Quantum Dots

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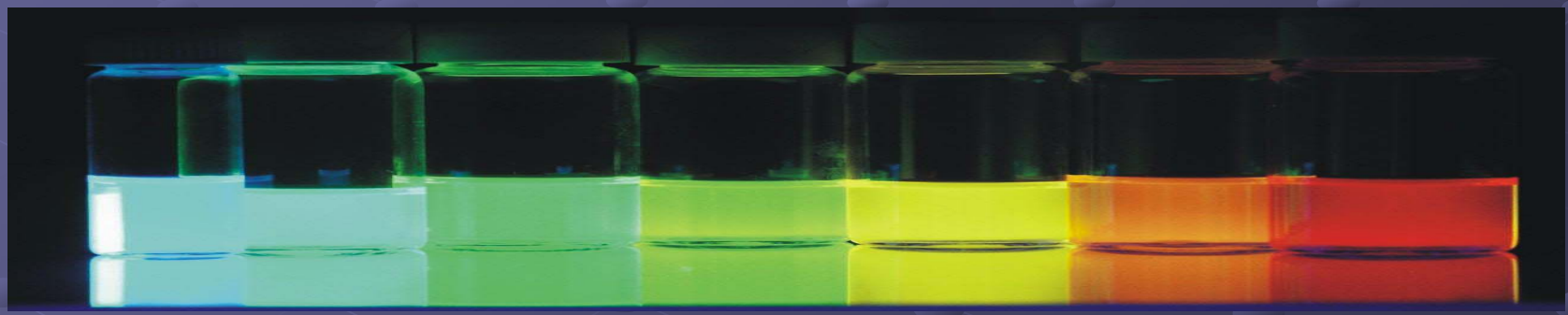


Size: 2.3nm → 5nm

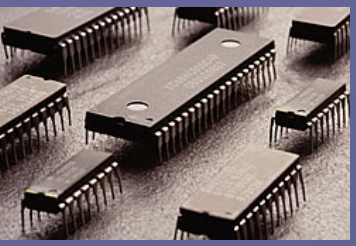
Source: http://www.greenspine.ca/media/quantum_dots_c.jpg

Why Quantum Dots?

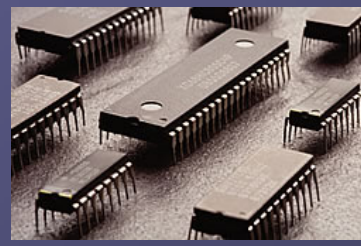
- I chose to research quantum dots because of an article that I read in a magazine over the summer. I thought that quantum dots sounded like they had a lot of applications and I wanted to know how they came up with the idea. I learned a lot about them and have come to the conclusion that they aren't as cool as I originally thought they were – THEY'RE BETTER!

What are Quantum Dots?

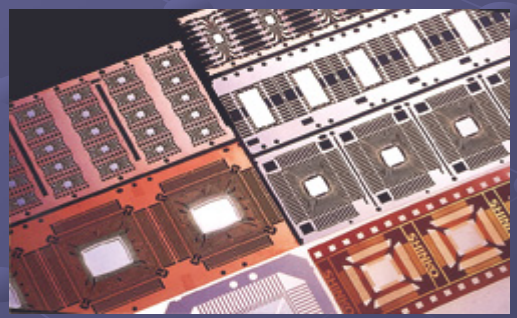
- Quantum dots are semiconductor nanocrystals that are so small they are considered dimensionless.
- Quantum dots range from 2-10 nanometers (10-50 atoms) in diameter.
- Animation

