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RESEARCH ARTICLE

NANOTECHNOLOGY PRESENT PAST AND FUTURE PROSPECTIVE: NANOELECTRONICS

*Naadir Kamal

Department of Electronics and Communication, Sana Engineering College, Kodad-508206, Telangana, India

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ABSTRACT

The science and technology of nanomaterials has created great excitement and expectations in the last few years. The past few decades have seen an explosive increase in our ability to create nanostructures and nanosystems with a great degree of control, using a diversity of techniques. This ability has been accompanied by a similar enhancement in our ability to characterize structures and systems at the nanoscale. Nanoelectronics refer to the use of nanotechnology in electronic components. The term covers a diverse set of devices and materials, with the common characteristic that they are so small that inter-atomic interactions and quantum mechanical properties need to be studied extensively. Some of these candidates include: hybrid molecular/semiconductor electronics, one-dimensional nanotubes/nanowires, or advanced molecular electronics. This article examines the important facets of nanomaterials research, highlighting the current trends and future directions. It covers structural characteristics and properties of nanostructures, nanofabrication techniques, methods for characterizing nanostructures, and applications for nanomaterials. The article also provides a thought-provoking assessment of the possible implications of nanotechnology in society, and likely future trends.

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INTRODUCTION

Nanotechnology is a multidisciplinary field that covers a vast and diverse array of devices derived from engineering, physics, chemistry, and biology. Research and product developments in the area of nanotechnology have steadily increased especially due to new, beneficial properties of nanomaterials. Nanotechnology as a cross-cutting technology, nowadays used in electrical devices, in construction and composite materials, as catalysts is more and more present in workplaces as well as consumer products. This steady increase is accompanied with larger production, handling and processing facilities for nanostructured materials and higher tonnage of nanomaterials. Nanotechnology has gained increased popularity largely due to design, creation, utilization of materials whose constituent structures exist at Nanoscale i.e physical dimensions that are in the range of one billionth (10-9) of a meter or 10 -to -100 -nm size range. Materials of these sizes have been prepared using two techniques, the top -down and the bottom -up methods (Takano and Koguchi, 2003). The Top-down approaches seek to create smaller devices by using larger ones to direct their assembly such as Giant magnetoresistance-based hard drives (Applications/Products National Nanotechnology Initiative, 2010) where as the bottom -up method is seek to arrange smaller components into more complex assemblies like nanolithography. Some functional approaches are seek to develop components of a desired functionality without regard to how they might be assembled. Molecular scale electronics seeks to develop molecules with useful electronic properties. These could then be used as single-molecule components in a nanoelectronic device. For an example rotaxane (Gates *et al*., 2007).

Corresponding author: Naadir Kamal,
Department of Electronics and Communication, Sana Engineering College, Kodad-508206, Telangana, India

Nanoelectronics

Nanoelectronics refer to the use of nanotechnology in electronic components. The term covers a diverse set of devices and materials, with the common characteristic that they are so small that inter-atomic interactions and quantum mechanical properties need to be studied extensively. Nanoelectronics holds some answers for how we might increase the capabilities of electronics devices while we reduce their weight and power consumption.

