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A view on transport and quantum confinement properties of nano-scale materials - applications

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ABSTRACT

Today nano fields are integrated into many components of everyday life. It is one of the important fields that involves the different fields like Physics, Chemistry, Biology, medicine,
Quantum electronics, computers engineering, information technology etc. The application and use of this technology in various fields day by day has been changing due to their transport, thermal, optical, electromagnetic properties at nano size are changed when compared to the bulk material. Also nano scale science quenches for clean and inexpensive energy. This paper is focused on certain nano scale applications related to the transport and quantum confinement of nano particles.

KEY WORDS: Nanotechnology, nanoscience, nanoparticles.

1. INTRODUCTION

Particles with size range 1-100 nm are called nanomaterials and the fabrication of devices/application within that size range is a technological side for nano researchers. Nobel physicist Richard P Feynman in his historical lecture in 1959, mentioned about smaller tools in the place of big machines and he said "this is a development which I think cannot be avoided". His thought has given us an origin for nano technology and further studies went down to the atomic level. The nonmaterial has unique properties due to its increases surface area with respect to volume and quantum size effect. Also it is learnt that most of the materials properties are affected due to size effect. When the material size /particle size is less than the Debroglies wavelength of electrons then very closely existing discrete energy levels configuration is formed with electrons and holes as spatially confined as electric dipoles was observed. At nanoscale dimensions, elements have extremely unique characteristics that are being used for expansive applications in nanotechnology.

Nano scale –Application: Nanoparticles, on the basis of their dimensionality generally classified as 1D, 2D and 3D nanomaterials.1D nanomaterials are in one dimensional nanometer scale. These are like thin films or surface coatings. They are very much useful in the fields of engineering and chemistry. Using the materials one can make computers circuit chips, hard coating anti-reflection eyeglasses. The two dimensional nano materials are called 2D nano materials. These are useful in nanopore filters, asbestos fibers etc. 3D nanomaterials are nano scale in all three directions Best example of them is colloids

The Increase in surface to volume ratio for nanoparticles, the inter atomic spacing varies and there by the surface pressure changes. Due to these changes, the Surface energies, the transport properties like momentum or diffusion, viscosity, conductivity will be effected. Also at nano level of a substance, the atomic particles behavior can be compared to that of gas particles behavior. According to molecular theory of gases the transport properties;

Thermal conductivity

$$K = 1/3\ mn\ C\ Cv\ \lambda = 1/3\ mn\ C\ Cv\ (1/\sqrt{2}\ \pi d^2 n) = 1/3\ m\ C\ Cv\ (1/\sqrt{2}\ \pi d^2) \quad (1)$$

Viscosity

$$\eta = 1/3\ mn\ C\ \lambda = 1/3\ mn\ C\ (1/\sqrt{2}\ \pi d^2 n) = 1/3\ m\ C\ (1/\sqrt{2}\ \pi d^2) \quad (2)$$

Diffusion

$$D = 1/3\ C\ \lambda = 1/3\ C\ (1/\sqrt{2}\ \pi d^2 n) \quad (3)$$

In all above cases, we can observe that thermal conductivity, viscosity and diffusion are function of mass, m, particles density, n, average velocity, C, specific heat of substance at constant volume and mean free path λ. Knowledge of transport properties of the industrially important solutions is often required for industrial applications such as making cleaning products, paints, inks, adhesives, dispersions for textiles, papers, polystyrene, etc.

Basing on transport properties we have developed number of applications. They are;

- The property of more surface area to volume character in Zinc oxide particles scientists found that they are useful in showing blocking of UV radiation. The windows of Audi A4 series cars are coated with glass laminates that block harmful ultraviolet radiation that can cause skin cancer.
- UV/VIS spectroscopic studies shows that particles which are smaller, absorb more amount of solar radiation. Hence for increasing absorption of solar radiation in photovoltaics, silicon nano embedded thin films on the panels are very useful.
- Nano particles are very much useful in all sun screen lotions since they block ultraviolet radiation in falling on skin directly.
- For a nanoparticle materials, as they have large surface area compared to their volume, they interact more

with the liquid medium and as a result of it they gain good ability to form suspension in the medium. Also, when we move from bulk to dot dimensions that are to nano scale, the electronic energy levels narrow down and become discrete. At this stage, nano particle behaves like a particle in potential well of box of length L. Applying quantum mechanics concept, we have energy of particle in the the box as discrete and it is given as

$$En = n^2 h^2 / 8m L^2 \quad (4)$$

In the case of bulk materials the graph studied between N(E) versus E_n is a continuous curve whereas for nano dot particles (3D) the curves studied are quasi continuous bands. Due to this the electrical properties of nano particles changes. Also in some materials due to discrete energy levels configuration, the atomic particles may orient in one direction so that it may show super paramagnetic property. The nano materials which show strong magnetism now a days are very useful in memory storage devices ie Medical data recording instruments, cell phones etc.

We may observe that the nanoparticles possess unexpected optical properties. It is because of quantum effects energies changes and hence wavelength changes. For example, gold nanoparticles appear deep red to black in solution. Also, depending on the nano particle size different colors are seen. Basing on this unusual color paints are prepared with nano particles.

Nanoparticles technology is helpful in computers, communications, and other electronics applications to provide faster, smaller, and more portable systems that can manage and store more and more amounts of information. These continuously evolving applications include:

- Nanoscale transistors
- Displays of new TVs, laptop computers, cell phones, and digital cameras devices incorporate organic light-emitting diodes of nanostructure polymer films called as OLED. These screens offer brighter images and also wider viewing angles, at low power consumption.
- Nano coated thin-film solar electric panels are used to power mobiles, electronic devices and computers.
- Clothing with piezoelectric material nanowires as fabric will generate usable energy with incident light, or body friction.
- Nanotechnology is helpful in providing us clean drinking water at low-cost. Researchers have discovered unexpected magnetic interactions between ultra-small specks of rust. It helps us in removing arsenic or carbon tetrachloride from water. Also nanostructure filters and use of nano fiber electrodes will remove virus cells and salts from water.
- Nanoscale sensors provide cost-effective structural monitoring of the condition and performance of bridges, tunnels and rails.

2. CONCLUSION

Today the roots of nano science and technology deeply entered into different fields. Their transport and quantum confinement properties are helpful in creating ard studying different applications in various fields today. It is open to everyone. The economy of any country depends on its energy management and efficiently using the upcoming new technology with their resources. In meeting with the energy demand for the growing need one has to protect our environment also. Today many scientists are looking into ways to develop this nanotechnology, along with means to reduce energy consumption and lesser toxicity burdens on the environment.

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