Metal Halide Perovskites at the Nanoscale: high quality optoelectronic materials with unique functionality and distinctions from thin film perovskites.

Joseph M. Luther

National Renewable Energy Laboratory, Golden, CO, USA

*E-mail: joey.luther@nrel.gov

The rediscovered metal halide perovskite semiconductor system has the potential to be extremely transformative for all optoelectronic devices, especially photovoltaics (PVs). Perovskites show a unique tolerance to crystalline defects that cause trouble in most other semiconductors. Therefore the potential offered is that very high efficiency PVs can be fabricated in extremely fast and inexpensive ways, thus offering a revolution for the solar industry and a direct route toward producing the world's energy with a simple and clean technology. Long-term durability of the devices is the critical remaining challenge to be solved. Two examples of major instabilities in device performance are the volatility of the organic cation and the specific crystal habit in which the material embodies.

Nanoscale versions (often termed quantum dots (QDs)) of the all-inorganic metal halide perovskite ($CsPbI_3$) tend to retain the desired perovskite phase due to strain effects at the surface of the QDs whereas conventional films of the same material "relax" to an orthorhombic non-perovskite structure at room temperature. Therefore, these QDs potentially solve both of the instability issues. This customizable new nanomaterial system has incredible potential for many applications in optoelectronics, including photovoltaics, LEDs, displays and lasers. This talk will cover several related projects that describe:

1) the phase stability of all-inorganic perovskite QDs
2) surface treatments to manipulate transport in perovskite QD arrays
3) cation exchange-based synthesis of homogeneous alloyed QDs
4) our latest work in QD solar cell device architectures
5) doping of perovskite QD films for manipulating electronic properties (enhanced mobility).

Joseph M. Luther
Chemical and Materials Sciences
Center for Hybrid Organic/Inorganic Semiconductors for Energy (CHOISE)
National Renewable Energy Laboratory
Golden, CO, USA

Joseph M. Luther current leads the Molecular and Catalysis Sciences group within the Chemical Materials and Nanoscience Center at the National Renewable Energy Laboratory (NREL). For the past ten years, he has focused his research efforts on developing low cost, solution processed photovoltaic technologies. His research interests lie in the growth, electronic coupling and electrical devices formed from colloidal nanocrystals, and understanding of fundamentals of perovskite-based solar cells.

He obtained B.S. degrees in Electrical and Computer Engineering from North Carolina State University in 2001. At NCSU he began his research career under the direction of Salah Bedair, who was the first to fabricate a tandem junction solar cell. Luther worked on growth and characterization high-efficiency III-V materials including GaN and GaAsN. His interest in photovoltaics sent him to the National Renewable Energy Laboratory (NREL) to pursue graduate work. He obtained a Masters of Science in Electrical Engineering from the University of Colorado while researching effects of defects in bulk semiconductors in NREL's Measurements and Characterization Division. In 2005, He joined Art Nozik's group at NREL and studied semiconductor nanocrystals for multiple exciton generation for which he was awarded a Ph.D. in Physics from Colorado School of Mines. As a postdoctoral fellow under the direction Paul Alivisatos at the University of California and Lawrence Berkeley National Laboratory, he studied synthesis and unique ion exchange reaction and resulting novel properties of colloidal nanomaterials. In 2009, he rejoined NREL as a senior research scientist.