Riding The Nanowave

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1. Introduction

Over the last few decades the size of the electronic components has been shrinking at a rapid pace. Recent advancement in the field of nanotechnology will greatly help this process of micro-miniaturisation. Before going into details, let us have a rough idea of the scale we are talking about. A nanometer is a billionth of a meter i.e. about 1/80,000 of the diameter of a human hair or 10 times the diameter of a hydrogen atom. Nanotubes are the key components of nanotechnology. Carbon nanotubes, which were discovered in 1991, consist of rolled up sheets of carbon hexagons. Researchers have found that attractive forces among the atoms and molecules hold nanotubes firmly on the surface they are placed on. Their positions and orientations and hence their shapes, can be altered by bending them. Nanotubes can be electrically conductive or semiconductive depending on their helicity leading to nanoscale wires that exhibit electrical conductivity as high as copper, thermal conductivity as high as diamond, strength 100 times greater than steel at 1/6th of its weight and high strain to failure.

2. Application Areas of Nanotechnology

2.1 Nanotechnology in medical field

Medical researchers are planning to use nanoscale tubes to push very tiny amount of drugs dissolved in water to exactly where they are needed in human body. But real-life application of the theory poses the problem of building pumps on nanoscale that would do the job without getting clogged by any biological molecule. The solution suggested is use of photocapillarity i.e. when light just beyond the visible range is incident on the light responsive molecules they attract water and trigger the advancement of water through the channel. Moreover, scientists have used nanotechnology to create a biochip that can rapidly identify DNA and protein molecules.

2.2 Nanotube displays

When current is sent through carbon nanotubes, if the voltage is high enough, the electrons arriving at the end of the tube will fly towards the anode. Such a "field emission" effect is being used in flat panel displays. Carbon nanotubes act as the source of electrons. By squeezing a paste of single walled carbon nanotubes through a 20 micrometer mesh, the tubes were forced into vertical position on a series of metal strips mounted on a glass sheet. The strips serve as cathodes, while the glass serves as the back of finished display. The front of display is another glass containing red, green and blue phosphors and a strip of indium-tin-oxide anode running from side to side. This has reduced the thickness of flat panel displays a great deal.

2.3 Nanotubes in Integrated circuits (ICs)

Carbon nanotube technology breakthroughs will pave the way for microprocessors beyond silicon. Nanotube transistors can be made using individual multi-wall or single-wall nanotubes as the channel of a FET (Field Efect Transistor). The current flowing through a nanotube can be changed by a factor of 1,00,000 by changing the voltage applied to a gate. As the FET is cooled down from room temperature to 4K its behaviour changes to that of a single electron transistor. Scientists have successfully

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constructed logic gates based on carbon nanotubes and integrated a series of devices on a single chip. These nanoscale ICs would circumvent the physical limits to miniaturisation of conventional lithographic techniques. Scientists are said to have grown catalyst-free nanotube networks on silicon-carbide substrate also. Electron-beam mehod for joining nanotubes could be applied for construction of ultra dense circuits.

2.4 Nano-electronics

Carbon nanotubes that conduct huge current without heating could be the basis of new electronics. Ballastic conductance (a phenomenon in which electrons pass through a conductor without heating it at room temperature) has been observed in multi-walled carbon nanotubes of 5 micron length. It is interesting in case of ultra small electronics, as we can constrain current flow in narrow areas without heating. Nanotubes obey Ohm's law and above a temperature of about 1,500^{0}K they emit light. Scientists suggest this is an example of incandescence. Beacause of this new found control over heating, nanotubes might be ideal spot sources of heat and light with electrons acting as nanometric filaments.

A significant progress has been made towards creating a 3 - dimensional nanobattery containing nano-anodes and nano-cathodes. These electrodes are 100 times more powerful than traditional ones and can survive through 1,500 recharges as compared to 500 in electrodes of lithium-ion batteries. This new technology could improve cell-phones and portable electronics which use lithium ion batteries.

3. Conclusion

In recent developments, scientists have claimed to have developed grow carbon nanotubes at room temperature. This could be a tremendous breakthrough in the field of nanotechnology. Thus, we may say that nanotechnology is a multidisciplinary area of research which encompasses precision engineering as well as electronics electromechanical systems as well as mainstream biomedical applications such as gene therapy, drug delivery and drug discovery techniques.

"There is no subject so old that something new cannot be said about it."

- F. M. Dostoyevsky