Discovery of new hybrid materials based on halide perovskites and nanostructures: atomic-level insights from atomic-resolution electron microscopy

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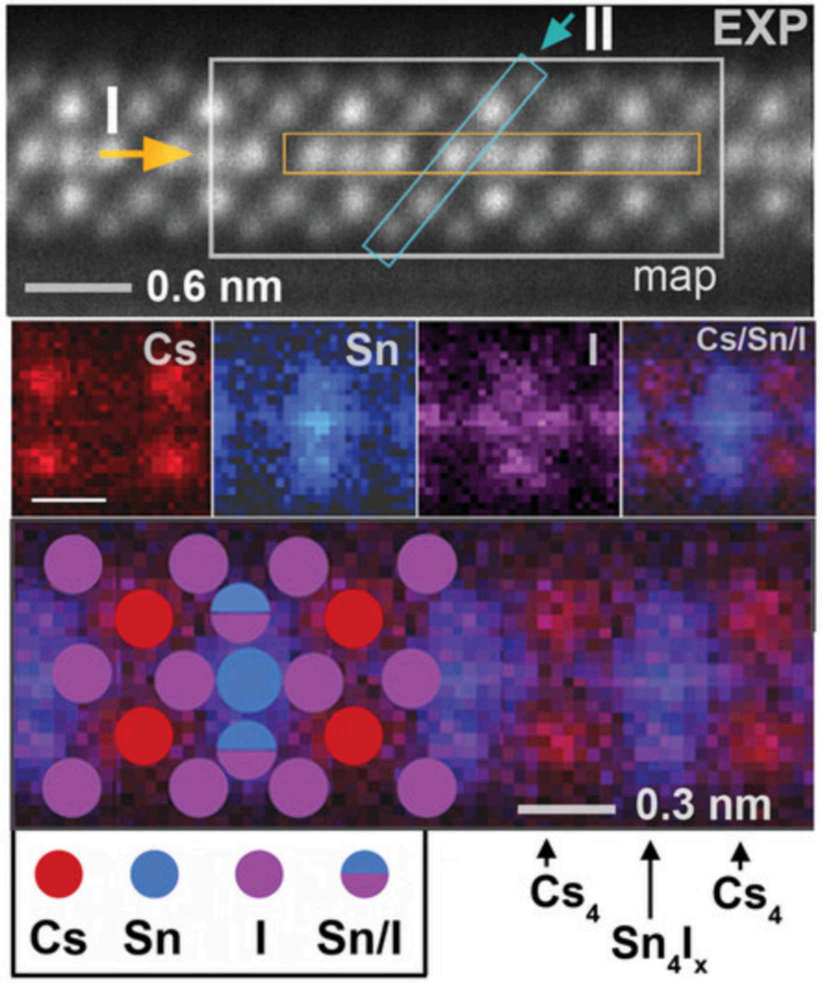
Halide perovskite solar cells have achieved impressive power conversion efficiencies exceeding those of the industry-standard silicon solar cells. However, commercial rollout of these devices is limited by their sensitivity to environmental factors, such as humidity, oxygen, high temperature, and light exposure. We wondered if this challenge could be addressed by combining them with inorganic nanostructures, such as carbon nanotubes. The result surprised us – not only did the halide perovskites become more stable, but we have discovered a completely new class of hybrid materials in which the perovskite fills the carbon nanotube while preserving structural continuity along its length. I will discuss the synthetic strategies we developed to create these new materials and the high-resolution EM techniques (HAADF STEM experiments combined with TDS STEM simulations) that enabled us to determine their structure at the atomic level. Accessing this new quantum confinement regime in halide perovskites may have substantial implications across the board in optoelectronics, quantum electronics, nanotechnology and condensed matter physics. I will also provide an overview of my ongoing and future research that builds on this new materials discovery and involves the formation of perovskite hybrids with other nanostructures, porous materials, including MOFs, and the use of 3D-ED to determine their atomic-level structure.



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