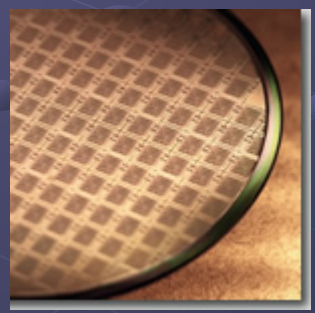


Quick Review of Semiconductors



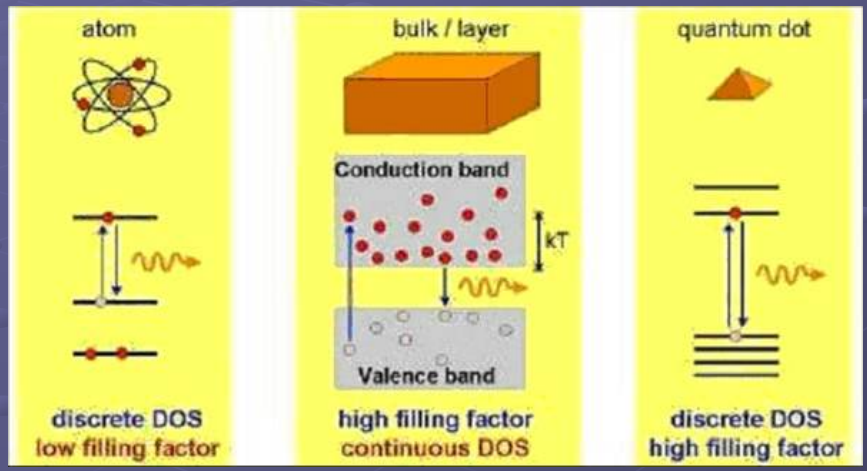
- A semiconductor is a material that has a small band gap between the valence and conduction band.
- An exciton pair is defined as an electron and the hole that it leaves behind when it is excited up to the conduction band.
- An exciton bohr radius is the distance in an electron-hole pair.
- A Quantum Dot is a semiconductor so small that the size of the crystal is on the same order as the size of the exciton bohr radius.
- This unique size property causes the “band” of energies to turn into discrete energy levels.





Source: http://www.smtresource.com/web/images/sections/icon-semi-150x150.jpg
http://www.export-japan.com/hocci/worldmetal/img/worldmetal01.jpg http://www.cpu-world.com/CPUs/32081/L_NS-NS32081D-6.jpg

Artificial Atoms?

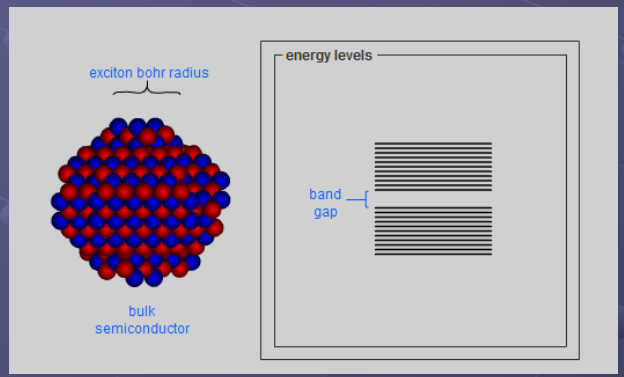


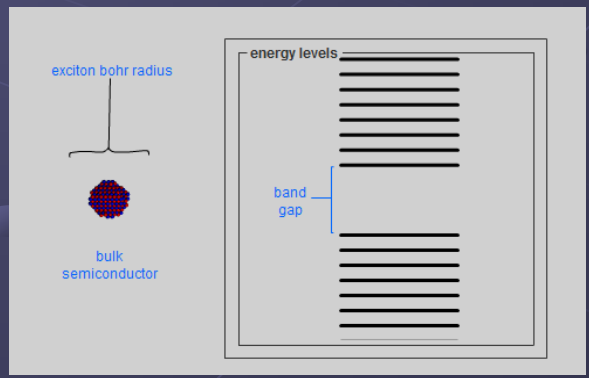
- Quantum Dots are more closely related to atoms than a bulk material because of their discrete, quantized energy levels.
- They have been nicknamed Artificial Atoms.

Source: http://www.nanop.de/animationen/graifkdateien/Mocvd_5.jpg

Exciton Bohr Radius & The Band Gap

- Band Gaps, and therefore the energy associated with them, depend on the relationship between the size of the crystal and the exciton bohr radius.
- Animation

