# Quantum dots essay

A quantum dot is a nanoparticle or nanocrystal, a billionth of a meter in size [1]. These dots belong to the class of materials called semiconductors, which are actually crystals made of " periodic groups of II-VI, III-V, or IV-VI materials [2]. " Semiconductors are, of course, the foundation of the modern-day electronics industry. Whether they are used in personal computers or as light emitting diodes – their significance lies in the fact that an external stimulus, such as voltage or photon flux, may immensely alter their electrical conductivity.

This makes semiconductors an essential part of modern electrical circuits in addition to a variety of optical applications [2]. Quantum dots are unique semiconductors because of their size, ranging from 1-10 nanometers in diameter [3]. At such small sizes, materials are known to behave in a distinctive fashion. As a matter of fact, the size of a quantum dot gives it " unprecedented tunability [2]" and enables it to become a fundamental part of new technologies that the world has thus far been unacquainted with. Scientists working in the field of nanotechnology are hugely excited by the possible applications of quantum dots in the near future.

The practicability of these semiconductors " comes from their peak emission frequency's extreme sensitivity to both the dot's size and composition, which can be controlled [2]" with appropriate engineering techniques. The extraordinary sensitivity attached to quantum dots is, no doubt, quantum mechanical by character [2]. A quantum dot works pretty much as a large atom, which is stimulated most commonly by ultraviolet light before its electrons are energized and raised to a higher level. When the electrons return to their “ lower and stable state [4],” the extra energy is released as light that corresponds to a certain frequency.

In point of fact, the size of a quantum dot is dependent on the number of atoms that it is composed of [4]. Quantum dots may exhibit the entire range of colors of a rainbow [5]. However, the color of light that is emitted is determined by the size of the quantum dot [4]. The basic material that a quantum dot is composed of is a substance with one electron missing in its “ valence band giving it a positive charge [6].

The basic material is very small. At the size of a dot, electrons begin to orbit it. Given that quantum dots do not possess protons or neutrons, the mass at the center of a quantum dot is much smaller than that of an atom. Therefore, a quantum dot exerts a smaller force on the electrons that orbit it. This creates an orbit that is larger than that of a simple atom.

Due to its small mass, scientists are capable of accurately calculating and changing the size of the quantum dot’s band-gap. It is the band-gap that determines the frequencies that a quantum dot would respond to. Being in control of the process of changing the band-gap, scientists are provided with greater flexibility in handling the applications of quantum dots [6]. Quantum dots could be manufactured with a variety of materials, including silicon, germanium, indium phosphide, zinc sulphide, cadmium selenide and lead sulphide [3].

Because quantum dots have made their way into the hands of biologists, who are currently using them to discover new ways of curing diseases, a protective polymer can be used to coat these luminous dots in order to prevent toxic materials from harming the human body. There are many processes of manufacturing quantum dots, such as molecular beam epitaxy, electron beam lithography, colloidal synthesis and chemical vapor deposition [6]. The easiest and the cheapest method to manufacture them is benchtop colloidal synthesis. Moreover, both electrochemical techniques as well as chemical vapor deposition could be used to create " ordered arrays of quantum dots on a substrate material [4]. " Scientists have not thus far realized all possible applications of quantum dots.

One of the ways in which this technology would be of tremendous use to humanity is by making solar cells " ultra-efficient [1]. The following is a summary of the advantages of quantum dots when applied as solar cell semiconductors: The first advantage of quantum dots is their tunable bandgap. It means that the wavelength at which they will absorb or emit radiation can be adjusted at will: the larger the size, the longer the wavelength of light absorbed and emitted. The greater the bandgap of a solar cell semiconductor, the more energetic the photons absorbed, and the greater the output voltage. On the other hand, a lower bandgap results in the capture of more photons including those in he red end of the solar spectrum, resulting in a higher output of current but at a lower output voltage.