Applications of Nanoelectronics

Several nanoelectronics projects are carried out like Cadmium selenide nanocrystals deposited on plastic sheets have been shown to form flexible electronic circuits. Researchers are aiming for a combination of flexibility, a simple fabrication process and low power requirements. Integrating silicon nanophotonics components into CMOS integrated circuits. This optical technique is intended to provide higher speed data transmission between integrated circuits than is possible with electrical signals. Researchers at UC Berkeley have demonstrated a low power method to use nanomagnets as switches, like transistors, in electrical circuits. Their method might lead to electrical circuits with much lower power consumption than transistor based circuits. Researchers at Georgia Tech, the University of Tokyo and Microsoft Research have developed a method to print prototype circuit boards using standard inkjet printers. Silver nanoparticle inkwas used to form the conductive lines needed in circuit boards. Researchers at Caltech have demonstrated a laser that uses a nanopatterned silicon surface that helps produce the light with much tighter frequency control than previously achieved. This may allow much higher data rates for information transmission over fiber optics. Building transistors from carbon nanotubes to enable minimum transistor dimensions of a few nanometers and developing techniques to manufacture integrated circuits built with nanotube transistors. Researchers at Stanford University have demonstrated a method to make functioning integrated circuits using carbon nanotubes. In order to make the circuit work they developed methods to remove metallic nanotubes, leaving only semiconducting nanotubes, as well as an algorithm to deal with misaligned nanotubes. The demonstration circuit they fabricated in the university labs contains 178 functioning transistors. Developing a lead free solder reliable enough for space missions and other high stress environments using copper nanoparticles. Using electrodes made from nanowires that would enable flat panel displays to be flexible as well as thinner than current flat panel displays. Using semiconductor nanowires to build transistors and integrated circuits. Transistors built in single atom thick graphene film to enable very high speed transistors.Researchers have developed an interesting method of forming PN junctions, a key component of transistors, in graphene. They patterned the p and n regions in the substrate. When the graphene film was applied to the substrate electrons were either added or taken from the graphene, depending upon the doping of the substrate. The researchers believe that this method reduces the disruption of the graphene lattice that can occur with other methods. Combining gold nanoparticles with organic molecules to create a transistor known as a NOMFET (Nanoparticle Organic Memory Field-Effect Transistor). Using carbon nanotubes to direct electrons to illuminate pixels, resulting in a lightweight, millimeter thick "nanoemmissive" display panel. Using quantum dots to replace the fluorescent dots used in current displays. Displays using quantum dots should be simpler to make than current displays as well as use less power. Making integrated circuits with features that can be measured in nanometers (nm), such as the process that allows the production of integrated circuits with 22 nm wide transistor gates. Using nanosized magnetic rings to make Magneto resistive Random Access Memory (MRAM)which research has indicated may allow memory density of 400 GB per square inch. Researchers have developed lower power, higher density method using nanoscale magnets called magnetoelectric random access memory (MeRAM). Developing molecular-sized transistors which may allow us to shrink the width of transistor gates to approximately one nm which will significantly increase transistor density in integrated circuits. Using self-aligning nanostructures to manufacture nanoscale integrated circuits. Using nanowires to build transistors without p-n junctions. Using buckyballs to build dense, low power memory devices. Using magnetic quantum dots in spintronic semiconductor devices.

Spintronic devices are expected to be significantly higher density and lower power consumption because they measure the spin of electronics to determine a 1 or 0, rather than measuring groups of electronics as done in current semiconductor devices. Using nanowires made of an alloy of iron and nickel to create dense memory devices. By applying a current magnetized sections along the length of the wire. As the magnetized sections move along the wire, the data is read by a stationary sensor. This method is calledrace track memory. Using silver nanowires embedded in a polymer to make conductive layers that can flex, without damaging the conductor. IMEC and Nantero are developing a memory chip that uses carbon nanotubes. This memory is labeled NRAM for Nanotube-Based Nonvolatile Random Access Memory and is intended to be used in place of high density Flash memory chips.Researcher have developed an organic nanoglue that forms a nanometer thick film between a computer chip and a heat sink. They report that using this nanoglue significantly increases the thermal conductance between the computer chip and the heat sink, which could help keep computer chips and other components cool. Researchers at Georgia Tech, the University of Tokyo and Microsoft Research have developed a method to print prototype circuit boards using standard inkjet printers. Silver nanoparticle inkwas used to form the conductive lines needed in circuit boards (Earl Boysen).

Development in Nanotechnology

Compound semiconductors, represented by GaAs (important for light-emitting devices), were believed to be a replacement for silicon in the field of electronics because of their excellent properties. These semiconductors, however, failed to establish a large industry due to slow progress in related technologies. Excellent in their properties, it is difficult to integrate compound semiconductors. Nanotechnology might be limited in use unless the performance of highly integrated nano devices is impressive, no matter how impressive the performance of a single nano element is. Nanotech nolog y m ig ht not replace al l micro-scale technologies immediately. Smooth transition from micro to nano, or the smooth integration of nanotechnology with conventional technologies, is essential (Hiroshi Komatsu).

Conclusion

In this review the chief scientific and technical aspects of nanotechnology are introduced, and some of its potential clinical applications are discussed. In the coming years we will see significant introduction of nanomaterials and novel production processes based on Nanotechnology which will address key issues of importance to the electronics industry.

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