CHAPTER SIX

6.1 Nano Materials applications

Nanotechnology and nanoscience have gained remarkable interest since the last decade and played an important role in improving modern applications due to its unique combination of properties. The controlled synthesis of nanostructures is a promising candidate that plays a vital role in the potential applications because the evolution of the morphology of films have a significant effect on the performance of functional surfaces by adopting a larger area, and mass-production-compatible methods remain a challenge. The growth of nanostructures has been extensively studied to produce specific shapes, sizes, and surface densities because of the great influence in their potential applications. The large aspect ratio and subwavelength diameter of nanostructures have superior optical and electrical properties such as optical anisotropy and surface band bending. Moreover, success in various applications requires the definition and control of the size and geometry of the nanostructures. Consequently, establishing the ability to customize the growth of nanostructures to produce specified surface densities, sizes, and orientation is necessary for many applications. Below we list some key applications of nanomaterials. Most current applications represent evolutionary developments of existing technologies: for example, the reduction in size of electronics devices.

a) Opto-Electronics:

Optoelectronics is an interesting branch of electronics that combines both electronics and optics. Optoelectronic devices find different applications in laser diodes, light emitting diodes, solar cell and plasma screen displays, UV detector etc. In today's world it is virtually impossible to find a piece of electrical equipment that does not employ optoelectronic devices as a basic necessity – from CD and DVD players to televisions, from automobiles and aircraft to medical diagnostic facilities in hospitals and telephones, from satellites and space-borne missions to underwater exploration systems – the list is almost endless. Optoelectronics is in virtually every home and business office in the developed modern world, in telephones, fax machines, photocopiers, computers and lighting, as shown in Fig.6.1. Optoelectronics is a remarkably broad scientific and technological field that supports a multi-billion US-dollar per annum global industry, employing tens of thousands of scientists and engineers. The optoelectronics industry is one of the great global businesses of our time.

Light emitting diode Laser diode Solar cell UV detector

Figure 6.1: Some examples of optoelectronic devices

b) Sensors of Gases:

The gases like N2 and NH3 can be detected on the basis of increase in electrical conductivity of nanomaterials. This is attributed to increase in hole concentration in nanomaterials due to charge transfer from nanomaterials to N2 as the gas molecules bind the nanomaterials.

c) Food:

Nanotechnology can be applied in the production, processing, safety and packaging of food. A nanocomposite coating process could improve food packaging by placing anti-microbial agents directly on the surface of the coated film. New foods are among the nanotechnology created consumer products coming onto the market at the rate of 3 to 4 per week.

d) Energy:

The most advanced nanotechnology projects related to energy are: storage, conversion, manufacturing improvements by reducing materials and process rates, energy saving. Today's best solar cells have layers of several different semiconductors stacked together to absorb light at different energies but they still only manage to use 40 percent of the Sun's energy. Commercially available solar cells have much lower efficiencies (15-20%). Nanotechnology could help increase the efficiency of light conversion by using nanostructures.

e) Sunscreens and Cosmetics:

A sunscreen based on nanoparticles such as titanium dioxide offer several advantages. Titanium oxide nanoparticles have a comparable UV protection property.

Nanosized titanium dioxide and zinc oxide are currently used in some sunscreens, as they absorb and reflect ultraviolet (UV) rays and yet are transparent to visible light and so are more appealing to the consumer. Nanosized iron oxide is present in some lipsticks as a pigment. The use of nanoparticles in cosmetics has raised a number of concerns about consumer safety.

f) Paints:

Nanoparticles in paints could improve their performance, for example by making them lighter and giving them different properties. Thinner paint coatings ('light weighting'), used for example on aircraft, would reduce their weight, which could be beneficial to the environment.

g) Displays:

The big market for large area, high brightness, flat-panel displays, as used in television screens and computer, is driving the development of some nanomaterials. Nanocrystal line zinc selenide, zinc sulphide, cadmium sulphide and lead telluride synthesized by sol gel techniques are candidates for the next generation of light-emitting phosphors.

h) Batteries:

With the growth in portable electronic equipment (mobile phones, laptop computers, remote sensors), there is request for low-weight, high-energy density batteries. Nanocrystal line materials synthesized by sol–gel techniques are candidates for separator plates in batteries because of their foam-like (aerogel) structure, which can hold considerably more energy than conventional ones. Nickel–metal hydride batteries made of

nanocrystal line nickel and metal hydrides are envisioned to require less frequent recharging and to last longer because of their large surface area.

