Studying the future prospective of nanotechnology computer science

This paper explores the present impact of nanotechnology on the consumer market. It situates the technical aspects of nanotechnology and describes some early successes of nanomaterials embraced. It includes a description of technology developments in the area of automotive industry, biomedicine, household appliances, nanowires, nanotubes, nanobubble, nanochips, healthcare and numerous other nanostructured materials with a brief description of the number of research and development activities that are in various stages of testing and qualification.

II. INTRODUCTION

Nanotechnology is derived from the combination of two words Nano and Technology. Nano means very small or “ miniature”. So, Nanotechnology is the technology in miniature form. It is the combination of Bio- technology, Chemistry, Physics and Bio-informatics, et Nanotechnology is a generic term used to describe the applications that work with matter so small that it exists in the molecular and atomic realm. As the name indicates, the fundamental unit in any nanotechnology system is a nanometer, nm, which is one billionth part of a meter. Nanotechnology research shows that at such micro level, the physical, chemical and biological properties of materials are different from what they were at large scale. Nanotechnology originated in India around 16 years back. This new sphere of scientific innovation has a broader scope. Several Indian institutes have introduced degree courses in Nanotechnology at both the UG and PG levels. The areas covered in the Nanotech are Food and Beverage, Bio- Technology, Forensic Sciences, Genetics, Space Research, Environment industry, Medicine, Agriculture and Teaching. The fundamental idea is to harness these altered and often improved properties to develop materials, devices and systems that are superior to the existing products. For instance, breaking a material down into nanoparticles allows it to be rebuilt atom by atom, often improving material strength and decreasing weight and dimensions. Based on this concept, researchers have been able to develop a myriad of nanomaterials with amazing properties.

The Council of Scientific and Industrial Research, also known as CSIR has set up 38 laboratories in India dedicated to research in Nanotechnology. This technology will be used in diagnostic kits, improved water filters and sensors and drug delivery. The research is being conducted on using it to reduce pollution emitted by the vehicles . Looking at the progressive prospects of Nanotechnology in India, Nanobiosym Inc., a US-based leading nanotechnology firm is planning to set up India’s first integrated nanotechnology and biomedicine technology park in Himachal Pradesh. Nanotechnology has certainly acquired. In the long term scenario, nanotechnology promises to make revolutionary advances in a variety of fields. Possible uses of nanomaterials may include the cleaning of heavily polluted sites, more effective diagnosis and treatment of cancer, cleaner manufacturing methods and much smaller and more powerful computers.

III CORE CHAPTERS

A. History

The first use of the concepts found in ‘ nano-technology’ (but pre-dating use of that name) was in “ There’s Plenty of Room at the Bottom”, a talk given by physicist Richard Feynman at an American Physical Society meeting at Caltech on December 29, 1959. Feynman described a process by which the ability to manipulate individual atoms and molecules might be developed, using one set of precise tools to build and operate another proportionally smaller set, and so on down to the needed scale. In the course of this, he noted, scaling issues would arise from the changing magnitude of various physical phenomena: gravity would become less important, surface tension and vander waals attraction would become increasingly more significant, etc. This basic idea appeared plausible, and exponential assembly enhances it with parallelism to produce a useful quantity of end products.

The term “ nanotechnology” was defined by Tokyo Science University Professor Norio Taniguchi in a 1974 paper as follows “‘ Nano-technology’ mainly consists of the processing of, separation, consolidation, and deformation of materials by one atom or by one molecule.” In the 1980s the basic idea of this definition was explored in much more depth by Dr. K. Eric Drexler, who promoted the technological significance of nano-scale phenomena and devices through speeches and the books Engines of Creation: The Coming Era of Nanotechnology (1986) and Nanosystems: Molecular Machinery, Manufacturing, and Computation, and so the term acquired its current sense. Engines of Creation: The Coming Era of Nanotechnology is considered the first book on the topic of nanotechnology. Nanotechnology and nanoscience got started in the early 1980s with two major developments; the birth of cluster science and the invention of the scanning tunneling microscope (STM). This development led to the discovery of fullerenes in 1985 and carbon nanotubes a few years later. In another development, the synthesis and properties of semiconductor nanocrystals was studied; this led to a fast increasing number of metal and metal oxide nanoparticles and quantum dots. The atomic force microscope (AFM or SFM) was invented six years after the STM was invented. In 2000, the United States National Nanotechnology Initiative was founded to coordinate Federal nanotechnology research and development and is evaluated.

