ELECTRONICS GROUP SUMMARY

INTRODUCTION

Electronics is currently the workhorse technology for computing and communications, as well as a major component of consumer goods. It has become a major part of everyday life and is apparent in cell phones, televisions, computers, automobiles, and many other products that people make use of. Long-term investment based on well-planned strategy is essential for materializing next-generation technologies, such as nanotechnology. For this reason it is important to research the electronic applications of nanotechnology. In A Gentle Introduction to Nanotechnology, Northwestern University Professor Mark Ratner states that "application of nanostructures in electronics is one of the most vibrant and challenging aspects of nanoscience" and that "charge transport on the molecular or nanoscale level draws on a whole set of new concepts that challenge our understanding of electronics." The application of nanotechnology to electronics brings great promise to the future of electronic goods and their impact on society. Nanotechnology provides the building blocks for bottom-up electronics, which will result in faster, more stable computers, a decrease of size and energy requirements of circuit components, and an overall improvement in the quality of electronic goods.

RESEARCH

Nanotechnology broadly encompasses all technologies that incorporate nano-scale materials and handle phenomena in the 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 & Koguchi 1). The top-down method is applied to process macro-scale materials into nano-scale materials, whereas the bottom-up method is epitomized by self-assembly. Self-assembly is a manufacturing method used to construct things at the nanometer-scale. In self-assembly the final (desired) structure is encoded in the shape and properties of the molecules that are used, as compared to traditional techniques, such as lithography, where the desired final structure must be carved out from a larger block of matter ("Self-assembly" 1). The bottom-up method has recently been successfully combined with the top-down method by researchers at universities and companies in the U.S., showing that nanotechnology is being smoothly extended to conventional electronics (Komatsu & Ogasawara 43).

The subgroup's research into the different electronic applications of nanotechnology was broken into four different categories: molecular electronics, power systems, quantum computing, and circuit components. The two main developments of nanotechnology applied to molecular electronics are carbon nanotubes and nanowires. Carbon nanotubes are a new form of carbon made by rolling up a single graphite sheet to a narrow, but long tube closed at both sides by fullerene-like end caps. Nanotubes were discovered in 1991 by Sumio Iijima and have a very broad range of electronic, thermal, and structural properties that change depending on the diameter, length, and twist of its structure (Adams 1). Nanotubes are strongly structured and have a good thermal conductivity, extending the ability to fabricate devices such as molecular probes, pipes, bearings, springs, gears, and pumps. Their future applications include molecular transistors, field emitters, spacecraft electronics, and much more. Fabrication of optical fibers and thin metallic wires are among the most basic technologies of the information age. Nanotechnology allows for the creation of nanowires, which have great electronic potential and allow for size reduction in electronic systems. These nanowires will allow interfacing between micro-scale and nano-scale materials.

The next category that was researched was the application of nanotechnology in power systems. Two important examples of progress in this area of electronics were electrochemical power storage and nano-based batteries. Electrochemical power storage allows for the precise control of power, which can be activated on demand. With nanotechnology advancements, the startup times and operating temperatures for these storage elements have been highly reduced. Nano-based batteries, which are still under development, meet the demands for high-power, long-life battery capacity for electronic devices. Since these batteries are small in size and are capable of delivering a great amount of power, they will be very useful in emergency and reserve power applications. Power outages will easily be handled in the future with the introduction of nano-based batteries and electrochemical power storage elements.

The third category that was researched was circuit component applications. With the use of nanofabrication circuit components such as transistors, diodes, and logic gates will require less energy and will decrease in size. There has been an exponential increase in the density of transistors on conventional integrated circuit computer chips over the past 40 years, and with the help of nanotechnology this trend will continue (Montemerlo 1). In the future, nano-circuit design will probably begin with a chip containing 10^{24} components, as compared to today’s average of 40 million (Shishkova 1). This increase in components will yield electronics with greater stability and performance. It will also be useful in quantum computing.

Quantum computing is the fourth category researched by the subgroup. A few applications within quantum computing include magnetic random access memory (MRAM), improved read heads for hard disk drives, and a dramatic decrease in personal computer size. MRAM will use nanotechnology to yield memory that will operate faster than standard RAM used today. It will consume less energy and space, as well as provide greater stability. When applied to read heads on hard disk drives, nanotechnology will allow hard drives to seek information faster, store more data, and operate more accurately. In general, nanotechnology will allow for faster, more stable computers by reducing component size and heat dissipation.

CONCLUSION

In order to further the team's knowledge of nanotechnology, a subgroup was assembled to research the applications of nanotechnology in electronics. During this process, information about future uses and benefits of nanotechnology were uncovered. Nanotechnology is a realistic, promising technology for the future due to recent progress in this field, where nanotechnology has been combined with conventional silicon-based electronics. It gives us tools that allow us to make nanomaterials with special properties that will become commercially important when they give a cost and performance advantage over existing products. Over the next five 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 (Rae 39). Longer term use of nanotechnology will allow manufacturers to meet customer requirements by extending existing technologies or replacing them with new ones.

BIBLIOGRAPHY

Adams, Thomas. "Physical Properties of Carbon Nanotubes". Internet. < http://nanotube.msu.edu>.

H. Komatsu and A. Ogasawara. "Applying Nanotechnology to Electronics". Science & Technology Trends—Quarterly Review: No. 16, July 2005.

M. Montemerlo, J. Love, and J. Ellenbogen. "Overview of Electronic Nanocomputers". Internet. <http://www.mitre.org/tech/nanotech/nano_elect_ovw.html>.

J. Takano and N. Koguchi. "Trend of Self-Organization in Materials Research". Science & Technology Trends—Quarterly Review: No.6, February 2003.

Rae, Alan. "Real Life Applications of Nanotechnology in Electronics". OnBoard Technology—October 2005.

Ratner, Mark. A Gentle Introduction to Nanotechnology. Prentice Hall, 2002.

Shishkova, Serafina. "Number of Transistors on an Integrated Circuit". Internet. <http://hypertextbook.com/facts/2001/SerafinaShishkova.shtml>.

"Self-assembly." Wikipedia, The Free Encyclopedia. Internet. <http://en.wikipedia.org/w/index.php?title=Self-assembly&oldid=37977062>.