What is Nanotechnology?

The word "nano" originates from Greek and means "dwarf" and nanometer is one billionth (10-9) of a meter – about one hundred thousandth of the width of a human hair. Nanotechnology or "engineering at a very small scale" is the technology of creating and applying materials and structures with at least one critical dimension below 100nm which lead to new functionalities and properties.

For example, nano coatings can help create stain-proof clothing, easy-to-clean windows and anti-bacterial and scratch resistant surfaces. Nanotechnology can also help create devices that are smaller and cheaper with greater functionality and high energy efficiency.

Due its enormous impact in multiple application areas from medical devices to electronics and even environment, governments around the world have thus far (till 2008) invested nearly S$56 billion (US$40 billion) in nanotechnology research. It is expected that government funding in nanotechnology around the world for 2009 alone will reach S$9.3 billion (US$9.3 billion). Increasingly this funding is moving away from fundamental research to more application-oriented research.

Specific examples of application of nanotechnology in different vertical industries are given below:

Automation technology: The growth of low cost, high reliability, wireless sensors to measure parameters was once thought to be impossible previously. It has also enabled the creation of even smaller electronic devices with ever-increasing functionality and high density storage devices. It has also enabled the development of flexible displays.

Building and construction: The development of a variety of new materials developed from nanotechnology is reshaping the building and construction industry. For example, materials such as nanosilica can increase the durability of cement and enhance its mechanical properties. Adding photocatalytic TiO2 to conventional cement can help reduce CO and NOx emissions on highways. Nanotechnology also enables the creation of more environmentally-friendly high-strength cement substitutes and to incorporate novel wireless sensing elements to monitor the structural integrity of concrete structures.

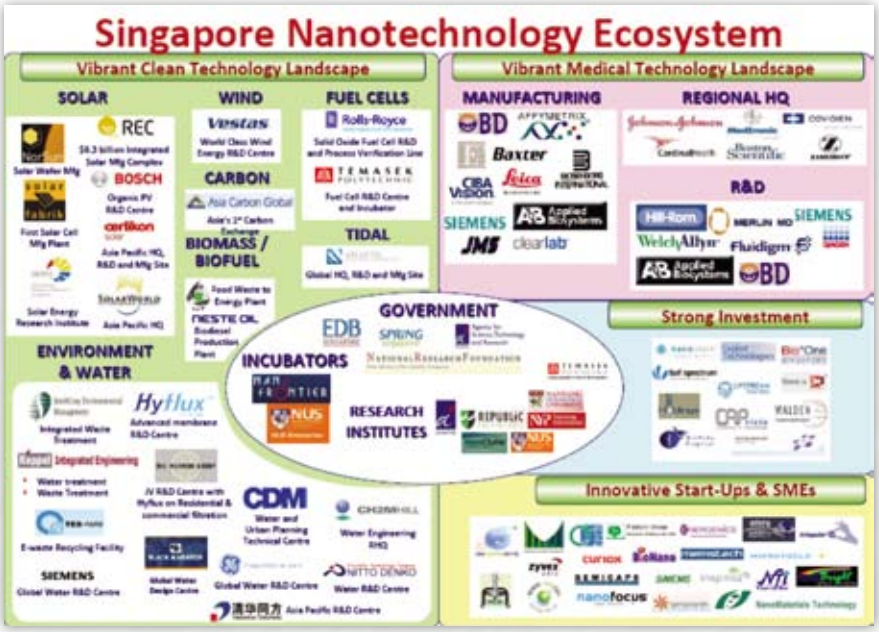
Electronics industry: Nanotechnology has a growing importance in the development of data storage and batteries with better performance. In 2006, Hard-Disk Drives (HDDs) enabled by giant magnetoresistance (GMR) accounted for $25 billion in 2006 with 450 million units shipped, while 60% of Li-Ion batteries used are already using nanofibers. It is also changing the face of the optoelectronics industry with tighter integration of the optical and electronic components in devices that are becoming smaller and smaller. Organic electronics strongly enabled by nanotechnology is also set to drastically reduce the cost of electronic devices.

Food and beverages: Nanotechnology is found in the production of food and beverage with lower cost and higher safety levels. For example, bottles made with nanocomposites minimize the leakage of CO2 and are much cheaper than glass bottles or aluminum cans. Plastic food storage bins are being embedded with silver nanoparticles to impart anti-bacterial properties and keep the food fresh for longer periods of time. Nanosensors are also being used in plastic packaging to detect food spoilage and to amount of pesticides on fruit and vegetables.

