to increase light-to-fuel conversion efficiency and eliminate the need for expensive separations. I will also discuss specific applications of new nanoscale spectroscopic techniques developed in my lab, like Quantum Molecular Sequencing (QM-Seq), which enable new high-throughput, single-molecule, label and reagent free sequencing of DNA, RNA and epigenomics modifications for development of novel biomarkers for disease states, and can lead to new advances in personalized medicine and gene therapy.