Thus, there is an optimum bandgap that corresponds to the highest possible solar- electric energy conversion, and this can also be achieved by using a mixture of quantum dots of different sizes for harvesting the maximum proportion of the incident light. Another advantage of quantum dots is that in contrast to traditional semiconductor materials that are crystalline or rigid, quantum dots can be molded into a variety of different orm, in sheets or three-dimensional arrays. They can easily be combined with organic polymers, dyes, or made into porous films. In the colloidal form suspended in solution, they can be processed to create junctions on inexpensive substrates such as plastics, glass or metal sheets.

When quantum dots are formed into an ordered three-dimensional array, there will be strong electronic coupling between them so that excitons will have a longer life, facilitating the collection and transport of ‘ hot carriers’ to generate electricity at high voltage. In addition, such an array makes it possible to generate multiple excitons from the absorption of a single photon [1]. Quantum dots may very well be used in the quantum computers of tomorrow, in addition to high resolution TV screens. As suggested previously, these dots of light could turn out to be extremely useful in the field of medical science to boot. Quantum dots could be encased in a shell that is “ tuned to mimic organic receptors [4]” in the human body. Such receptors could correspond to specific diseases or viruses.

The quantum dots within their shells could then find and attach themselves to the disease or virus en masse. Seeing that the quantum dots are fluorescent in nature, the location of the medical problem could be made easily detectable by means of them. Another advantage of applying quantum dots in this manner is that the number of receptors that are needed on the surface of a dot is smaller than the number of receptors on the entire surface area of the dot. Hence, there is left plenty of room on the dot to place other things, for example, particular drugs to treat a disease that the quantum dot has been enabled to find. This is the reason why medical scientists are working on tuning quantum dots to find cancer cells and also to deliver drugs for chemotherapy directly to those cells.

In this manner, healthy cells could be saved from being poisoned, and the atrocious side effects of cancer treatments can be avoided [4]. Quantum dots may also be used in household lighting appliances in the future. The energy that is released from these dots as light is approximately one hundred percent of the energy that goes into the system. This exceedingly high efficiency makes quantum dots very appealing for lights, and " as individual colour pixels in vibrant colour flat panel displays [4].

" In order to be used in lighting systems, quantum dots can be layered and then sandwiched between " two electrically conductive layers" [4]. When a current is directly applied to the sandwiched quantum dots in between the layers, they would fluoresce, thereby becoming a highly efficient light source [4]. Yet another possible use of quantum dots is in biosensors that are used in the detection of biological warfare agents. Nowadays the " fluorescence-based biosensors [3]" are dependent on natural dyes for tagging the agents.

These dyes light up so as to advise whether a deadly biological warfare agent is present. The problem with these dyes lies in the fact that they light up with a " broad spectral width [3]" which limits their usefulness to a rather small number of hues. The organic dyes are also known to degrade. With the use of quantum dots, these problems can be transcended, however.

Quantum dots make the entire spectrum of colors available, and there is very little degradation in them over time. Quantum dots further make it possible to very easily manufacture light emitting diodes. These dots can be put in a polymer to make films that are 1000-2000 angstroms thick. Once again, because of their size it is possible to easily make “ precisely tuned blue or green [3]” light emitting diodes. Quantum dots light emitting diodes can be used in future to release white light for use in laptops.

These practical dots may additionally be used in the creation of extremely fast, “ all-optical switches and logic gates [3]. ” These all-optical switches and logic gates could “ work faster than 15 terabits a second [3]. Whereas the Ethernet normally handles approximately 10 megabits every second, a system based on quantum dots would work a million times faster. What is more, quantum dots could be used in “ all-optical demultiplexers [3]” that could separate a number of “ multiplexed signals in an optical fiber [3]. ” Other possible applications of quantum dots include encryption as well as “ all-optical computing [3].

” Seeing that modern-day innovations in science and technology are constantly in want of smaller packages, greater capacities in addition to faster speeds, quantum dots appear as a real blessing. A single quantum dot could function as an entire microelectronic system to establish the foundation of nanoelectronics. At their unique sizes, billions of quantum dots could fit on a pin head. The dots could work together at an incredible speed. Furthermore, they have very “ low power requirements [3].

” For all of the above reasons, the world of science may expect a heavy increase in the applications of quantum dots in the near future. Indeed, quantum dots are made to stay with us for as long as we can imagine.