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Investing and Manipulating Materials in the Nano-Scale

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***Abstract*-Nano-technology makes it possible to achieve several benefit Cohen you manufacture materials. The breakthrough of nano-technology has been permitted in the past few decider by the advent of apparatus allowing the manipulation and observation of the nano-world. Now a days, nanometric and nanoparticles are used for many application in our daily life, such as in the field of electronics, catalysis, optics, biology and medicine. This article presents an overview about the several forms of microscopy which are used for characterization of nano-materials.**

***Keywords*- Nano-technology, Scanning materials, Electron Gun, Microscopes.**

I. INTRODUCTION

Nano Technology is the science and technology of small things that are less than 100nm in size. Scientists have discovered that materials at small dimension. (Eg.) Small particle, thin films, etc. The observation of materials in the Nanoscale can be done using electrons, photons, scanning probes, icons, atoms and etc. The resulting information can be processed to yield images or spectra which reveal the topographic, geometric, structural, chemical or physical details of the material.

II. MICROSCOPE

We use microscopy in order to see objects in more details. The best distance that one can resolve with optical instruments, disregarding all aberrations, is about 0.5λ, or of the order of 250nm with visible radiation.Under ideal conditions, the smallest object that the eyes can resolve is about 0.07mm. The advantages of a microscope is that it effectively brings the object closer to the eye. This allows us to see a magnified image with greater details.

Several forms of microscopy are available for studying nano materials. These can be broadly grouped under the following categories,

(i) Optical microscopes
(ii) Electron microscopes
(iii) Scanning probe microscopes
(iv) Others

While the first three categories are more common, others also used for nano measurement. A few of the techniques which are also useful as spectroscopies, are also discussed.

A microscope is an instrument used to form enlarged images. The word microscope is derived from two great words micros meaning small and skopos meaning to look at microscopes developed by *Antoni van Loeuwen hoek (1632-1723)* were the state of the art for about 200 years. They helped in the discovery of bacteria. As his research was not appreciated, van loevwen hoek destroyed most of his 500 odd microscopes before his death at the age of 91.

III. SEVERAL KIND OF SCANNING MICROSCOPES

a) Scanning Electron Microscope (SEM)

Fig. 1. Scanning Electron Microscope (SEM)

In this, a monochromatic electron beam is passed over the surface of the specimen which induces various changes in the sample. The resulting particles from the sample are particles from the sample are used to create an image of the specimen. The information is derived from the surface of the sample. Although the images appear to be three-dimensional a true three-dimensional image is obtained only by using a combination of two pictures.In this, charged ions are used to obtain the image and the process etches away the top surface.

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b) Scanning Acoustical Microscope (SAM)

Fig. 2. Scanning Acoustical Microscope (SAM)

The uses ultrasonic waves to form images. The best resolution achieved is of the order of 2.5microns, which is limited by the wave length of sound. Its advantages is that it allows one to look at live biological material.

c) Scanning Light Microscope (SLM)

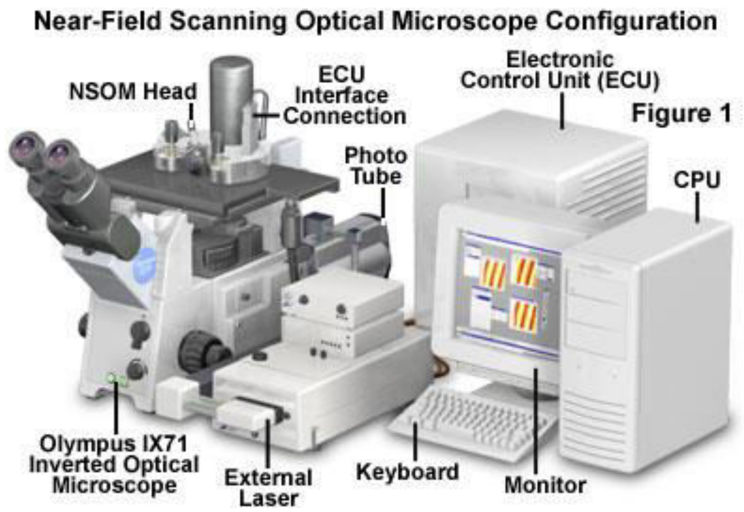

Fig. 3. Scanning Light Microscope (SLM)

In this, a fine beam of visible light is passed over the surface to build up the image point-by-point. It facilitates increased depth of field and colour enhancement.

d) Scanning Confocal Microscope (SCM)

In this, a finely focused team of white or monochromatic light is used to scan a specimen. It allows one to optically section through a sample. This technique is more commonly referred to as confocal microscopy.

