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QUANTUM DOTS- SMART SEMICONDUTOR NANOMATERIALSLIGHTENING THE OPTOELECTRONIS FIELDS

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ABSTRACT

Light is the power of perception by vision. Due to technological development, quantum dots are developed into new, promising classes of material for superior lighting and display systems. Quantum dots have many interesting and important applications in nanotechnology. They have remarkable optical properties, which can be used for fabrication of quantum LEDs, white LEDs, photo detector devices. Here, we will discuss the benefits, applications and future trends of quantum dots.

Keywords: Quantum dots, LED light, Nano-technology, Semi-conductors.

1. INTRODUCTION TO NANOTECHNOLOGY

Nanotechnology is the engineering of functional system at the molecular scale[1]. It is the art and science of manipulating matter at the nanoscale to create new and unique materials and products with enormous potential to change society. 1nanometer (nm) =1billionth of a meter. There are two important approaches in nanotechnology.

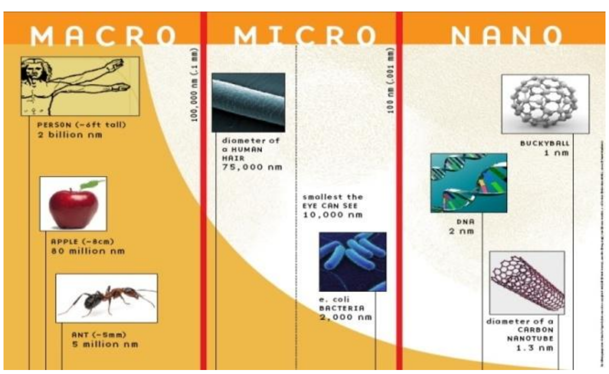

Fig (1): micro, macro and Nano diagrammatic representation

In top down approach, building something by starting with a larger component and carving away material (like a sculpture). In bottom up approach, building something by assembling smaller components (like building a car engine).

2.INTRODUCTION TO QUANTUM DOTS

Quantum dots may be the future of computing. They are small devices that contain a tiny droplet of free electrons. Typical dimensions are between nanometer to a few microns. Quantum dot can have anything from a single electron to a collection of several thousand [2]. The size, shape and number of electrons can be precisely controlled. As same as an atom, the energy levels are quantized due to the confinement of electrons. The 3D spatial confinement is observed in the quantum dots. In some of them even if one electron leaves the structure there is a significant change in properties. Unlike atoms however, quantum dots can be easily connected to electrodes and are therefore excellent tools to study atomic like properties. The potential of nearby metal gate is changed. The atomic structure might behave as a lead one minute and gold next minute

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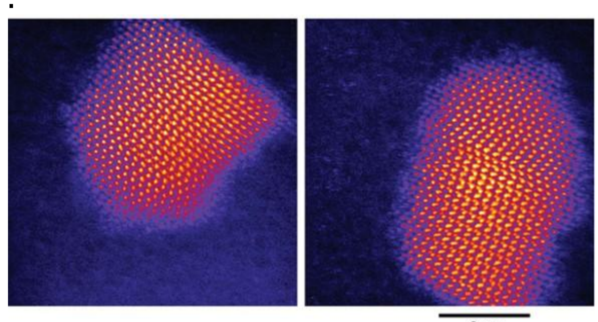

Fig (2): TEM image of 3nm quantum dots

3. FABRICATION OF QUANTUM DOTS

There are three major fabrication methods for quantum dots. The first method involves growing quantum dots in a beaker. This approach was introduced by Louis Brus in the late 1970s when he was at Bell Labs. Originally, the quantum dots grown were semiconductors such as cadmium selenide or cadmium telluride, but now people have made quantum dots of nearly every semiconductors and also of many metals (gold, silver, nickel, cobalt, to name a few) and insulators as well. The semiconductors have the fascinating property that their color depends on the size of the dot, thus it is possible to use one chemical substance and yet make structures with a wide variety of colors simply by varying the size of the dot. The metal dots have a range of interesting electrical, magnetic and catalytic properties [3]. The architecture of these chemically grown dots is formed by coating one material with another becoming more common. These structures can be used to shield a chemically or electrically sensitive dot from an unfriendly environment

Fig (3): Image of colloidal quantum dots

In second method, quantum dots create at or near the surface of a semiconductor crystal. Originally, such quantum dots were formed by growing a semiconductor hetero structure (a plane of one semiconductor sandwiched between two others). If the sandwiched layer is thin enough, about ten nanometers or less, electrons can no longer move vertically in a classical fashion, they are effectively trapped in that dimensions. Such a structure is called a quantum well. Quantum wells generate photons of very specific wavelengths and can be found in lasers used in laser pointers or key rings. Quantum wires can make lasers that are switchable at very high speeds and can be used as wave guides. Now rotate ninety degrees and do the same again. The electrons are now ready to use in all three dimensions and you have a quantum dot.