http://upload. wikimedia. org/wikipedia/commons/thumb/4/41/C60a. png/175px-C60a. png

Fig. 1. Buckminsterfullerene C60, also known as the buckyball, is a representative member of the carbon structures known as fullerenes and is a major subject of research in nanotechnology.

B. Current Research

Nanomaterials field includes subfields which develop or study materials having unique properties arising from their nanoscale dimensions. Interface and colloid science has given rise to many materials which may be useful in nanotechnology, such as carbon nanotubes and other fullerenes, and various nanoparticles and nanorods. Nanomaterials with fast ion transport are related also to nanoionics and nanoelectronics. Nanoscale materials can also be used for bulk applications; most present commercial applications of nanotechnology are of this flavor. Progress has been made in using these materials for medical applications; see Nanomedicine. Nanoscale materials are sometimes used in solar cells which combats the cost of traditional Silicon solar cell. Development of applications incorporating semiconductor nanoparticles to be used in the next generation of products, such as display technology, lighting, solar cells and biological imaging; see quantum dots.

1) Top-down Approaches: These seek to create smaller devices by using larger ones to direct their assembly. Many technologies that descended from conventional solid-state silicon methods for fabricating microprocessors are now capable of creating features smaller than 100 nm, falling under the definition of nanotechnology. Giant magnetoresistance-based hard drives already on the market fit this description, as do atomic layer deposition

2) Bottom-up Approaches: These seek to arrange smaller components into more complex assemblies. DNA nanotechnology utilizes the specificity of Watson-Crick basepairing to construct well-defined structures out of DNA and other nucleic acids. Approaches from the field of “ classical” chemical synthesis also aim at designing molecules with well-defined shape (e. g. bis - peptides). More generally, molecular self-assembly seeks to use concepts of supramolecular chemistry, and molecular recognitionin particular, to cause single-molecule components to automatically arrange themselves into some useful conformation. Peter Grunberg and Albert Fert received the Nobel Prize in Physics in 2007 for their discovery of Giant magnetoresistance and contributions to the field of spintronics. Solid-state techniques can also be used to create devices known as nanoelectromechanical systems or NEMS, which are related to microelectromechanical systems or MEMS. Atomic force microscope tips can be used as a nanoscale “ write head” to deposit a chemical upon a surface in a desired pattern in a process called dip pen nanolithography. This fits into the larger subfield of nanolithography. Focused ion beams can directly remove material, or even deposit material when suitable pre-cursor gasses are applied at the same time. For example,

this technique is used routinely to create sub-100 nm sections of material for analysis in Transmission electron microscopy.

3) Functional Approaches: These seek to develop components of a desired functionality without regard to how they might be assembled. Molecular 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 see rotaxane. Synthetic chemical methods can also be used to create synthetic molecular motors, such as in a so-called nanocar.

4) Biomimetic Approaches: Bionics or biomimicry seeks to apply biological methods and systems found in nature, to the study and design of engineering systems and modern technology. Biomineralization is one example of the systems studied. Bionanotechnology the use of biomolecules for applications in nanotechnology, including use of viruses.

C. Tools and Techniques

A microfabricated cantilever with a sharp tip is deflected by features on a sample surface, much like in a phonograph but on a much smaller scale. A laser beam reflects off the backside of the cantilever into a set of photodetectors, allowing the deflection to be measured and assembled into an image of the surface.