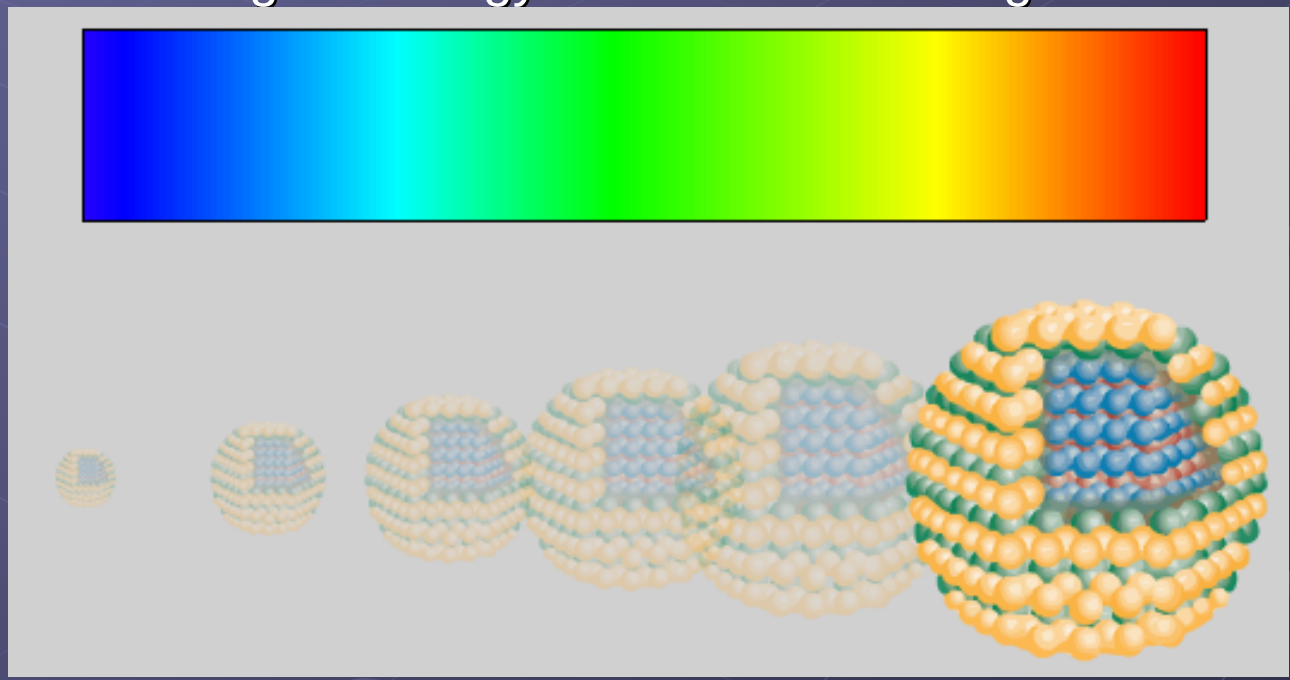




Source: http://www.evidenttech.com/qdot-definition/flash-player.php?mov=07_quantum_confine

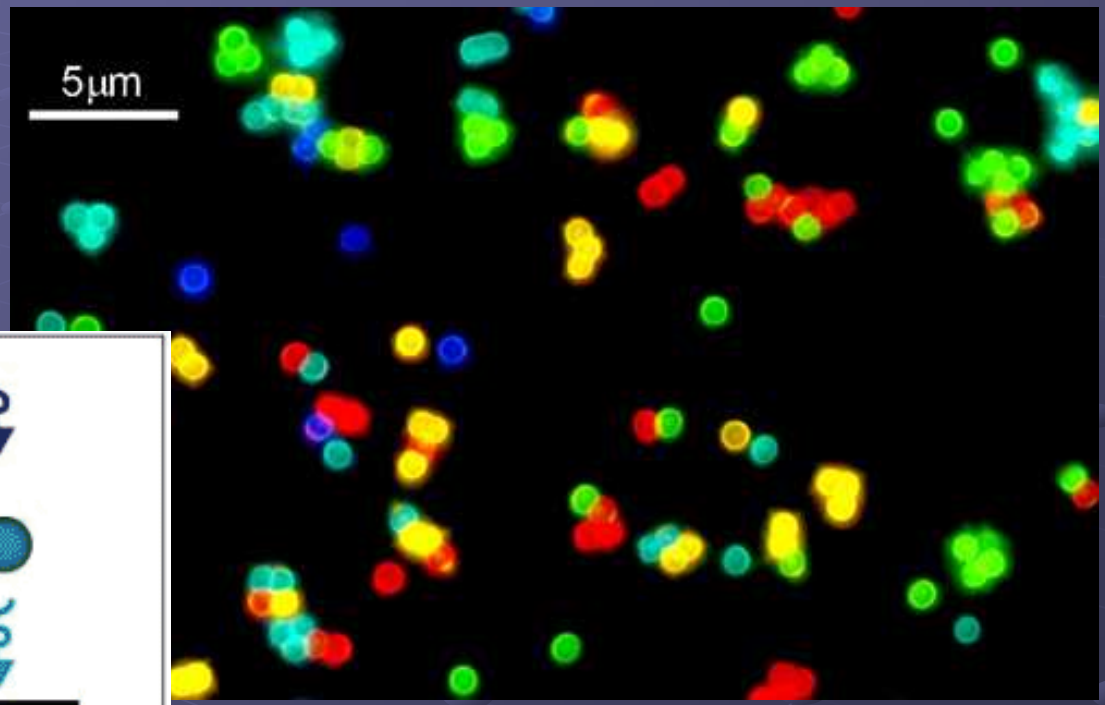
Colorific Properties

- The height, and energy difference, between energy levels increases as the size of the quantum dot decreases (remember the animation we just saw).
- Smaller Dot = Higher Energy = Smaller Wavelength = Blue Color



