

Application of Nano-Technology in Electronics

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Abstract: *The advances in nanotechnology have brought new tools to the field of electronics and sensors. New designed materials offer new and unique properties enabling the development and cost efficient production of state-of-the-art components that operate faster, has higher sensitivity, consume less power, and can be packed at much higher densities. Numerous products based on nanotechnology have been reaching the market for some years, all the way to end users and consumers. For instance, at the nano-scale, the resistance dependence of a material on an external magnetic field is significantly amplified, which has led to the fabrication of hard disks with a data storage density in the gigabyte and terabyte ranges. Nanotechnology has also enabled the development of sensors suitable for measurements at the molecular level with an unprecedented sensitivity and response time, mainly due to their high surface to volume ratio.*

Keywords: nano technology

1. Carbon-Based Sensors and Electronics

The semiconductor industry has been able to improve the performance of electronic systems for more than four decades by downscaling silicon-based devices but this approach will soon encounter its physical and technical limits. This fact, together with increasing requirements for performance, functionality, cost, and portability have been driven the microelectronics industry towards the nano world and the search for alternative materials to replace silicon. Carbon nano-materials such as one-dimensional (1D) carbon nano-tubes and two-dimensional (2D) graphene have emerged as promising options due to their superior electrical properties which allow for fabrication of faster and more power-efficient electronics. At the same time their high surface to volume ratio combined with their excellent mechanical properties has rendered them a robust and highly sensitive building block for nano-sensors.

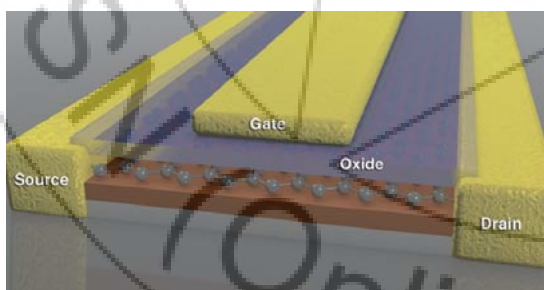


Figure 1: A layer of graphene acts as the conducting channel in a field-effect transistor.

1.1 Graphene Transistor

In 2004, it was shown for the first time that a single sheet of carbon atoms packed in a honeycomb crystal lattice can be isolated from graphite and is stable at room temperature. The new nano-material, which is called graphene, allows electrons to move at an extraordinarily high speed. This property, together with its intrinsic nature of being one-atom-thick, can be exploited to fabricate field-effect transistors that are faster and smaller.

1.2 Carbon Nano-Tube Electronics

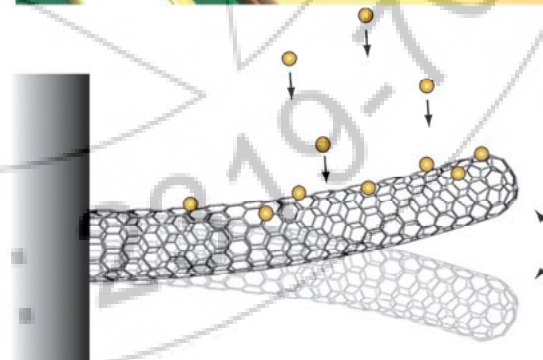
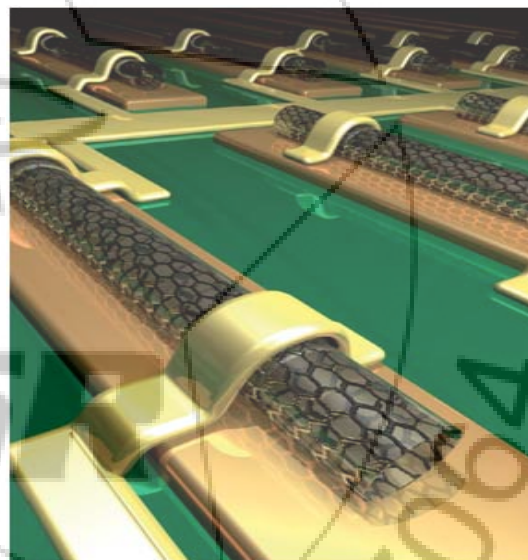


Figure 2: carbon nano-tubes

When a layer of graphene is rolled into a tube, a single-walled carbon nano-tube (SWNT) is formed. Consequently, SWNTs inherit the attractive electronic properties of graphene but their cylindrical structure makes them a more readily available option for forming the channel in field-

effect transistors. Such transistors possess an electron mobility superior to their silicon-based counterpart and allow for larger current densities while dissipating the heat generated from their operation more efficiently. During the last decade, carbon nanotube-based devices have advanced beyond single transistors to include more complex systems such as logic gates and radio-frequency components.

1.3 Carbon-Based Nano-Sensors

In addition to the exceptional electrical properties of graphene and carbon nano-tubes, their excellent thermal conductivity, high mechanical robustness, and very large surface to volume ratio make them superior materials for fabrication of electromechanical and electrochemical sensors with higher sensitivities, lower limits of detection, and faster response time. A good example is the carbon nano-tube based mass sensor that can detect changes in mass caused by a single gold atom adsorbing on its surface.

2. Molecular Electronics

Recent advances in nanofabrication techniques have provided the opportunity to use single molecules, or a tiny assembly of them, as the main building blocks of an electronic circuit. This, combined with the developed tools of molecular synthesis to engineer basic properties of molecules, has enabled the realization of novel functionalities beyond the scope of traditional solid state devices.

