International Research Journal of Natural and Applied Sciences
ISSN: (2349-4077)
Impact Factor 5.46 Volume 7, Issue 5, May 2020
Website- www.aarf.asia, Email : editor@aarf.asia , editoraarf@gmail.com

A Study of Nano Structured Materials and Its Properties

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Abstract

Utility of nano materials increasing day by day. The uses of nanotechnology, commonly include medicinal, industrial, and energy uses. In this paper we are providing the information about nano structure and its properties. The paper consists of information about nano particle, nano materials, nano composites and properties of nano materials etc.

Keywords: Microcrystal Matrix, Nanotechnology, Nanocomposites

Introduction

Nanotechnology simply means any technology on a nanoscale (less than the size of 100 nm) that has applications in recent and modern advancements [1]. Nanotechnology is an area of science and technology whose motif is the control of the size of matter. Nanotechnology is often concerned with the development of materials, electronics, or other structures having at least one dimension ranging from 1 to 100 nanometers. It is the design, characterization, manufacture, and application of structures, devices, and systems at the nanoscale scale by manipulating shape and size. [2,3]. Nanotechnology is a multidisciplinary field including material science, interface & colloid science, chemical, mechanical, biological, and electrical engineering, etc. [4].

Nanotechnology has come a long way in comparison to semiconductor technology, information technology, or cellular and molecular biology in the second half of the twenty-first century. Construction and manufacturing, nano-electronics, the medical industry, biotechnology, information technology, and national security all benefit from scientific

research and technology in nanotechnology. Nanotechnology is widely considered to be the next industrial revolution.

Nanometer-scale features are built primarily on their basic components. A nanomaterial/nanoparticle definition is a mixture of atoms attached to a radius between 1 and 100 nanometers. Nanomaterials can have quite different qualities than high-quality materials. When the size of the property is reduced from the mass, then the structures remain the same at first, then small changes show, and finally, the size decreases below hundred (100) nanometers, large changes may occur in the material area [5].

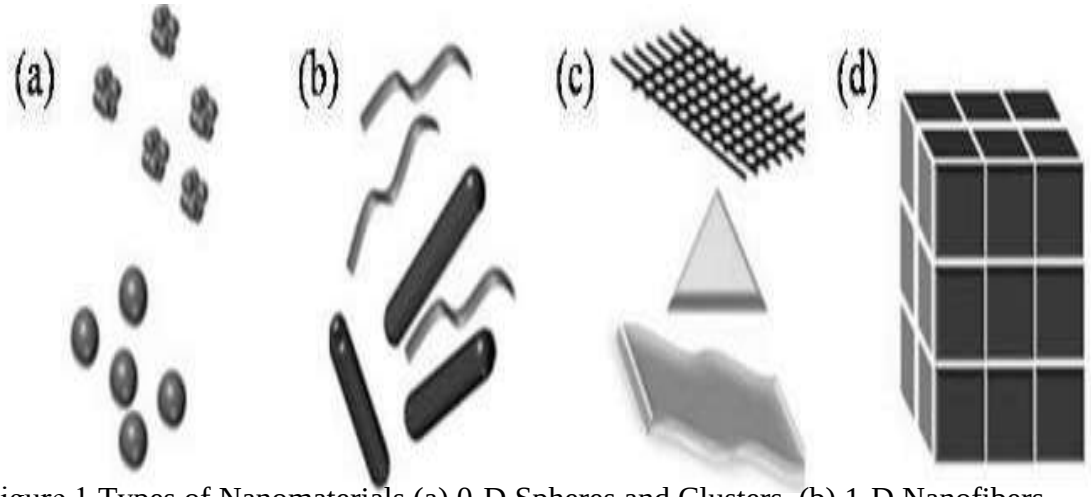
Nano-scale materials are normal to find many unique and advanced applications. The analysis of novel nanomaterials, their processes, properties, and applications for the expansion of new techniques for research gives new prospects for the development of nanosystems and nanostructured materials. It is widely estimated that nanotechnology will be the next revolution in industry. This field are expected to open new platforms in science and technology [6].

1.1 Nanomaterials

Nanomaterials have a very small size with as a minimum one dimension of the order of 100 nanometers or less. Such materials can be nanoscale in 1-D (surface films), 2-D (strands or fibers), or 3-D (particles). They come in spherical, tubular, and irregular shapes and can be solitary, fused, aggregated, or agglomerated. Various Type of nanomaterials include nano-tubes, quantum dots (QDs), and fullerenes, etc.