There are several important modern developments. The atomic force microscope (AFM) and the Scanning Tunneling Microscope (STM) are two early versions of scanning probes that launched nanotechnology. There are other types of scanning probe microscopy, all flowing from the ideas of the scanning confocal microscope developed by Marvin Minsky in 1961 and the eloped by Calvin Quate and coworkers in the 1970s, that made it possible to see structures at the nanoscale. The tip of a scanning probe can also be used to manipulate nanostructures (a process called positional assembly). Feature-oriented scanning-positioning mescanning acoustic microscope (SAM) dev thodology suggested by Rostislav Lapshin appears to be a promising way to implement these nanomanipulations in automatic mode. However, this is still a slow process because of low scanning velocity of the microscope. Various techniques of nanolithography such as optical lithography, X-ray lithography dip pen nanolithography, electron beam lithography or nanoimprint lithography were also developed. Lithography is a top-down fabrication technique where a bulk material is reduced in size to nanoscale pattern.

The top-down approach anticipates nanodevices that must be built piece by piece in stages, much as manufactured items are made. Scanning probe microscopy is an important technique both for characterization and synthesis of nanomaterials. Atomic force microscopes and scanning tunneling microscopes can be used to look at surfaces and to move atoms around. By designing different tips for these microscopes, they can be used for carving out structures on surfaces and to help guide self-assembling structures. By using, for example, feature-oriented scanning-positioning approach, atoms can be moved around on a surface with scanning probe microscopy techniques. At present, it is expensive and time-consuming for mass production but very suitable for laboratory experimentation.

D. Nanotechnology’s Future

Over the next two decades, this new field for controlling the properties of matter will rise to prominence through four evolutionary stages. Today nanotechnology is still in a formative phase–not unlike the condition of computer science in the 1960s or biotechnology in the 1980s. Yet it is maturing rapidly. Between 1997 and 2005, investment in nanotech research and development by governments around the world soared from $432 million to about $4. 1 billion, and corresponding industry investment exceeded that of governments by 2005. By 2015, products incorporating nanotech will contribute approximately $1 trillion to the global economy. About two million workers will be employed in nanotech industries, and three times that many will have supporting jobs.

Descriptions of nanotech typically characterize it purely in terms of the minute size of the physical features with which it is concerned–assemblies between the size of an atom and about 100 molecular diameters. That depiction makes it sound as though nanotech is merely looking to use infinitely smaller parts than conventional engineering. But at this scale, rearranging the atoms and molecules leads to new properties. One sees a transition between the fixed behavior of individual atoms and molecules and the adjustable behavior of collectives. Thus, nanotechnology might better be viewed as the application of quantum theory and other nano-specific phenomena to fundamentally control the properties and behavior of matter.

Over the next couple of decades, nanotech will evolve through four overlapping stages of industrial prototyping and early commercialization. The first one, which began after 2000, involves the development of passive nanostructures: materials with steady structures and functions, often used as parts of a product. These can be as modest as the particles of zinc oxide in sunscreens, but they can also be reinforcing fibers in new composites or carbon nanotube wires in ultra miniaturized electronics. The second stage, which began in 2005, focuses on active nanostructures that change their size, shape, conductivity or other properties during use. New drug-delivery particles could release therapeutic molecules in the body only after they reached their targeted diseased tissues. Electronic components such as transistors and amplifiers with adaptive functions could be reduced to single, complex molecules.

Starting around 2010, workers will cultivate expertise with systems of nanostructures, directing large numbers of intricate components to specified ends. One application could involve the guided self-assembly of nanoelectronic components into three-dimensional circuits and whole devices. Medicine could employ such systems to improve the tissue compatibility of implants, or to create scaffolds for tissue regeneration, or perhaps even to build artificial organs.

