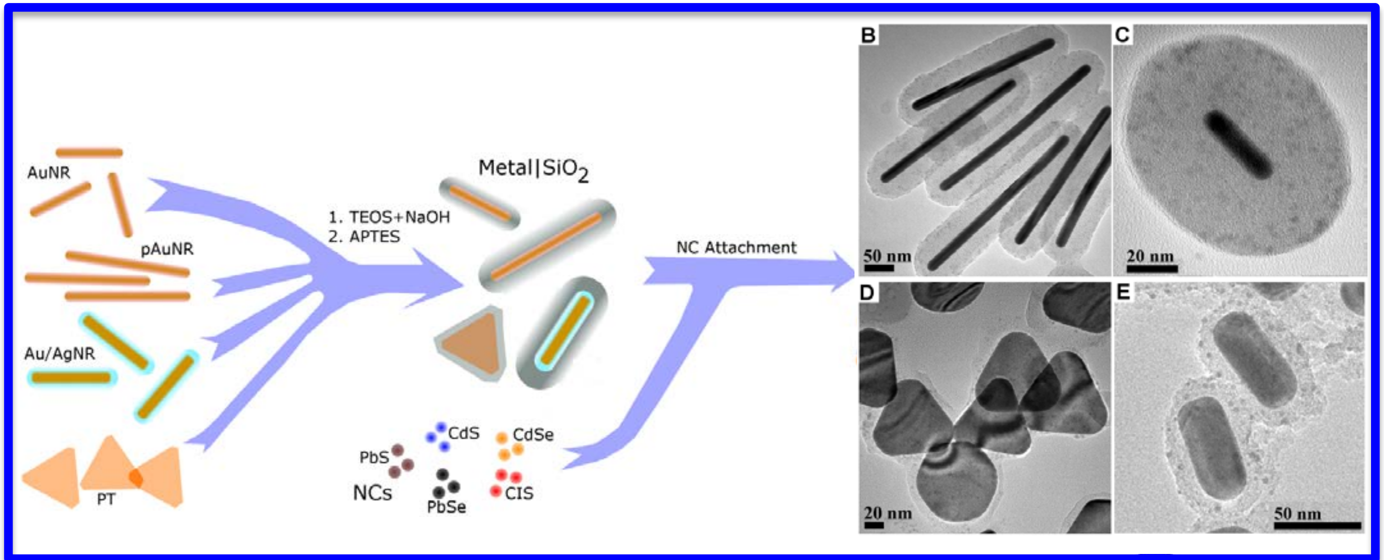
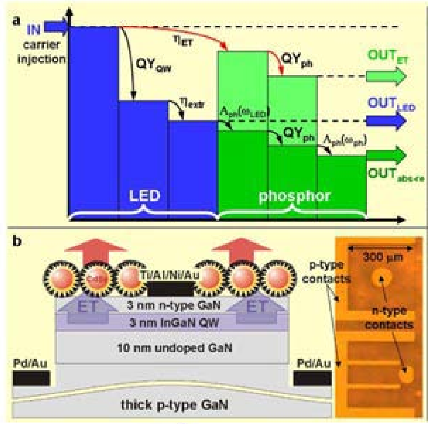
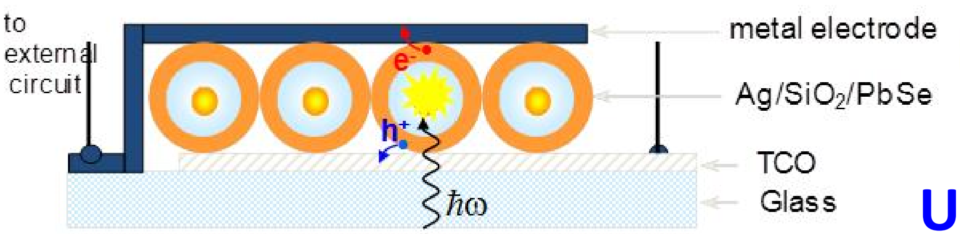
Mesoscale Priority Research Direction

Cooperative Phenomena in Excitonic-Plasmonic Systems: Plasmon-enhanced quantum-dot devices

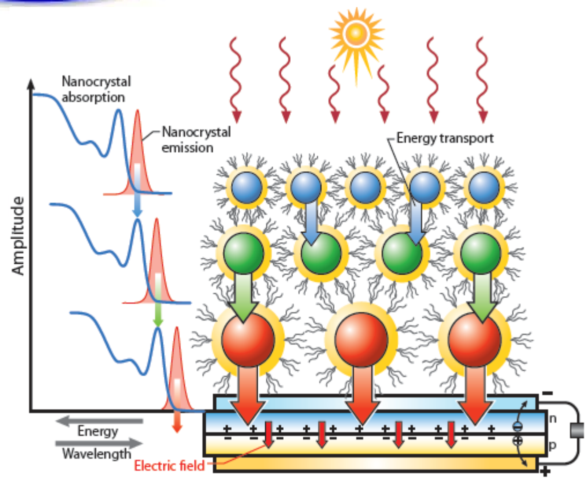




Efficient LEDs



Ultra-thin photovoltaics



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Opportunity

Semiconductor quantum dots have shown great promise as the active materials for efficient, low-cost light-harvesting and light-emitting devices. Plasmonic metal nanoparticles can greatly enhance absorption, emission and transport of excitations in such devices. Full exploitation of these effects requires advanced understanding and control over the interactions between disparate nanomaterials in an extended structure.

Meso Challenge

The functional building blocks are discrete nanoparticles, but the interactions of interest must occur on the mesoscale in order to be relevant to functional devices. The challenge is to design, fabricate and probe mesoscale-ordered superstructures, arrays and architectures.

Approach

- Powerful modeling tools for semiconductor and metal nanostructures can be combined to guide efforts to, e.g., enhance absorption or energy transfer.
- Advanced wet-chemical synthesis techniques will allow us to create mesoscale hybrid structures from nanomaterials of any size, shape and formulation.
- New spectroscopic, electronic and hybrid opto-electronic measurement techniques can probe charge carrier creation and motion in increasingly complex structures over a range of distance and time scales.

Impact

Combining metal and semiconductor nanoscale building blocks into exquisitely controlled mesoscale structures can result in large efficiency gains for the basic processes relevant to real optoelectronic devices. Thus, plasmon-enhanced quantum-dot devices are potentially the next big step in low-cost, high efficiency photovoltaics, light-emitting diodes, and radiation detectors.

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