The perovskite fever: absorbing and emitting light

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The remarkable discoveries of highly efficient solar cells from lead halide perovskites have led to feverish research activities on this class of hybrid organic-inorganic semiconductors. In this lecture, I will discuss unique physical properties of these materials that give rise to their exceptional solar cell performance. These properties include, among others, the non-covalent nature of the crystalline lattice with little charge carrier trapping and the intrinsic disorder of the electronic energy landscape due to orientational freedom of the organic cations. The latter can give rise to static (Anderson) and dynamic (polarization) localization and the formation of intrinsic heterojuncitons from ferroelectric domains that spatially separate the electron from the hole. These are likely reasons for the exceptionally long carrier lifetimes and, hence, high solar-to-electric power conversion efficiency.

The same physical properties that have led to numerous demonstrations of highly efficient solar cells are also ideal for the reverse process of light emission, particularly in semiconductor lasers. Indeed, recent experiments in my laboratory (in collaboration with Song Jin of UW-Madison) have shown room temperature and wavelength tunable lasing from single crystal lead halide perovskite nanowires with the lowest lasing thresholds and highest quality factors reported to date for semiconductor nanowire lasers. Kinetic analysis based on time-resolved fluorescence reveals little charge carrier trapping in these single crystal nanowires and gives estimated lasing quantum yields approaching 100%, which represents orders of magnitude improvements over other NW lasers from conventional semiconductors. Such lasing performance, coupled with facile solution growth of single crystal NWs and broad tunability of emission color from stoichiometry, makes lead halide perovskites ideal materials for the development of nano-photonics, in parallel with the rapid development in photovoltaics from the same materials.