Commercialization of Nanotechnology

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ABSTRACT

Nanotechnology is an enabling technology and as such, will have an impact on electronics, computing, data storage, communications, materials and manufacturing, energy, environment, transportation, health and medicine, national security and space exploration. This lecture will cite examples in each of these sectors and present a forecast of short term (< 5 years), medium term (10 years) and long term (> 15 years) prospects. In addition, the challenges currently being faced to commercialize nanotechnology will be discussed in detail. A summary outlining efforts across the world in terms of commercialization, startup activities, participation of major multinational corporations, government funding etc. will be presented.

It is important to recognize that nanotechnology is not any one technology or a one-sector technology. Its reach is extremely broad: electronics, computing, data storage, communications, aerospace, materials, manufacturing, health, medicine, energy, environment, transportation and national defense. In that sense, it is an enabling technology.

In the electronics and computing, we can expect processors with million times better performance than the state-of-the-art with less power consumption, multi-terabit storage in small mass devices, and quantum computing from advances in nanotechnology. Also, it is possible to envision integration of logic, memory and sensing on the same chip. In the nearer term, one major area to benefit from nanotechnology is field emission devices for large area flat panel devices.

In the materials sector, the major focus is on high strength, low weight composites enabled by nanomaterials. Other characteristics researchers are currently paying attention include multifunctionality and self-healing. Biologically-inspired materials are also receiving much attention and examples include synthetic gecko, and self-cleaning glass (inspired by the lotus flower).

In health and medicine, the biggest impact can come from fast gene sequencing devices. A nanopore based technology appears to have the potential to sequence the entire human genetic makeup in less than two hours. This advance would enable 'individualized medicine'. Other possibilities include effective drug delivery approaches, early warning sensors for serious illnesses, rejection-proof artificial ligaments, bones and other parts.

In the energy sector, while the major focus is on how nanomaterials can improve the long standing efficiency problems in solar and other alternative energy sources, the most significant benefit may well be in the energy

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utlilization. The conventional filament light bulbs, though inexpensive, are very energy inefficient. Solid state lighting in contrast is extremely energy efficient. Current efforts include novel materials and processes to make this technology cost-competitive.

The transportation sector would benefit from high strength, low weight composites for increased fuel efficiency, wear-resistant tires, advanced sensors for hydrogen based economy, efficient catalytic converters with reduced use of expensive noble metals like platinum, and wear-resistant coatings. In the environment sector, the large surface area of nanomaterials, translated into high adsorption rates, can help with waste remediation, pollutant conversion, other environmental cleanup operations, high efficiency filters and membranes.

As summarized above, the potential of nanotechnology in various sectors is promising. While there are some niche applications where nanotechnology products have just penetrated the market, the major impact will be at least a decade away. Currently there are a few cosmetic products incorporating nanoparticles on the market such as suntan lotions, eye liners, and flat irons. Automotive companies have mixed small quantities of carbon nanotubes in the process of making fenders to render them electrically conducting so that the parts can be painted inexpensively in electrochemical baths. Stain resistant cotton coated using novel processes is currently used in textile manufacturing.

In the short term (< 5 years), commercial impact may include flat panel displays, nanoparticles in cosmetics, nanoparticles in automotive applications such as body moldings, engine covers, and catalytic converters, nanoparticles in catalyst and inkjet markets and tools. In the medium term, memory devices, biosensors for diagnostics, advances in lighting, advances in gene sequencing, are all possible. Routine use of nano composites in automotive and aerospace industries is a long term prospect as these are risk-averse sectors and extensive testing and characterization alone takes significant time. Nanoelectronics beyond silicon according to Moore’s Law is also a long term endeavor.