After 2015-2020, the field will expand to include molecular nanosystems–heterogeneous networks in which molecules and supramolecular structures serve as distinct devices. The proteins inside cells work together this way, but whereas biological systems are water-based and markedly temperature-sensitive, these molecular nanosystems will be able to operate in a far wider range of environments and should be much faster. Computers and robots could be reduced to extraordinarily small sizes. Medical applications might be as ambitious as new types of genetic therapies and antiaging treatments.

New interfaces linking people directly to electronics could change telecommunications.

Over time, therefore, nanotechnology should benefit every industrial sector and health care field. It should also help the environment through more efficient use of resources and better methods of pollution control. Nanotech does, however, pose new challenges to risk governance as well. Internationally, more needs to be done to collect the scientific information needed to resolve the ambiguities and to install the proper regulatory oversight. Helping the public to perceive nanotech soberly in a big picture that retains human values and quality of life will also be essential for this powerful new discipline to live up to its astonishing potential.

Drastic advancements have been encountered in the fields of electronics, medicines, science, fabrication and computational related to nanotechnology. The details are as below.

1)Future of Nanoelectronics: The recent progress of nanoelectronic devices has revealed many novel devices under consideration. Even though some devices have achieved experimental results comparable with some of the best silicon FETs, these devices have yet to show electrical characteristics beyond the basic, functional level. In several years from now, the planar MOSFET, combined with high-k dielectric and coupled with strained layer technology, is expected to maintain its domination the market, due to the fact that the manufacturers still attempt to exploit their existing manufacturing capabilities and seem reluctant to adopt new technology. However, the double- and multi-gate MOSFET scaling is superior to recent planar MOSFET and also to UTB FD MOSFET scaling, thus the double and multi-gate device is projected as the ultimate MOSFET. The role of double gate MOSFET and non-planar will take greater share, as this technology become mature and the risk are more understandable in near future.

On the other hand, several issues on fabrication in adoption route to standard fabrication have to be solved for every other technology. Figure indicates the projection for the first year of full scale production for future nanoelectronic devices by ITRS, which reflect the degree of complexity in fabrication for each technology. New MOSFET structures, starting with UTB-SOI MOSFETs and followed by multi-gate MOSFETs, will be implemented soon. The next generation devices, e. g. carbon nanotubes, graphene, spin transistor etc are promising, due to their performances shown by many researches. However, the processing issues force them to take longer step to be main devices for nanoelectronics.

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http://docsdrive. com/images/ansinet/jas/2010/fig8-2k10-2136-2146. gif

Fig. 2. Projection for the first year of full scale production for future nanoelectronic devices.

Nanochips: Currently available microprocessors use resolutions as small as 32 nm. Houses up to a billion transistors in a single chip. MEMS based nanochips have future capability of 2 nm cell leading to 1TB memory per chip.

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Fig. 3 A MEMS based nanochip

Nanoelectromechanical (NEMS) Sensor in Nanophotonic systems work with light signals vs. electrical signals in electronic systems. Enable parallel processing that means higher computing capability in a smaller chip. Enable realization of optical systems on semiconductor chip.

Fig. 4. A silicon processor featuring on-chip nanophotonic network

Fuel cells use hydrogen and air as fuels and produce water as by product. The technology uses a nanomaterial membrane to produce electricity.

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Fig. 5. Schematic of a fuel cell

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Fig. 6. 500W fuel cell

Nanoscale materials have feature size less than 100 nm – utilized in nanoscale structures, devices and systems.

Nanoparticles and Structures

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Fig. 7. Gold nanoparticles

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Fig. 8. Silver Nanoparticles

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Fig. 9. A stadium shaped “ quantum corral” made by positioning iron atoms on a copper surface

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Fig. 10. A 3-dimensional nanostructure grown by controlled nucleation of Silicon-carbide nanowires on Gallium catalyst particles.

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Fig. 11. Nanowire Solar Cell: The nanowires create a surface that is able to absorb more sunlight than a flat surface.