i) Catalysis:

In general, nanoparticles have a high surface area, and hence provide higher catalytic activity. Catalysis is important for the production of chemicals. Nanoparticles serve as an efficient catalyst for some chemical reaction, due to the extremely large surface to volume ratio. Platinum nanoparticles are now being considered in the next generation of automotive catalytic converters because the very high surface area of nanoparticles could reduce the amount of platinum required. Some chemical reactions are also carried out using nanomaterials. For example, reduction of nickel oxide to the base metal Ni.

j) Environmental:

Nanotechnology is being used in several applications to improve the environment.

i) **This includes cleaning up present pollution**

ii) **ii) improving manufacturing methods to reduce the generation of new pollution**

iii) **iii) making alternative energy sources more cost effective.**

k) Construction:

Nanotechnology has the potential to make construction more solid, faster, cheaper and safer. Automation of nanotechnology construction can allow for the creation of structures from advanced homes to massive skyscrapers much more quickly and at much lower cost.

6.2 Medical Applications of Nano Materials

The interface between nano-systems and bio-systems is emerging as one of the broadest and most dynamic areas of science and technology, bringing together biology, chemistry, physics and many areas of engineering, biotechnology and medicine. **The aim of the nanotechnology in the medical sciences is to develop new materials and methods to detect and treat diseases. The application of nanotechnology in the medical area is referred as Nanomedicine. Nanoparticles have potential applications in the field of medical sciences including;**

(i) **New diagnostic tools**

(ii) **Imaging methods**

(iii) **Medicine and Pharmacy for purposes of diagnostic, imaging and drug delivery**

(iv) **personal care (sporting goods, sunscreens, cosmetics)**

(v) **Bio-sensor (monitor blood oxygen levels, glucose sensor, skin analysis sensor, enzyme based sensor).**

(vi) **Bio implants and tissue engineering.**

(vii) **Drug delivery with high toxic potential like cancer chemotherapy drugs can be given with better safety profile with the service of nanotechnology.**

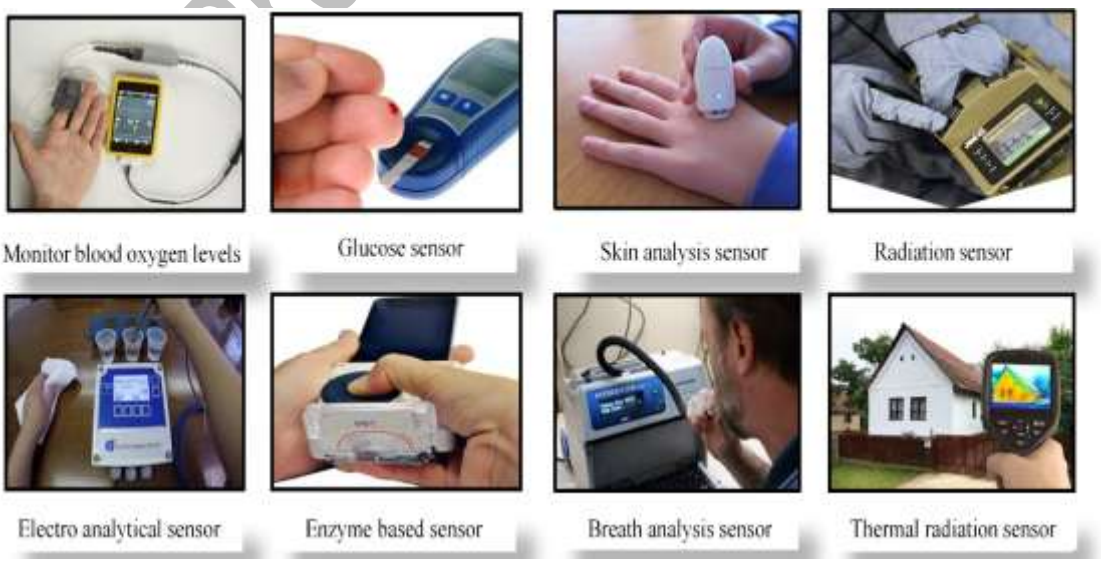

Figure 6.2: Some examples of Bio-sensor devices