e) Electron Gun

Fig. 4. Electron Gun

The electron gun provides a stable beam of electrons. The most common form of an electron gun is a thermionic emitter, where in the work function of the metal is overcome by the surface temperature of the filament. Typically a hairpin filament made of a tungsten wire of 100µm. The filament negative is held at a negative potential and heated to about 2000-2700K by resistive heating. The electrons are confined and focus by a grid cap. The brightness is of the order of 10^5(A/cm^{2}Sr) for the tungsten filament. An order of magnitude increased brightness is possible in the case of lanthanum hexa boride (LaB_6) based guns and still larger brightness is possible in the case of field emission guns. The emission is a single crystal of LaB_6 of 10µm diameter with 500µm length. The crystal is mounted on a rhenium or graphitic corbon base. Two kinds of field emission sources are commonly used, (ie) the cold field emitter (CFE) and the schottky field emitter (SFE).

f) SEM: Modern Advantages

SEM is the most widely used to electron microscopic techniques modern advanced SEM`s utilize field emission sources. There have been numerous advances in various aspects of the hardware such as lenses, detectors and digital image acquisition. Low voltage SEM is another new development. The extreme surface sensitivity of this techniques is a now a result of the reduced interaction volume. High resolution SEM is now routine analytical tool. In nano science and technology, this becomes an important high through put characterization tool. It is important to know the dimensions of the structures fabricated and the materials prepared when characterizing device structure.

g) Stem

STEM is a hybrid instrument with the features of both SEM and TEM. The same probe beam in TEM can be de-magnified and used as a probe beam, which can be scanned over the sample. The probe beam has to be small and bright and therefore, field emission sources are needed to obtain. Beam dimensions that are smaller than a nanometer.

h) Environmental Transmission Electron Microscopy

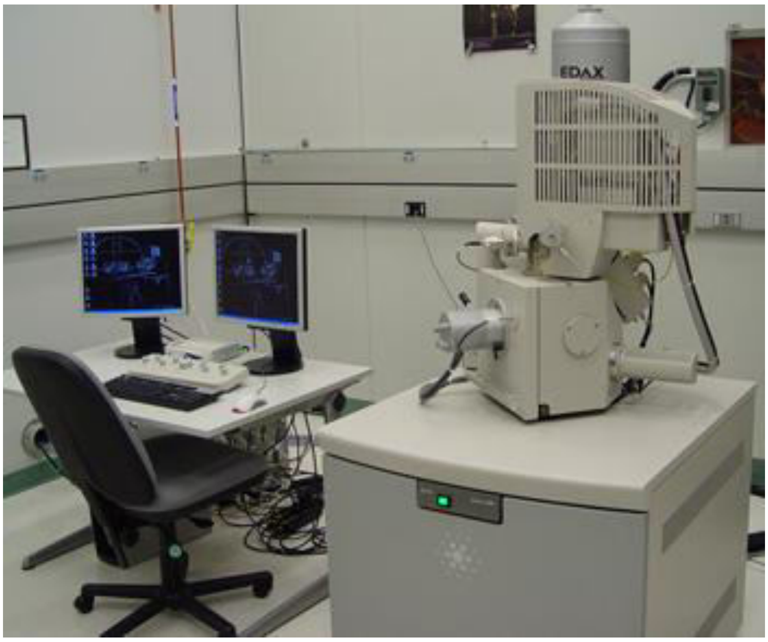

Fig. 5. Environmental Transmission Electron Microscopy

Science at the nanoscale is concerned with the variation of properties with size and shape. Structural and morphological changes occur in these occur in these materials with minor changes in temperature and other parameters such as atmosphere. In ETEM, the sample is confined in a high pressure region, as high as 150 torr, in such a way that the column vacuum does not deteriorate significantly. Due to the space requirements of such a cell, these kinds of cells have been used only in high energy instruments because of their larger pole-piece gaps. The medium energy TEM`s today have pole-piece gaps of 7-9mm, large enough to accommodate a cell.

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i) Atomic Force Microscopy

Fig. 6. Atomic Force Microscopy

In this technique, the interactions between a sharp probe and a sample are used for imaging, the cantilever which probes the surface atomically sharp tip which is brought into contact with the surface. The large scale use of AFM today is because of the application of micro fabricated tips of Si or Si_3N_4. In practical description of resolution, especially in the biological context, the width of DNA measured is considered as a measure of resolution. DNA in its β form is known to have a diameter of 2nm. Width alone is not enough to describe the resolution as SPM is a three-dimensional technique and height is important.