2) Nanotubes: Carbon nanotubes since their discovery are used as the building blocks in various nanotechnology applications. Although many applications are at preliminary stages of experimentation, carbon nanotubes has many future prospects in almost all spheres of electronics applications. Highly integrated circuit is one of the areas, where many researchers are focusing the research and electronic properties of carbon nanotubes are being exploited. Researchers have identified and fabricated the electronic devices having densities ten thousand times greater than the present day microelectronics. These technologies will either complement or replace the CMOS.

Further the electronic devices based on carbon nanotubes have additional and advance features such as conductivity, current carrying capacity and electromigration. Semi conducting carbon nanotubes having excellent nobilities and semiconductancies have been prepared and these are far better than the conventional semi conductors. Actually there are some major barriers for developing highly integrated circuits such as present fabrication methods produces the mixture of metallic and semiconductor nanotubes and exact electronic arrangements within a semiconductor nanoube is poorly understood. These are therefore the hurdles in manufacturing and fabricating highly integrating circuits, however continuous research in this area will lead to new and much more advance technology that will not only able to overcome from these barriers but will also open the door for new electronic applications also.

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Fig. 12 Nanotube

3) Future of Nanomedicine: Nanomedicine is the application of nanotechnology in medicine, including to cure diseases and repair damaged tissues such as bone, muscle, and nerve. To develop cure for traditionally incurable diseases (e. g. cancer) through the utilization of nanotechnology and provide more effective cure with fewer side effects by means of targeted drug delivery systems. Nanotechnology is beginning to change the scaleand methods of vascular imaging and drug delivery. NanomedicineInitiatives' envisage that nanoscale technologies willbegin yielding more medical benefits within the next10 years. This includes the development of nanoscalelaboratory-based diagnostic and drug discovery platform devices

such as nanoscale cantilevers for chemicalforce microscopes, microchip devices, nanopore sequencing, etc.

The National Cancer Institute has related programs too, with the goal of producing nanometer scale multifunctionalentities that can diagnose, deliver therapeuticagents, and monitor cancer treatment progress. These include design and engineering of targeted contrast agents that improve the resolution of cancer cells to the single cell level, and nanodevices capable of addressing the biological and evolutionary diversity of the multiple cancer cells that make up a tumor within an individual. Thus, for the full in vivo potential of nanotechnology in targeted imaging and drug delivery to be realized, nanocarriers have to get smarter. Pertinent to realizing this promise is a clear understanding of both physicochemical and physiological processes. These form the basis of complex interactions inherent to the fingerprint of a nanovehicle and its microenvironment. extracellular and intracellular drug release rates in different pathologies, interaction with biological milieu, such as opsonization, and other barriers enroute to the target site, be it anatomical, physiological, immunological or biochemical, and exploitation of opportunities offered by disease states (e. g., tissuespecific receptor expression and escape routes from the vasculature). There are numerous examples of disease-fighting strategies in the literature, using nanoparticles. Often, particularly in the case of cancer therapies, drug delivery properties are combined with imaging technologies, so that cancer cells can be visually located while undergoing treatment. The predominant strategy is to target specific cells by linking antigens or other biosensors (e. g. RNA strands) to the surface of the nanoparticles that detect specialized properties of the cell walls. Once the target cell has been identified, the nanoparticles will adhere to the cell surface, or enter the cell, via a specially designed mechanism, and deliver its payload.

One the drug is delivered, if the nanoparticle is also an imaging agent, doctors can follow its progress and the distribution of the cancer cell is known. Such specific targeting and detection will aid in treating late-phase metastasized cancers and hard-to-reach tumors and give indications of the spread of those and other diseases. It also prolongs the life of certain drugs that have been found to last longer inside a nanoparticle than when the tumor was directly injected, since often drugs that have been injected into a tumor diffuse away before effectively killing the tumor cells.