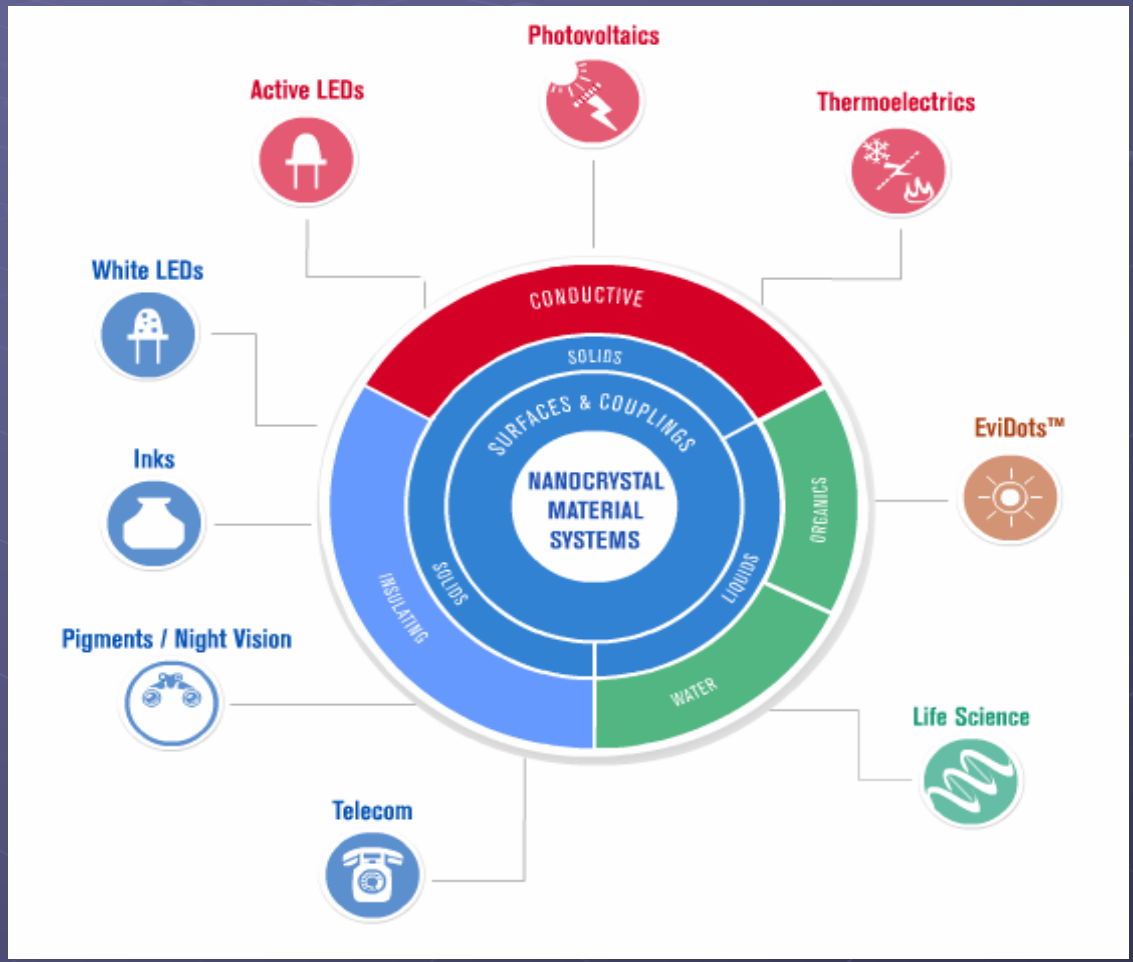
Source: http://www.evidenttech.com/qdot-definition/flash-player.php?mov=08_tunable

Color and Quantum Dots



Source:
http://optics.org/objects/news/7/7/2/Quantumdottag.jpg
http://www.qdots.com/live/images/figure9.gif

