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Materials Chemistry

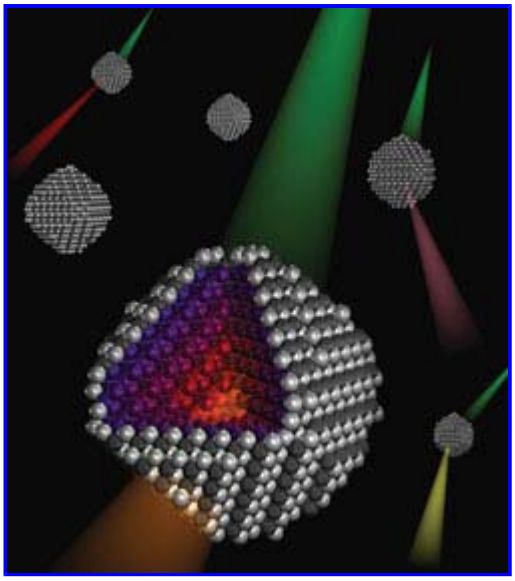
Quantum Dots That Don't Blink

Core structure suppresses blinking and leads to unusual spectral behavior

Celia Henry Arnaud

A team of scientists has synthesized semiconductor nanocrystals, or quantum dots, that are "nonblinking," in that they emit light steadily. Such behavior has long been a goal of scientists working with quantum dots and should improve the usefulness of the nanocrystals for biological labeling applications by increasing the number of photons the particles emit.

Blinking is a hallmark of fluorescent single molecules and nanometer-scale crystals; it occurs because the luminescence intermittently turns off even with continuous excitation. Excited quantum dots get rid of their extra energy through radiative processes—by emitting light—or nonradiative processes. "When the dot blinks off, nonradiative processes are winning," says team leader Todd D. Krauss, associate professor of chemistry at the University of Rochester. In quantum dots, this blinking is thought to be the result of extra charges that enhance nonradiative decay.



Ted Palwicki

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NO BLINKING Quantum dots with a gradient core emit continuously and at multiple wavelengths.

Krauss's team eliminates the blinking by making quantum dots whose compositions gradually change from the center to the shell (*Nature*, DOI: 10.1038/nature08072). They layer ZnSe on top of a CdSe core, anneal the layers, and deposit additional ZnSe around it. The process generates a ternary core with a radial composition gradient that smooths the particle's potential energy function and makes nonradiative processes less efficient.

However, the nonblinking comes with unusual spectral behavior. Quantum dots usually have a single, sharp emission peak. The new quantum dots, in contrast, have multiple peaks in their emission spectra. Multiple peaks might mean emission spectra of different quantum dots will overlap, which could complicate their use as biological sensors. The extra peaks come from part of the quantum dots' excitation energy being emitted as photons at longer wavelengths. In addition, the time the unblinking quantum dots stay in their excited state before emitting a photon is much shorter than that of traditional CdSe nanocrystals.

Krauss and coworkers, including Alexander L. Efros of the Naval Research Laboratory, posit that both the suppressed blinking and the unusual spectral characteristics can be explained by the lower efficiency nonradiative processes caused by the composition gradient. "Nonradiative processes become efficient only when you have very sharply defined potential barriers," Krauss says, and the gradient rounds off the corners of the potential energy function. Krauss plans to test their model of quantum dot behavior by varying the materials and sizes of nonblinking quantum dots.

Jennifer Hollingsworth, a chemist at Los Alamos National Laboratory who also is developing nonblinking quantum dots, comments that the work by Krauss and coworkers is "certainly an interesting addition" to earlier studies by two groups, including hers, that reported having significantly suppressed but not completely eliminated blinking in semiconductor nanocrystals. "It will be important to see whether they will be able to extend this approach to other systems and whether this thin-shell motif will hold up to processing."

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