4) Future of Nanoscience: ‘ Without carbon, life cannot exist’, the saying goes, and not only life. For technological development, carbon was the ultimate material of the 19th century. It allowed the beginnings of the industrial revolution, enabling the rise of the steel and chemical industries, it made the railways run, and it played a major role in the development of naval transportation. Silicon, another very interesting material which makes up a quarter of the earth’s crust, became the material of the 20th century in its turn. It gave us the development of high performance electronics and photovoltaics with large fields of applications and played a pivotal role in the evolution of computer technology. The increased device performance of information and data processing systems is changing our lives on a daily basis, producing scientific innovations for a new industrial era. However, success breeds its own problems, and there is ever more data to be handled- which requires a nanoscience approach. This cluster aims to address various

aspects, prospects and challenges in this area of great interest for all our futures.

Carbon exists in various allotropic forms that are intensively investigated for their unusual and fascinating properties, from both fundamental and applied points of view. Among them, the sp2 (fullerenes, nanotubes and graphene) and sp3 (diamond) bonding configurations are of special interest since they have outstanding and, in some cases, unsurpassed properties compared to other materials. These properties include very high mechanical resistance, very high hardness, high resistance to radiation damage, high thermal conductivity, biocompatibility and superconductivity. Graphene, for example, possesses very uncommon electronic structure and a high carrier mobility, with charge carriers of zero mass moving at constant velocity, just like photons. All these characteristics have put carbon and carbon-related nanomaterials in the spotlight of science and technology research. The main challenges for future understanding include i) material growth, ii) fundamental properties, and iii) developing advanced applications.

Carbon nanoparticles and nanotubes, graphene, nano-diamond and films address the most current aspects and issues related to their fundamental and outstanding properties, and describe various classes of high-tech applications based on these promising materials. Future prospects, difficulties and challenges are addressed. Important issues include growth, morphology, atomic and electronic structure, transport properties, superconductivity, doping, nanochemistry using hydrogen, chemical and bio-sensors, and bio-imaging, allowing readers to evalate this very interesting topic and draw perspectives for the future.

E. Foreign Prospect of Nanotechnology

Nanotechnology provides a significant opportunity to address global challenges. This is leading to intense global competition to commercialise different products enabled by nanotechnology. However, UK industry is well placed to capitalise on this opportunity and participate in the development of many new products and services by operating alone or in collaboration with international partners. Success in this area will lead to growth in employment and wealth creation. Today, nanotechnology is evolving with some mature products and many in the growth and developmental stage. This is not unlike the condition of computer science in the 1960s or biotechnology in the 1980s. Nanotechnology has been applied to the development of products and processes across many industries particularly over the past ten years. Products are now available in markets ranging from consumer products through medical products to plastics and coatings and electronics products.

There have been various market reports estimating the scale of potential future value for products that are “ nanotechnology enabled”. A report from Lux Research published in 2006 entitled The Nanotech Report 4th Edition, notes that nanotechnology was incorporated into more than $30 billion in manufactured goods in 2005.

The projection is that in 2014, $2. 6 trillion in manufactured goods will incorporate nanotechnology. Even if this is an over-estimate, it is clear that there is a vast market available for nanotechnology based products. It is extremely important to the UK economy that UK companies engaged in nanotechnology participate at each stage of the supply chain. While companies are moving speedily to develop further and more advanced products based on nanotechnology, they are becoming increasingly aware that there are many challenges to address.

It was with this background that a Mini Innovation and Growth Team (Mini-IGT) was formed comprising members of the NanoKTN and the Materials KTN as the secretariat, together with members of the Chemistry Innovation KTN and the Sensors and Instrumentation KTN, to prepare a report on nanotechnology on behalf of UK industry. A questionnaire was sent to the members of the various KTNs to solicit feedback on their views on nanotechnology focussing on their commercial position and also their concerns and issues. While the UK Government has commissioned reports and provided responses over the past decade, in the field of nanotechnology, the UK has not articulated an overarching national strategy on nanotechnology that can rank alongside those from the likes of the US and Germany. It is intended that this report, with its unique industry led views on nanotechnology, together with other strategic documents, including the Nanoscale Technologies Strategy 2009-2012 produced by the Technology Strategy Board, will provide a significant contribution to a future UK Government Strategy on Nanotechnology.

