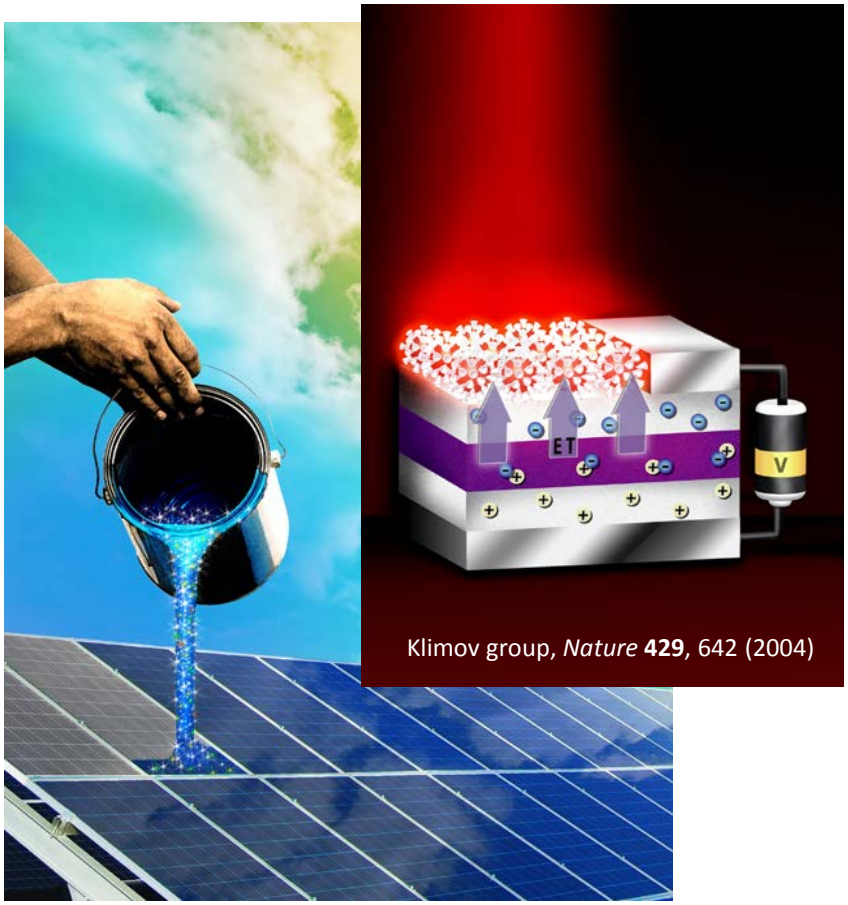
Emerging mesoscale conduction mechanisms: Charge transport in nanoscale assemblies and across complex interfaces

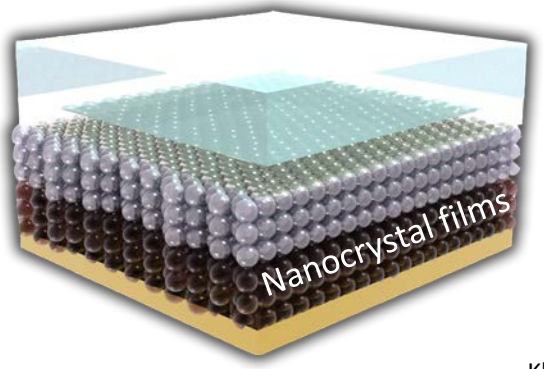
Solution-processable, cost-effective and highly efficient solid-state lighting and solar cells



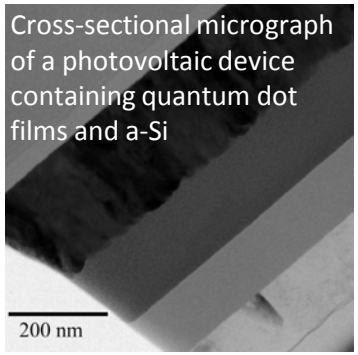
Klimov group, *Nature* **429**, 642 (2004)

Charge and energy transfer at disparate interfaces

"Nano-nano" interface

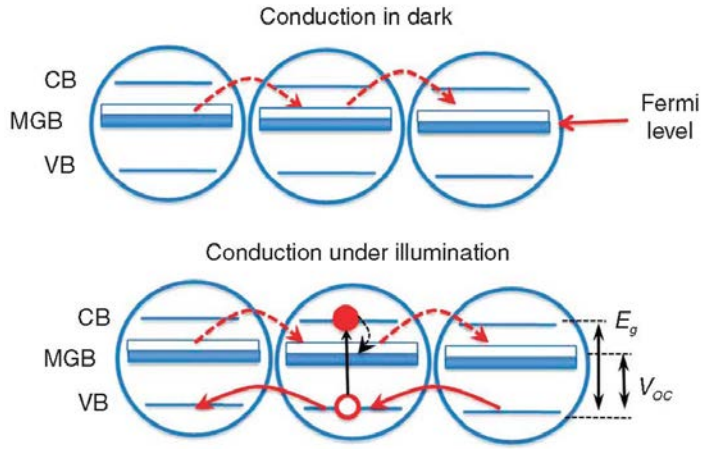


"Nano-bulk" interface



Klimov group, *Nano Lett.* **9**, 1235 (2009)

Emerging conduction pathways through collective interactions in quantum-dot arrays



Klimov group, *Nature Communications* **2**, 486 (2011)

Emerging mesoscale conduction mechanisms: Charge transport in nanoscale assemblies and across complex interfaces

Opportunity

Ordered and random arrays of nanostructures exhibit emerging properties that can be exploited for the benefit of photovoltaic- and solid state lighting devices. The overlap of electronic wavefunctions between neighboring nanostructures in a mesoscale array can lead to the development of novel charge conduction mechanisms, with conductivity increased by many orders of magnitude.

Meso Challenge

The challenge is to direct the assembly of nanoscale building blocks into mesoscale arrays (artificial solids) with controlled charge-transport properties. Application-specific goals include realizations of different regimes of electronic conduction such as band-edge, hot-electron or mid-gap transport of charges.

Approach

- Wet-chemistry approaches for synthesis of semiconductor nanocrystals with different shapes and compositions, including control of ligands and dopants
- Guided assembly or self-assembly of nanocrystals into superlattices with great control of inter-particle interactions
- Optical, electrical, and electro-optical measurements integrated with theory and modeling to determine optimal materials compositions and device architectures

Impact

Currently, poor charge transport properties of artificial solids constitute a major bottleneck in their real-world applications. Therefore, the realization of novel conduction mechanisms and/or precise control of traditional mechanisms in nanostructured arrays could facilitate their applications in a range of technologies from photovoltaics and solid state lighting to radiation detection.

Contact: Victor I. Klimov and Istvan Robel, LANL