Makers of quantum dots share 2023 Nobel Prize in Chemistry FREE

4 October 2023

Moungi Bawendi, Louis Brus, and Alexei Ekimov developed nanoparticles with properties that are dependent on the crystal size.

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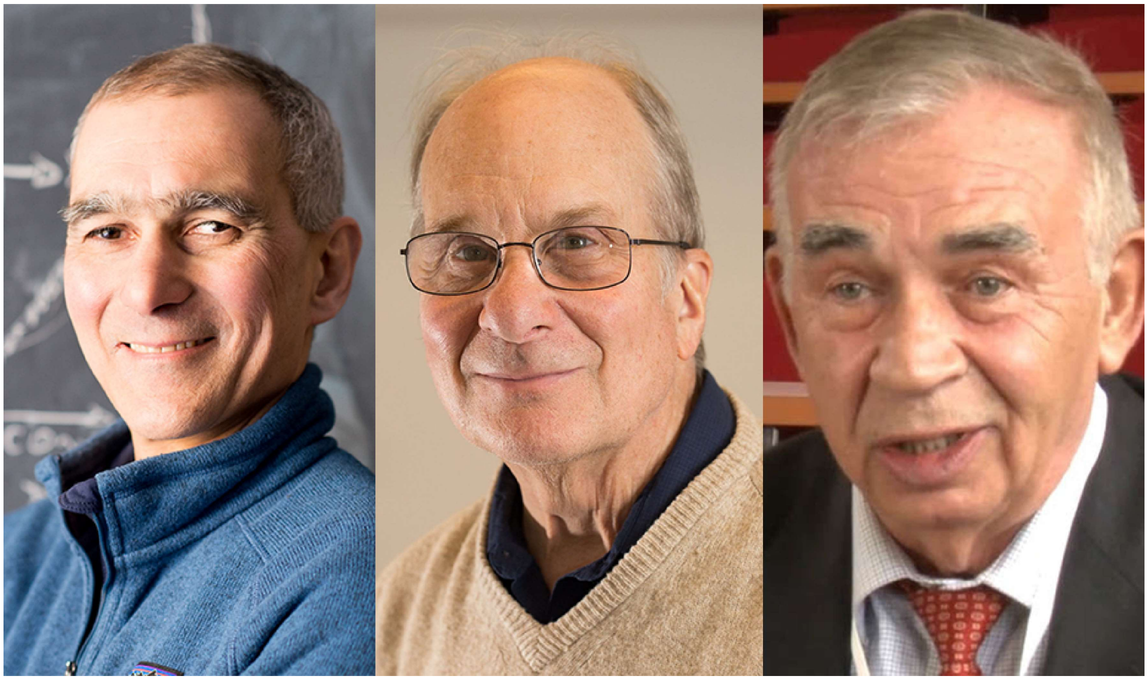
DOI: https://doi.org/10.1063/PT.6.1.20231004a



Left to right: Moungi Bawendi, Louis Brus, and Alexei Ekimov. Credits: Justin Knight, MIT, CC BY-SA 3.0; Columbia University; Nexdot

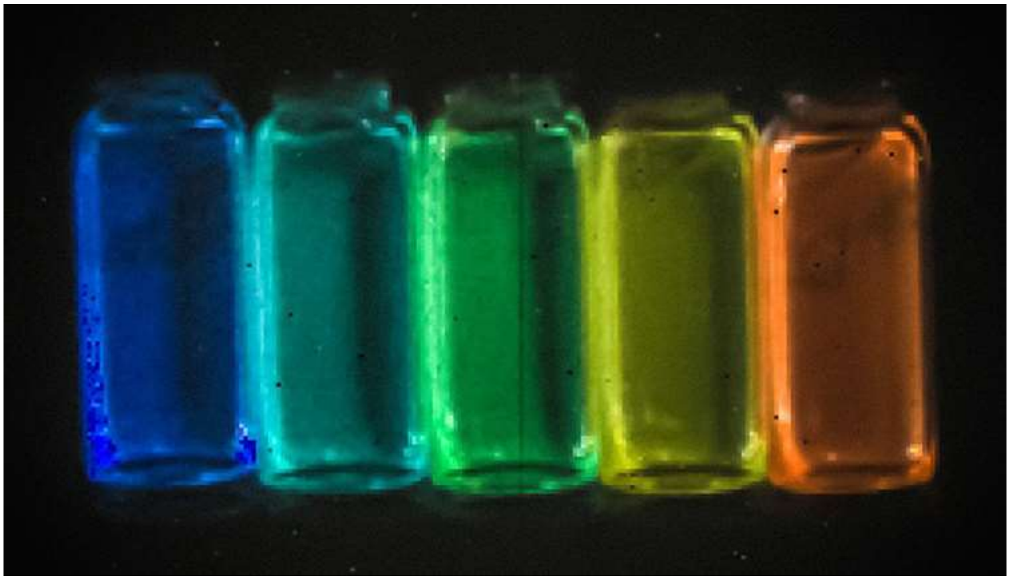
This article was updated on 4 October at 4:30pm EDT.