Nanotechnology uses of various types of nanomaterials and exhibits different physical/chemical characteristics/properties from normal elements (silver nano, CNT, fullerene, photocatalyst, carbon nano, silica) [7].

Nanostructured materials are divided into zero-dimensional (0-D), one-dimensional (1-D), two-dimensional (2-D), three-dimensional (3-D) nanostructures.



"Figure 1 Types of Nanomaterials (a) 0-D Spheres and Clusters, (b) 1-D Nanofibers, Wires, and Rods, (c) 2-D Films, Plates, and Networks, (d) 3-D Nanomaterials".

1.2 Nanocomposites

As we know, there are different types of nanocomposites forms and their classification is done depending on their structures. There are two main groups of nanocomposites are elaborated as follows.

1.2.1 Microcrystal Matrix

This is called macro-nano type nanocomposites. In this, nanometer-sized particles or inclusion (spherical, plate-like, fiber-like) of a second phase are dispersed in the inter-granular regions or in both inter/intragranular spaces of matrix grains.

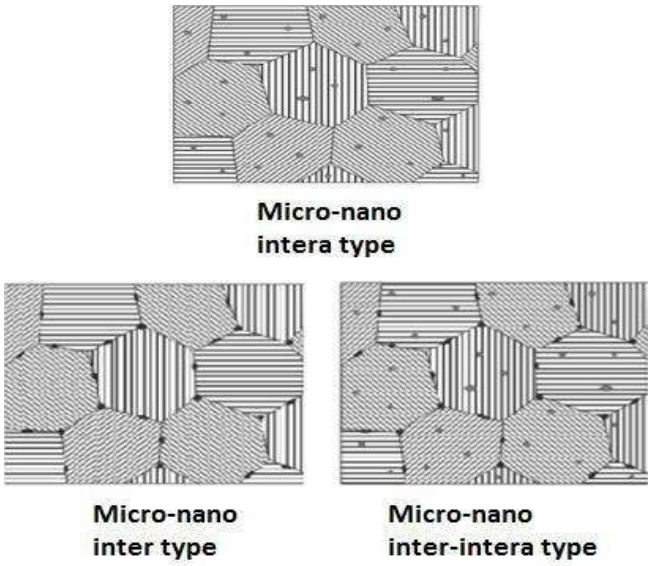


Figure 1.2 Different types of Microcrystal Matrix Structures

1.2.2 Nanocrystal Matrix

These nanocomposites are basically of three types.

1. **Nano-nano**: Amorphous inclusions or nanocrystalline phases in a nanocrystalline matrix.
2. **Nano-fiber**: nano-sized fibers dispersed in a nano crystalline matrix.
3. **Nano-nanolayer**: nanocrystalline grains in a second phase nanolayer.

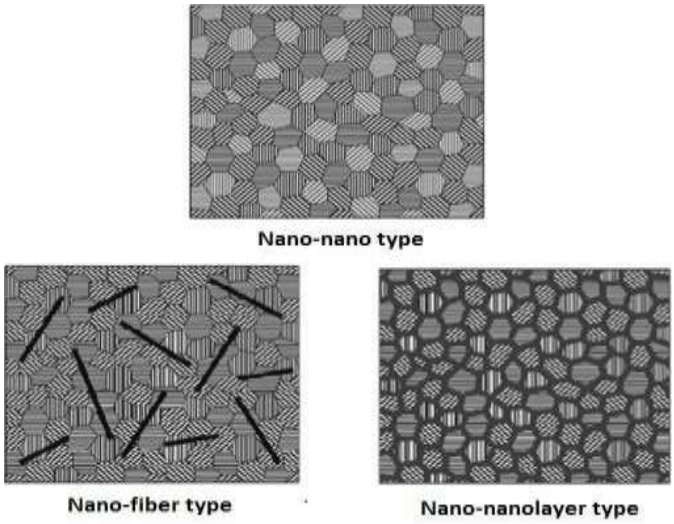


Figure 1.3 Different types of Nanocrystal Matrix Structures

Because of their unusual electrical and optical properties, semiconductor compounds have attracted a lot of research thought in the last few years due to their prospective uses in high-performance luminescence devices, photocatalysts, and optoelectronics.