2.1 Single Molecule Memory Device

A modern memory device, in its most common implementation, stores each bit of data by charging up a tiny capacitor. The continuous downscaling of electronic circuits, in this context, translates to storing less charge in a smaller capacitor. Ultimately, as memory device dimensions approach the nanometer range, the capacitor can be replaced by a single organic molecule such as Ferrocene, whose oxidation state can be altered by moving an electron into or out of the molecule.

2.2 Organic Transistor Odor Sensor

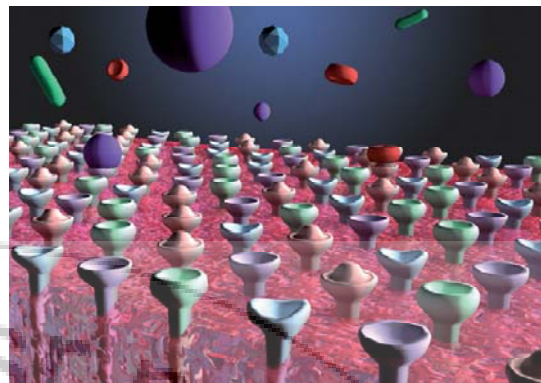
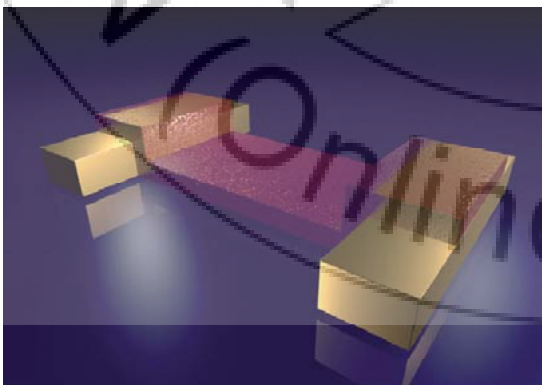


Figure 3: Structure of odor sensor

Organic field-effect transistors (OFETs) are a good example of the scope of traditional electronic devices being augmented by the chemical reactivity of an organic semiconductor material in their channel. In an odor sensor, for instance, the nano-scale chemical reactions upon exposure of the device to a certain atmospheric condition modify the electronic properties of the organic semiconducting material which is further reflected by a change in the current flowing through the transistor.

3. Quantum Computing

The excitement in the field of quantum computing was triggered in 1994 by Peter Shor who showed how a quantum algorithm could exponentially speed up a classical computation. Such algorithms are implemented in a device that makes direct use of quantum mechanical phenomena such as entanglement and superposition. Since the physical laws that govern the behavior of a system at the atomic scale are inherently quantum mechanical in nature, nanotechnology has emerged as the most appropriate tool to realize quantum computers.

4. Single Electron Transistor

In contrast to common transistors, where the switching action requires thousands of electrons, a single electron transistor needs only one electron to change from the insulating to the conducting state. Such transistors can potentially deliver very high device density and power efficiency with remarkable operational speed. In order to implement single electron transistors, extremely small metallic islands with sub-100 nm dimensions have to be fabricated. These islands, which are referred to as quantum dots, can be fabricated by employing processes made available by the advances in nanotechnology.

5. Spintronics

Similar to electrical charge, spin is another fundamental property of matter. While conventional electronic devices rely on the transport of electrical charge carriers, the emerging technology of spintronics employs the spin of electrons to encode and transfer information. Spintronics has the potential to deliver nano-scale memory and logic devices which process information faster, consume less power, and store more data in less space. The extension of the hard disk capacities to the gigabyte and the terabyte ranges was the

main achievement of spintronics by taking advantage of Giant Magneto-Resistance (GMR) and Tunnel Magneto-Resistance (TMR) effects which are effective only at the nano scale.

6. Nano-Electro-Mechanical Systems (NEMS)

All electronic tools have one thing in common: an integrated circuit (IC) acting as their “brain”. The extent to which this “brain” has influenced our lives has already been tremendous but what if its decision-making capability is augmented by “eyes” and “arms”? Nano-electro-mechanical systems have evolved during the last 10 years to make this dream come true by creating sensors (“eyes”) and actuators (“arms”) at the same scale as the accompanying nano-electronics. Recent developments in synthesis of nano-materials with excellent electrical and mechanical properties have extended the boundaries of NEMS applications to include more advanced devices such as the non-volatile nano-electro-mechanical memory, where information is transferred and stored through a series of electrical and mechanical actions at the nano-scale.

7. Conclusion

With the use of the nano-technology the power consumed by the electronic circuit gets reduced. Since the use of nano-technology in electronic circuit the size and the total power consumption also get reduced and this emerging technology will produce the new solution to the circuit complexity and makes circuits much compact.

References

- [1] Gardener, Elizabeth. “Brainy Food:Academe, Industry Sink Their Teeth into Edible Nano.” *Small Times*, June 21, 2002. Available at http://www.smalltimes.com/document_display.cfm?document_id=3989&keyword=brainy%20and%20food&summary=1&startsum=1, accessed July 5, 2006.
- [2] Macoubrie, Jane. *Informed Public Perceptions and Trust in Government*. Washington, DC: Project on Emerging Nano-technologies, Woodrow Wilson International Center for Scholars, September 2005, p. 9 and 11. Available at <http://www.nanotechproject.org/reports>, accessed July 5, 2006.
- [3] *Nano-scale Science and Engineering for Agriculture and Food Systems*. Washington, DC: United States Department of Agriculture, July 2003.
- [4] Searched databases include: USDA-Current Research Information System (CRIS), the United States Patent and Trademark Office (USPTO), EPA-Science Inventory, and NSF Awards.
- [5] Searched websites include NIH, DOD, DOE, DHS, and FDA.