Fire protection: Personal safety and fire protection industry is changing drastically through the use of fire retardant clothing, flame resistant material made with polymer nanocomposites filled with clay and carbon nanotubes and fire retardants made using nanoadditives to replace halogen retardants banned in different markets. Nanoadditives are also used to reduce the heat release rate during a fire event by forming surface char to insulate the underlying material.

Pharmaceuticals: The pharmaceutical industry is one of the early adopters of nanotechnology as it helps develop drugs with greater specificity, more controlled release profile and reduced side effects. Nanoparticles like quantum dots and magnetic nanoparticles also enable the development of better drugs by enhancing the bio imaging capability.

Lifestyle products: The cosmetics industry is the largest application industry for nanotechnology in terms of revenues. Examples of cosmetics incorporating nanotechnology include anti-wrinkle creams incorporating nanocapsules, ZnO2 nanoparticle based skin care products, TiO2 nanoparticle based sunscreen lotions and moisturizers with oxide and nanosilica. Nanotechnology is also changing the textile industry with clothing that can change color, self-clean and repel water. Nanosocks with embedded nanosilver particles lead to fresh smelling socks for longer durations. Other examples of nano-enabled lifestyle products are low weight high performance sporting goods such as mountain bicycles, golf clubs, kayaks etc made using nanocomposite materials embedded with carbon nanotubes.



Source: SingNano

Metal manufacturing: Nanoparticles are being used as additives in lubricants and coatings due to their ability enter contact area easily and work at ambient temperature. By selectively embedding nanoparticles inside different metals, we now have the ability to produce new metal materials with better mechanical (strength, elongation etc) and functional (corrosion resistance, electrical and magnetic) characteristics.

Medical devices: Nanotechnology can be used in tissue engineering for biomaterials scaffolding, cellular engineering and biomolecular manipulation. Engineering of scaffolds in nanoscale can bring novel properties, enhance biocompatibility and reduce the need for revision surgery. Stents with reduced incidence of stenosis and better drug release profile can be developed using nanocoatings. Nanotechnology also enables the development low cost, point-of-care diagnostic solutions.

Oil & gas industry: The development of highly effective catalysts can operate at lower temperatures and produce fewer by-products, hence creating highly selective membranes to reduce the cost of separation. In addition, nanotechnology is being explored to reduce the oil exploration costs and costs of offshore rigs.

Plastics and packaging: Nanotechnology can enable reduce the biggest problem faced by the plastics and packaging industry by effectively conversing waste plastic into a carbon source for SiC nanomaterals. It is also possible to turn CO2 to biodegradable plastics using nanotechnology. Nano CaCo3 can be used as fillers in plastic bags as fillers to reduce amount of polyethylene used and reduce wastage.

Nanotechnology in Singapore

Nanotechnology is recognized as a key enabler to sustain future development of the Singapore economy. The Singapore government spent about S$420 million (US$300 million) between 2003 and 2007 in nanotechnology-related R&D and manpower development. In addition, Singapore has a wide variety of programs to train manpower required for nanotech companies at different levels of expertise.

Singapore's investment into nanotechnology has already resulted in the contribution of nanotechnology-related products and services growing at about 8% to 21%. Multi-national companies such as BASF, Bayer, ST Microelectronics and Zyvex have decided to set up substantial R&D facilities in Singapore to take advantage and contribute to the growing nanotechnology ecosystem in Singapore. Local companies have also started to incorporate nanomaterials in their products. For example, Pasture Group has effectively used nanoparticles in their disposable masks. These masks have been approved by FDA for general use to prevent against the recent swine flue outbreak. Another local company, Haruna Paints makes easy-to-clean paints containing nanoparticles. There are also a growing number of new nanotechnology companies such as Amaranth Medical, NanoBright, Metarix that came out of local universities.

In summary, nanotechnology can deliver solutions to a number of existing problems in different industries and Singapore has the world-class research and infrastructure to deliver these solutions. However, significant challenges to large scale adoption of nanotechnology exist. These include the conservative nature of the manufacturing industry, the difficulty in scaling up nanomaterial production, as well as integrating nano-based solutions into existing solutions and incomplete knowledge of their health and safety impact. In spite of these challenges, as companies like Pasture Group have shown, nanotechnology can provide a decisive competitive edge to the early adopters. – CONNECT ■

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