Applications of Quantum Dots

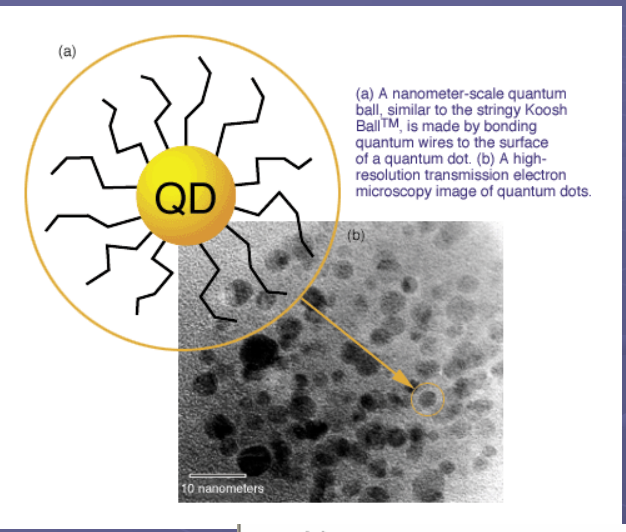


Source: http://www.evidenttech.com/applications/quantum-dot-applications.php

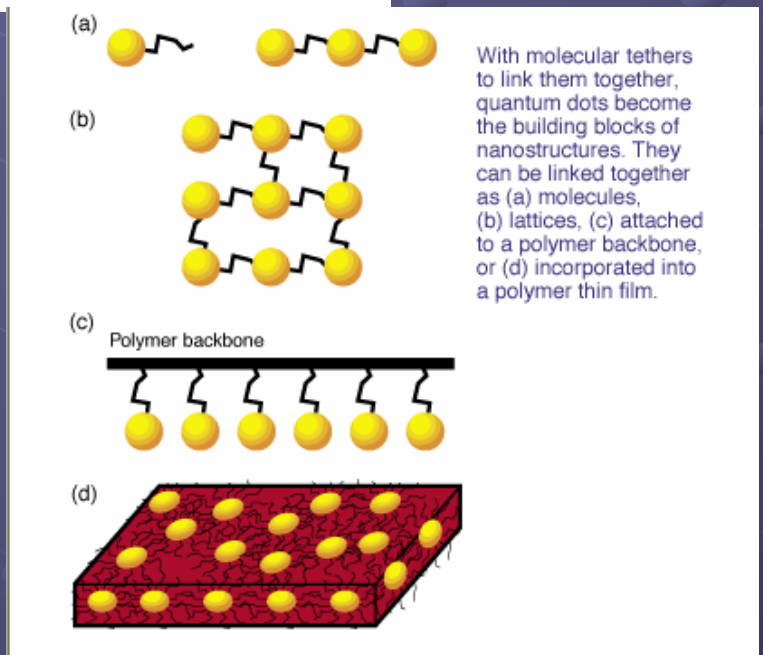
Future Applications of Quantum Dots

- White LED's – Replace Incandescent Light bulbs with red, green, and blue QD's to get white light.
- Active LED's – can get any color needed virtually pain free; since QD's are so small, they can be inserted into basically anything.
- Life Sciences – Can be used in place of traditional organic dyes; last longer and can be tuned more specifically than organic dyes.

Applications - Circuits



(a) A nanometer-scale quantum ball, similar to the stringy Koosh Ball™, is made by bonding quantum wires to the surface of a quantum dot. (b) A high-resolution transmission electron microscopy image of quantum dots.



With molecular tethers to link them together, quantum dots become the building blocks of nanostructures. They can be linked together as (a) molecules, (b) lattices, (c) attached to a polymer backbone, or (d) incorporated into a polymer thin film.

- By adding “quantum wires” to a quantum dot, many quantum dots have been strung together in various shapes and structures.
- Hypothetically, these quantum dot/wire structures could be used in circuits in place of traditional wires.

Source: http://www.llnl.gov/str/Lee.html

Conclusions

- Quantum Dots are a new and innovative perspective on the traditional semiconductor.
- Quantum Dots can be synthesized to be essentially any size, and therefore, produce essentially any wavelength of light.
- There are many possible applications of Quantum Dots in many different areas of industry/science.
- The future looks bright and exciting on all the possible applications of Quantum Dots.

Acknowledgements

- I would like to thank the Evident Technology company and, more specifically, their IT people for the great animations they have created.