Report on Nanoscience

Nanoscience involves working with objects on a very very small scale in other words, the study of phenomena on a scale of 1 -100mn. It offers ways to create smaller, cheaper, lighter and faster devices that can do more and cleverer things, use less raw materials and consume less energy.

A nanoparticle in general is a small particle with at least one dimension less than 100nm. It is combined with other atoms to form structures called nanostructures. Nanoparticle research is currently an area of intensive scientific research, due to wide variety of potential applications in biomedical, optical and electronical fields. Being able to see atoms means that we can isolate and then move them, thus enabling us to manipulate substances (atoms, molecules) in such a way that we can use their specific characteristics for new materials in industry.

An Atomic Force Microscope is used in order for us to see these tiny particles. If you were to look closer with a microscope you could examine the cells that make up your skin. This is a scale of micrometres (one-thousandth of a millimetre), sometimes referred to as the microworld.

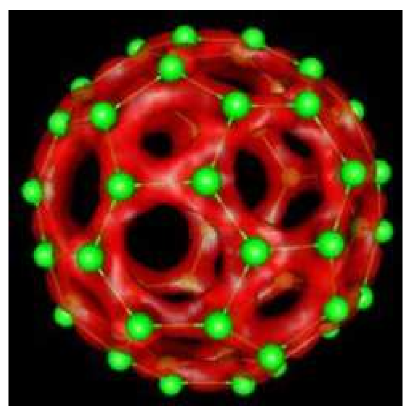
A nanometer is used to measure things that are very small. Atoms and molecules, the smallest pieces of everything around us, are measured in nanometer. One nanometer is 0.000000001m or 1nm. A nanometer is a unit of measure. Just like inches, feet and miles. A nanometer is one-billion of a meter. A meter is about 39 inches long.

Nonmaterial includes glass which is made into windows furthermore; there are other uses for nanoscience such as:

Some read computer data stored on CD-ROMs. Others are found inside cellular phones, pagers, medicines and replacement tissues and automobile tires; still others are part of lasers with accurate wavelengths, advanced chemicals, sensors, air bags and automobile engines.

Nanocomposites are materials that can be added to plastic to make it stronger, stiffer and lighter.

In conclusion, nanoscience is really important within the society as it enables us to study tiny particles.



A picture showing a fullerene related carbon nanostructure.

3 Science and applications

3.1 Introduction

1 In this chapter we provide an overview of some key current developments in nanoscience and nanotechnologies, and highlight some possible future applications. The chapter is informed by evidence from scientists and engineers in academia and industry. It illustrates the wide-ranging interest in these areas and provides a background to the later chapters, which address health, environmental, social, ethical and regulatory implications of nanotechnologies. It does not consider in detail the developments in nanoscience and nanotechnologies in all scientific and engineering fields.

2 As nanoscience and nanotechnologies cover such a wide range of fields (from chemistry, physics and biology, to medicine, engineering and electronics), we have considered them in four broad categories: nanomaterials; nanometrology; electronics, optoelectronics and information and communication technology; and bio-nanotechnology and nanomedicine. This division helps to distinguish between developments in different fields, but there is naturally some overlap.

3 Where possible, we define the development of future applications as short term (under 5 years), medium term (5–15 years), and long term (over 20years). It may be that some of the potential applications that we identify are never realised, whereas others that are currently unforeseen could have a major impact. We also identify potential in environmental, health and safety, ethical or societal implications or uncertainties that are discussed further in later chapters.

4 Current industrial applications of nanotechnologies are dealt with in Chapter 4, as are the factors that will influence their application in the future.

3.2 Nanomaterials

3.2.1 Introduction to nanomaterials

5 A key driver in the development of new and improved materials, from the steels of the 19th century to the advanced materials of today, has been the ability to control their structure at smaller and smaller scales. The overall properties of materials as diverse as paints and silicon chips are determined by their structure at the micro- and nanoscales. As our understanding of materials at the nanoscale and our ability to control their structure improves, there will be great potential to create a range of materials with novel characteristics, functions and applications.

6 Although a broad definition, we categorise nanomaterials as those which have structured components with at least one dimension less than 100nm. Materials that have one dimension in the nanoscale (and are extended in the other two dimensions) are layers, such as a thin films or surface coatings. Some of the features on computer chips come in this category. Materials that are nanoscale in two dimensions (and extended in one dimension) include nanowires and nanotubes. Materials that are nanoscale in three dimensions are particles, for example precipitates, colloids and quantum dots (tiny particles of semiconductor materials). Nanocrystalline materials, made up of

nanometre-sized grains, also fall into this category. Some of these materials have been available for some time; others are genuinely new. The aim of this chapter is to give an overview of the properties, and the significant foreseeable applications of some key nanomaterials.

7 Two principal factors cause the properties of nanomaterials to differ significantly from other materials: increased relative surface area, and quantum effects. These factors can change or enhance properties such as reactivity, strength and electrical characteristics. As a particle decreases in size, a greater proportion of atoms are found at the surface compared to those inside. For example, a particle of size 30 nm has 5% of its atoms on its surface, at 10 nm 20% of its atoms, and at 3 nm 50% of its atoms. Thus nanoparticles have a much greater surface area per unit mass compared with larger particles. As growth and catalytic chemical reactions occur at surfaces, this means that a given mass of material in nanoparticulate form will be much more reactive than the same mass of material made up of larger particles.

8 In tandem with surface-area effects, quantum effects can begin to dominate the properties of matter as size is reduced to the nanoscale. These can affect the optical, electrical and magnetic behaviour of materials, particularly as the structure or particle size approaches the smaller end of the nanoscale. Materials that exploit these effects include quantum dots, and quantum well lasers for optoelectronics.

9 For other materials such as crystalline solids, as the size of their structural components decreases, there is much greater interface area within the material; this can greatly affect both mechanical and electrical properties. For example, most metals are made up of small crystalline grains; the boundaries between the grain slow down or arrest the propagation of defects when the material is stressed, thus giving it strength. If these grains can be made very small, or even nanoscale in size, the interface area within the material greatly