1.3 Properties of Nanomaterials

The properties of nanomaterials can be controlled by regulating the size, morphology, and configuration of the nanoparticles. The various material properties i.e. electrical, mechanical, optical, thermal, catalytic, etc. are highly affected by the grain structure. The change in properties occurs when the size of the particle reduces from bulk to nano. There is various form of nanostructured materials like thin films, quantum well, quantum dot, powder, etc. depending on the synthesis methods. All nanomaterial is composed of grains and these grains are invisible to the necked human eye. A nanocrystalline material has grains of the order of 1-100nm [7]. **Physical properties**

The nanoparticles crystal structure is the same as a bulk structure with differ in lattice parameters. The melting point of nanoparticles also changes with size. The surface-to-volume

ratio phenomenon affects the nanoparticle's reactivity and solubility. They can be used for adhesion and lubrication and stabilization type technologies.

Mechanical properties

The mechanical strength of crystalline materials is great because the hardness of these materials increases as decreases crystal size. At the nanoscale, ceramic and metallic materials can exhibit this behavior.

Thermal properties

The melting point of nanoparticles drops when the nanoscale influences the atoms on the surface of the particles, compared to the identical materials on a larger scale. This is because atom motion occurs at lower temperatures in the nanoscale.

Electronic properties

When a particle size reduces to a nanoscale level by decreasing the dimensions on one or more sides, quantum confinement takes place. Then energy bands are changed into discrete energy levels and this increases or widens up the bandgap and then bandgap energy also increases.

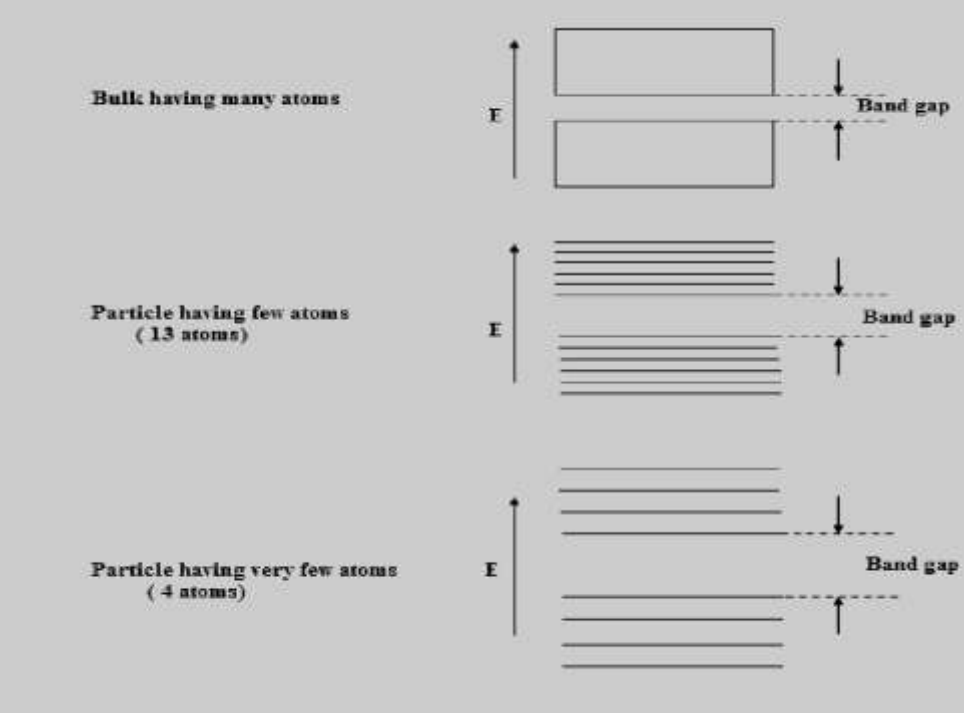


Figure 1.4 Representation showing bandgap larger as the material gets smaller

Optical properties

Compared to similar devices in bulk form, the wavelength at which light absorption begins differs when the device is at nanoscale level. So the size and type of material highly affect light absorption. Subsequently, nanoparticles are smaller than the wavelength of visible light, so light scattering over them can be expected as negligible.

Chemical properties

When the particle size is reduced to the nanoscale, the S/V ratio is increases, so then chemical reactivity also increases. It happens because most chemical reactions occur at the surface of Nano materials. The surface and interfacial properties may be modified by the presence of surfactants.

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