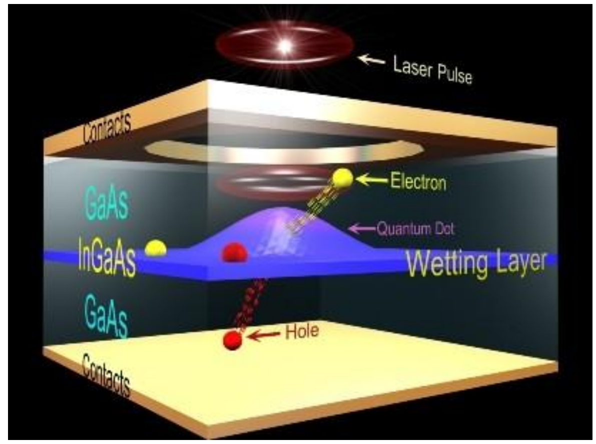

Fig (4): Sandwiched layer of InGaAs

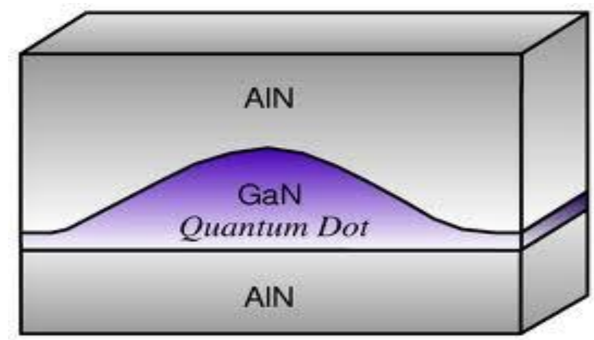

Fig (5): GaN quantum dot preparation on AIN

In third method, researchers began to grow "self-assembled" dots by depositing a semiconductor material with a larger lattice constant onto a semiconductor with a smaller lattice constant. Typical systems were germanium on silicon and indium arsenide on gallium arsenide. These self-assembled dots that have been used to fabricate quantum dot lasers. This same method was used to create a single photon detector [4].

4. APPLICATIONS OF QUANTUM DOTS

Quantum dots have wide range of applications, some of them are, and in different approach to creating white light several Sandia researchers have developed the first solid-state white light-emitting device using quantum dot [5]. In future, the use of quantum dots as light-emitting phosphors may represent a major application of nanotechnology. In the field of nanophotonics IBM announced that, future technology utilizing nanophotonics will be silicon chips that use light instead of or in addition to electrical signals. The most interesting thing in this technology is, it will work in standard ninety nanometer semiconductor form factor.

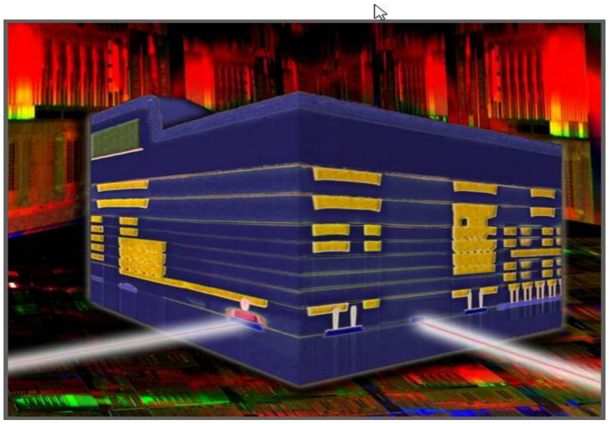

Fig (6): IBM is circulating this shot of a 90nm silicon-based nanophotonics chip cross section.

Quantum dots may someday light your homes, offices, streets and entire cities. Quantum dot LED's will produce any color of light, including white. [3] These LED's are extremely energy efficient. They use only a few watts, while a regular incandescent lamp uses 30 or more watts for the same amount of light. Quantum dots may one day power the world with clean, efficient energy. Solar cells can use quantum dots to convert sunlight into electricity more efficiently than conventional designs. Quantum dot solar cells are difficult to make and not yet cost effective. Quantum dots may one day save your life. Medical imaging has begun to colloidal quantum dots much like the ones we look today. Quantum dots last longer in the system and are brighter than many organic dyes and fluorescent proteins previously used to illuminate the interiors of cells.