Nanotechnology is the basis for many products that are in common use and is providing the capability to produce a very wide range of new products that will become commonplace in the near future. The UK, like many other countries, has invested heavily in nanotechnology and has considered, through a series of reports and Government responses, how to manage and fund nanotechnology developments. At the third meeting of the Ministerial

Group on Nanotechnology it was agreed that a nanotechnology strategy should be developed for the UK. As part of the strategy development process, Lord Drayson launched an evidence gathering website on 7th July 2009. Alongside this, four Knowledge Transfer Networks (Nanotechnology, Materials, Chemistry Innovation and Sensors & Instrumentation) with significant industrial interest in nanotechnology agreed that it was necessary for industry to contribute to policy development using the bottom up approach. It is intended that this report with its unique industry led views on nanotechnology will provide a significant contribution to a future overarching UK Government Strategy on Nanotechnology, alongside other input from inter alia the Technology Strategy Board and the Research Councils. In addition to the questionnaire, feedback was sought from industry at workshop discussions with invited industry leaders and others in the field of nanotechnology to gather information on what they are currently doing and what their future needs are to create enhanced value from nanotechnology. A full review of UK and international strategic approaches was also undertaken. This report considers where the UK currently sits in terms of investment in comparison with its major industrial competitors and reviews the UK’s capability to exploit nanotechnology given the organisations and funding bodies currently.

The following recommendations on Policy and Regulation, Funding, Skills and Engagement have been developed to provide a basis for implementation of the Government Strategy based on this feedback and are listed below. A view is also given of what the UK status on nanotechnology would be in 2020 assuming that the recommendations are followed in the intervening years.

These recommendations are in line with the UK Government’s strategy for New Industry, New Jobs which is part of Building Britain’s Future.

This report, informed and led by the UK’s nanotechnology industry, recommends that the following are paramount to the successful exploitation of nanotechnology in the UK. These are listed under four headings and under each heading the recommendations are ranked in order of importance. These recommendations focus on areas where Government can make a significant difference.

F. Nanotechnology Health and Environmental Concerns

Human and the environment come under exposure to nanomaterials at different stages of the product cycle. Nanomaterials have large surface to volume ratio and novel physical as well as chemical properties which may cause them to pose hazards to humans and the environment. Health and the environmental impacts associated with the exposure to many of the engineered nanomaterials are still uncertain. The environmental fate and associated risk of waste nanomaterials should be assessed – e. g. toxic transformation, and interactions with organic and inorganic materials

Fig. 13. Exposure of human and the environment to nanomaterials at different stages of product life cycle.

G. Nanotechnology in Food

Nanotechnology is creating engineered particles in the size range 1 to 100 nanometers. At the nano-scale, materials exhibit novel behaviours. Nine billion dollars is currently invested annually in nano-research, with the explicit intention of rapid commercialisation, including food and agriculture applications.

Nanotechnology is currently unregulated, and nano-products are not required to be labelled. Health, safety and ecological aspects are poorly understood, and there have been calls for a moratorium. Two consumer surveys indicate that public awareness of nanotechnology is low, there is concern that the risks exceed the benefits, that food safety is declining along with declining confidence in regulatory authorities. A majority of respondents (65%) are concerned about side effects, and that nano-products should be labelled (71%), and only 7% reported they would purchase nano-food. There is an opportunity, for the organic community to take the initiative to develop standards to exclude engineered nanoparticles from organic products.

CONCLUSION

This paper covers the major aspects of the latest advancements that have been encountered in the past few years in the field of nanotechnology. Its implementation and usage in various fields makes it even more demandable. The implementation of nanotechnology in optical engineering, biomedicine, defence and electronics has been elaborated. Its applications when used in these fields are also discussed which extend from food to nanochips and nanorobots.