NREL Highlights SCIENCE

Measurements of Spin Dynamics Reveal that Shape of Excitons in Quantum Rod Heterostructures Changes with Size

NREL discoveries will inform the design of high-efficiency nanostructured materials.

Changing the combination of semiconductors that compose a quantum rod heterostructure, along with its size and shape, can change electronic properties such as tendency for electron-hole separation—a particularly important parameter for efficient charge capture in solar cells. National Renewable Energy Laboratory (NREL) researchers used an advanced spectroscopic technique that monitors spin dynamics on the femtosecond timescale to determine that the exciton (the bound electron-hole pair) does not expand and separate along the length of a CdSe-seeded CdS rod, as had been previously proposed. In fact, for larger seed sizes, strain due to the mismatch of the crystal structures at the nanoscale CdSe/CdS interface causes the exciton to be compressed perpendicular to the long axis of the nanocrystal.

This work shows that cross-polarized transient grating experiments can provide information about both the size and shape of an exciton in a quantum rod heterostructure that cannot be definitively inferred using other optical techniques such as time-resolved photoluminescence, and without the instrumental complexity of scanning tunneling spectroscopy or near-field optical techniques. This knowledge can inform the design of nanostructured materials engineered for efficient charge separation and transport, ultimately supporting efforts to improve the conversion efficiencies of solar cells.

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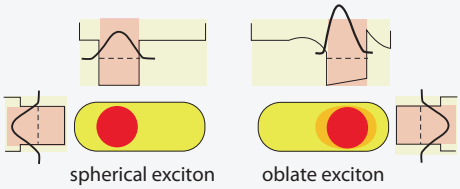
Reference: Smith, E.R.; Luther, J.M.; Johnson, J.C. (2011). "Ultrafast Electronic Delocalization in CdSe/CdS Quantum Rod Heterostructures," *Nano Lett.* 11, 4923.



Researchers discovered that for larger excitons, the strain due to the mismatch of the crystal structures at the nanoscale CdSe/CdS interface causes the exciton to be compressed perpendicular to the long axis of the nanocrystal.

Key Research Results

Achievement

Using femtosecond cross-polarized transient grating (CPTG) and polarization anisotropy, NREL was able to probe the extent of electronic delocalization in CdSe/CdS quantum rod heterostructures (QRH) with a "dot-in-rod" geometry.

Key Result

The findings show that CPTG is a sensitive technique that can provide new information about exciton size and shape as well as interfacial crystalline structure.

Potential Impact

This knowledge can inform the design of nanostructured materials engineered for efficient charge separation and transport, leading to improved efficiency in solar cells.

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