Moungi Bawendi (MIT), Louis Brus (Columbia University), and Alexei Ekimov (Nanocrystals Technology Inc) are to be awarded the 2023 Nobel Prize in Chemistry “for the discovery and synthesis of quantum dots,” the Royal Swedish Academy of Sciences announced on Wednesday. The researchers’ work harnessing quantum mechanics to tune the color of semiconductor crystals is included in a range of new technologies, including flexible electronics, LED lights, and TVs and other displays.

“This prize was very well deserved,” says Peter Lodahl, a quantum physicist at the University of Copenhagen. “We can now design artificial atoms to have the optical properties we wish rather than relying on the optical properties offered by nature.” Each laureate will receive an equal share of the 11 million Swedish kronor (about $1 million).

Composed of thousands or tens of thousands of atoms, quantum dots lie at the interface between the microscopic and macroscopic worlds. When the electrons in semiconductor nanocrystals are excited by an external light source, they behave more similarly to those of a single atom. Because the electrons are confined by the potential energy at the quantum dot’s boundaries, each is limited to discrete wavelengths, and the available energy states are quantized (see the article by Dan Gammon and Duncan Steel, *Physics Today*, October 2002, page 36). Quantum dots with diameters of 5–6 nm emit orange and red light, whereas 2–3 nm ones emit green and blue.

In 1979 at the S. I. Vavilov State Optical Institute in Saint Petersburg, USSR, Ekimov began studying silicate glass purposefully tinted with a little bit of copper chloride. He and Alexei Onushchenko measured the material’s optical absorption and found that the smaller the CuCl nanocrystals that formed in the glass, the shorter the wavelength of light the material emitted.



By changing the sizes of quantum dots, researchers can produce colors that span the visible part of the electromagnetic spectrum. Credit: Bawendi Group at MIT

In 1983 Brus and his colleagues independently found a way to make quantum dots without having them frozen in glass. They suspended 4.5 nm cadmium sulfide crystals in a liquid. Over time, they dissolved and then recrystallized to different sizes. Using absorption spectroscopy, Brus and his colleagues found that the older, larger particles had a spectrum similar to that of bulk CdS, but the younger, smaller particles exhibited the same blue-shifting effect that Ekimov had measured earlier.

Bawendi introduced a different synthesis method about a decade later. He and his coworkers manufactured their quantum dots by injecting the precursor materials into a heated solvent and then carefully controlling the temperature to grow specifically sized nanocrystals. The resulting quantum dots were free of defects, their sizes could be carefully controlled, and the method was adaptable to all sorts of materials.

Beyond the many commercial applications, researchers today are studying quantum dots for their various applications in nanotechnologies. By harnessing quantum dots as a source of single photons, for example, researchers are designing photon-based quantum bits to store and carry information across vast distances. (See the article by Lodahl, Arne Ludwig, and Richard Warburton, *Physics Today*, March 2022, page 44.) “The quantum technology aspects of quantum dots,” Lodahl says, “is what gets me out of bed in the morning.”

Selected articles in *Physics Today*

- Exploring mesoscopia: The bold new world of nanostructures (October 1993)
- Experiment signals a new phase of quantum dot measurements (January 1997)
- Optical studies of single quantum dots (October 2002)
- An optical probe can map quantum dot wavefunctions (November 2003)
- Engineering the energy levels in quantum dots leads to optical gain (July 2007)
- Beyond quantum jumps: Blinking nanoscale light emitters (February 2009)
- A deterministic source of single photons (March 2022)