They also have the advantage of monitoring changes in cellular processes while most high-resolution techniques like only provide images of cellular processes frozen at one moment. Quantum dots may be the future of computing. Lots of effort is currently being put into the field of spintronics to progress toward quantum computers. A quantum computer would use spin of the electron instead of the charge like current computers. In this way it may use considerably less energy than a regular computer while being significantly faster.

5. FUTURE SCOPE OF QUANTUM DOTS

The future is bright for quantum dots, the usefulness and application of quantum dot technology continues to expand and research is striving to bring their benefits to more and more technologically applied fields.

Anti-counterfeiting capabilities: In this technique, the quantum dots are injected into liquid mixtures, fabrics and polymer matrices. Ability to specifically control absorption and emission spectra to produce unique validation signatures, almost impossible to mimic with traditional semi-conductors [6].

Counter-espionage/ Defense applications: Integrate quantum dots into dust that tracks enemies. Protection against friendly-fire events.

In future LED televisions using quantum dots will be remarkable technology. Traditional solar cells are made of semi-conductors and expensive to produce [7].

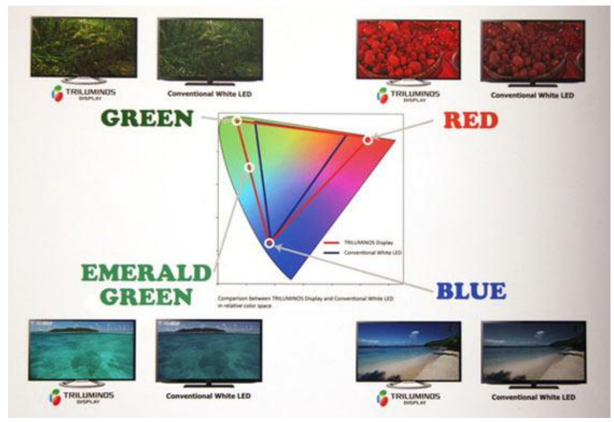

Fig (7): Quantum dots exhibiting different colors.

Theoretical upper limit 33% efficiency for conversion of sunlight to electricity for these cells. Utilizing quantum dots realization of third-generation solar cells at 60% efficiency in electricity production.

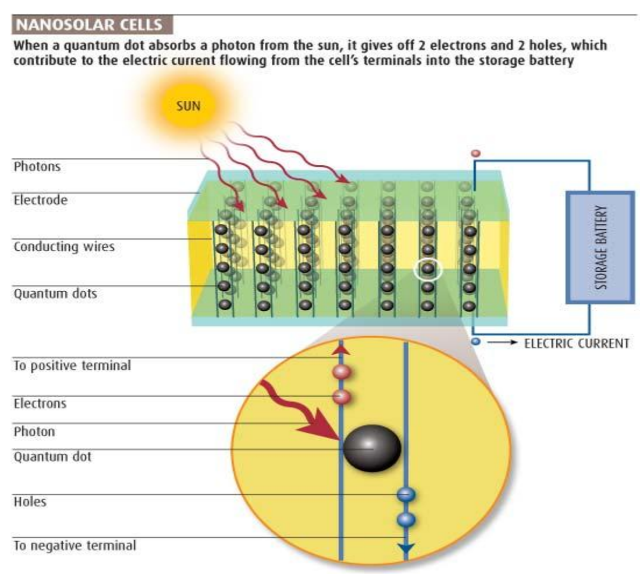

Fig (8): Quantum dot solar cell

In the future, quantum dots could also be armed with tumor-fighting toxic therapies to provide the diagnosis and treatment. Quantum dots can be useful tool for monitoring cancerous cells and providing a means to better understand its evolution.

Quantum dots offer a wide broadband absorption spectrum while maintaining a distinct, static emission wavelength.

6. CONCLUSION

In this paper we mainly focused on quantum dots fabrication and its various applications. Quantum dot LEDs are used for fiber optic communications and solar cell fabrication. According to the market demand and higher requirements of applications, future research directions are figured out and needed to be realized soon. In future we may expect quantum dots will rule the entire lightening devices in the world.

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