j) Focused Ion Beam

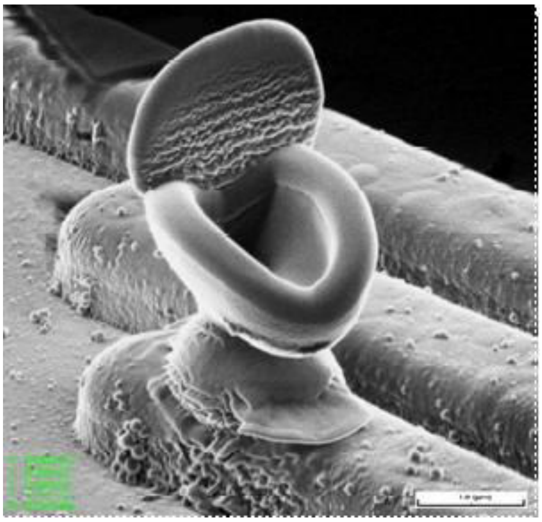

Fig. 7. Focused Ion Beam

The focused ion beam technique utilize a liquid metal ion source and the interaction of high energy ion with the sample is used to investigate or modify the sample. Elastic and inelastic collisions take place when the ion beam strikes the sample. Elastic collisions lead to the sputtering of atoms and inelastic collisions yield secondary electrons and X-rays, Ions are also ejected. In addition to single ion beam, an ion beam and an electron beam combination may be used, which will combine the capabilities of FIB and SEM. This can help achieve lithography, Imaging and characterization together such an instrument has several application in Nano Technology.

k) Dynamic Light Scattering

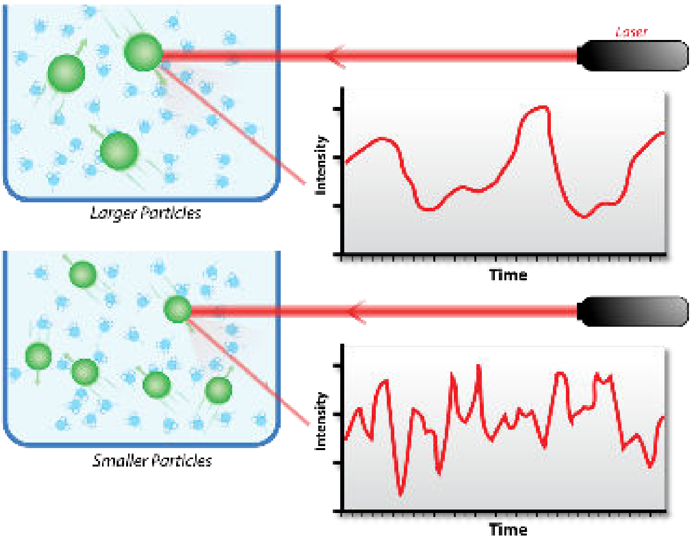

Fig. 8. Dynamic Light Scattering

Dynamic light Scattering is also called quasi-elastic light Scattering (QELS) or photon correlation spectroscopy. This is one of the foremost techniques used to measure the foremost techniques used to measure the radius of a particle in a medium. The motion of particles of micron or lower size is uncorrected. (i.e) they are random. As light scatters from such particles, there will be a shift in the phase of the scattered light which is random and as a result, when the scattered light rays from several particles are added together, constructive or destructive interference occurs. In principle, the technique can distinguish the nature of particles, separated or aggregated, over a range of particle sizes. Typically measurements are done in the nano meter to one micrometer size region.

l) Associated Techniques

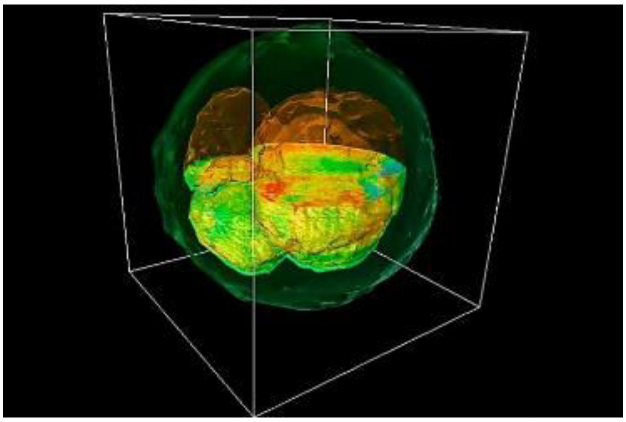

Fig. 9. Associated Techniques

In additionto theabove, various analytical techniques are also used for nano measurements. Broadly, any technique used for material characterization can be applied in this area too. Several of these techniques such as zeta potential will be discussed at appropriate places in the text where a discussion on these studies imply that almost every tool is adaptable for adaptable for nanomaterial investigations.

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FarvezBasha born in 2000, pursuing his Bachelor degree in physics in Thanthai Hans Roever College, Perambalur, India. He has achieved Inspire Award and Rajyaprishkar Award and has won several prizes in District, University and State levels. He has presented 2 international and 1 national level paper presentation across India.