Quantum Dots

Moungi G. Bawendi, Louis E. Brus and Alexei I. Ekimov were recently awarded the Nobel Prize in Chemistry for the discovery and development of quantum dots (QDs).

What is a quantum dot?

A quantum dot is an extremely small semiconductor particle between 2 and 10 nanometers in diameter. A relatively new, powerful field of science called "nano science", studies these tiny pieces of material.

Egad! I don't understand very much of those sentences . . .
Nanometer? Semiconductor?

What is a Nanometer?

A nanometer is one-billionth of a meter or 10^{-9} of a meter.

1. If a centimeter $= \frac{1}{100}$ of a meter, how many nanometers are in a centimeter?

2. A millimeter is one-thousandths of a meter. How many nanometers are in a millimeter?

A human hair is approximately 80,000–100,000 nanometers wide. Nanometers are *tiny*.

When a material is separated into a tiny portion its characteristics change. Each little piece of material has greater surface area when compared to its volume than a larger quantity of that material. Let's check this out.

Helpful formulas:

Sphere volume = $\frac{4}{3} * \pi * r^3$

Sphere surface area = $4 * \pi * r^2$

3. Compare the surface area of two spheres to their volumes and show your comparison like this; Surface area : Volume. Reduce their ratios to unit ratios like this … 4 : 1 .
   a. A pea has a diameter of about 1 centimeter (~ 0.394 inches). (Be careful, we just gave you it's diameter not its radius.)

   b. A soccer ball has a diameter of about 22 cm (8.66 inches).

The algebra involved: $\frac{Surface\ area}{Volume} = \frac{4 * \pi * r^2}{\frac{4}{3} * \pi * r^3} = \frac{4}{1} * \frac{3}{4} * \frac{1}{r} = \frac{3}{r}$

4. As the radius of our sphere gets smaller what happens to the value of the ratio ($\frac{3}{r}$)?

5. When you compare these two calculated ratios, how does the “surface area : volume” ratio change when you compare the little pea to the larger soccer ball?

So why is the surface area to volume ratio important? In smaller pieces, most of the is contained on its surface. As energy approaches the surface of that material, the energy can spread very quickly from its surface area and into its (relatively) tiny volume.

Consider an ice cube and a snowflake resting near each other.

6. At room temperature, which do you think will melt sooner?

What is a semiconductor?

Different materials are better at carrying electrical charges, light, heat or movement than others. Let’s see what you already know.

7. If you were flying a kite in a very active electrical lightning storm (duh), what would be the most scary string for your kite? Thin string or thin copper wire?

8. Why do you think that?

Your kitchen toaster has a cord that plugs in to a wall outlet. The cord is probably made of copper wire surrounded by rubber.

9. Why do you think that the rubber is necessary for the safety of your appliance?

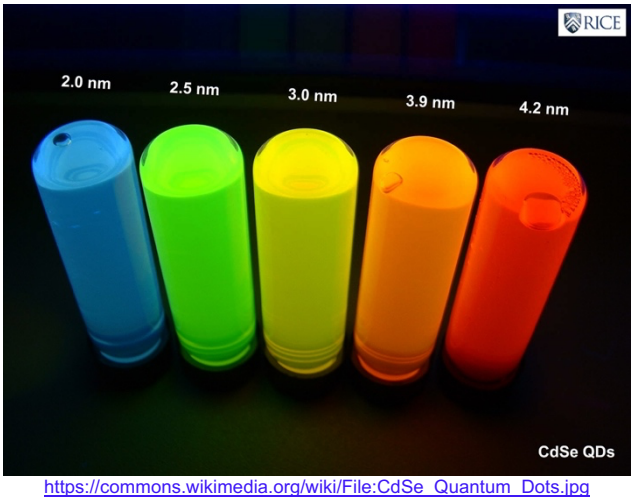
Semiconductors can be both a conductor and an insulator. When semiconductors are conducting energy, they do not do it as well as conductors. When semiconductors and insulating energy transfer, they do not do it as well as an insulator. The state that the semiconductor is in (such as being heated) determines how well it is able to conduct or insulate.
There are ways to measure how well a material conducts energy. Here are some common materials that are classified as conductors, semiconductors, or insulators.

Conductors	Semi conductors	Insulators
Metal Water Human body	Sand - SiO_2 - silica Silicon Carbon	Plastics Glass Rubber

10. Looking back at our original definition of a Quantum Dot. “Extremely small semiconductor particles between 2 and 10 nanometers in diameter.” Does this definition make more sense now?

So, what are these things good for?

Visual displays: Because of the ability to create various sizes of quantum dots, the ratio of Surface Area to Volume can be controlled. Light will be displayed for the different sized dots as very clear colors associated with the dot's size. The result is a more accurate display.



https://commons.wikimedia.org/wiki/File:CdSe_Quantum_Dots.jpg

Besides the excellent ability to display clear colors and incredible detail, quantum dots can be attached to or injected into other substances to mark or label something that needs to be monitored.

11. Can you imagine how this quantum dot technology being used today or will be used?

There are so many applications and uses for this nanotechnology that haven't yet been imagined or tried.

12. Can you imagine yourself entering into this field as your life's work?

Sources: https://innovate.samsungdisplay.com/blog/understanding-quantum-dots/ - :~:text=These are extremely small semiconductor,between its size and color.
https://www.nano.gov/about-nanotechnology/just-how-small-is-nano
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