Fundamentals of nanotechnology

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Synthesis Routes of Nano-Structured Materials

2. Top- Down Approach

1. Ball milling method

One of the top-down approach is ball milling method. In ball milling, small hard balls are allowed to rotate inside a container and then it is made to fall on a solid with high force to crush the solid into nano crystal. Ball milling is also known as mechanical alloying or crushing. The hardened steel or tungsten carbide balls are put in a container along with powder of particles (< 50 μm) of a desired material. The container is closed with tight lids. When the container is rotating around the central axis, the material is forced to press against the walls. The milling balls impart energy on collision and produce smaller grain size of nano particle. Few milligram to several kilograms of nanoparticles can be synthesized in a short time. This technique can be operated at large scale.

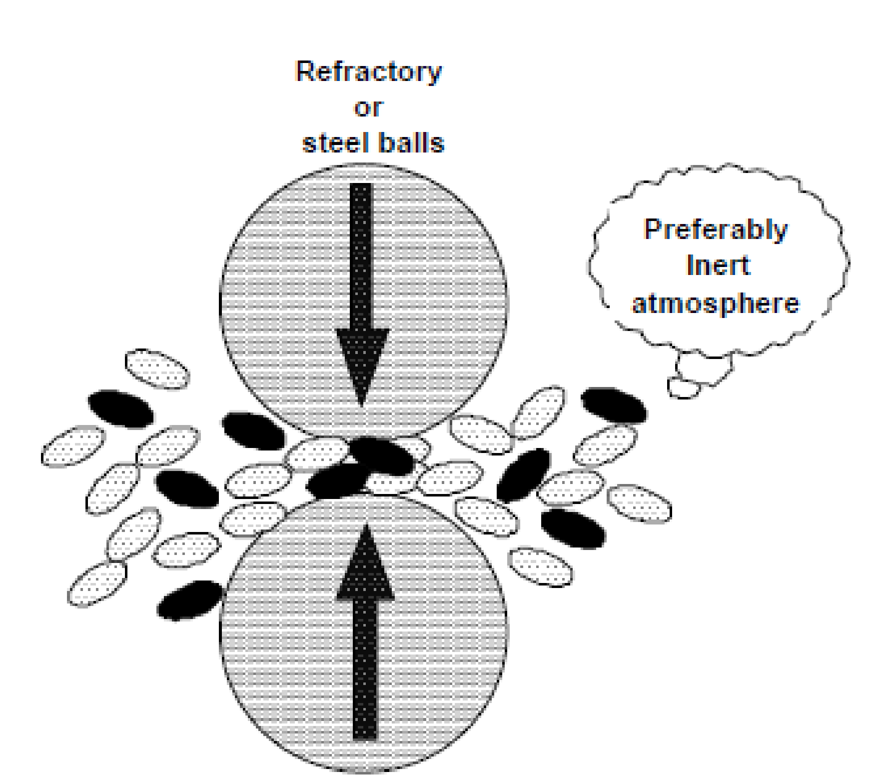

Fig. ٦. Schematic representation of the principle of mechanical milling

2. Electro-deposition Method

This technique is used generally in electroplating and in the production of nano-films. In this technique, two electrodes (anode E1 and cathode E2) are immersed inside the electrolyte [aqueous solutions of salt, acids etc]. When the current is passed through the electrodes, certain mass of substance is liberated from one electrode say for example from electrode E1 and is deposited on the surface of the other electrode say E2 and hence forms a thin nano - film on the surface of the electrode E2. The thickness of the nano-films can be adjusted by controlling the current and the time of deposition. These films are mechanically robust, highly flat and uniform.

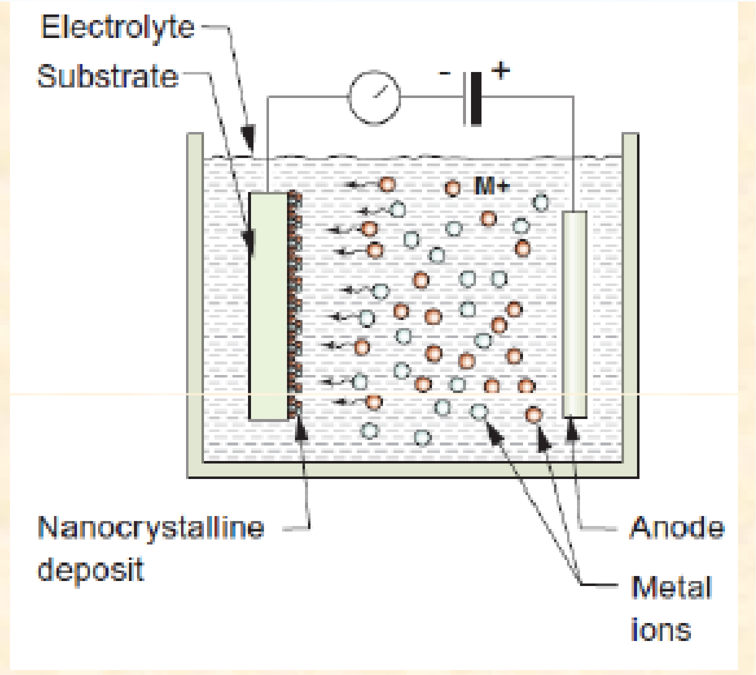

Fig. V Electroplating technique

The principle of electrodeposition is inducing chemical reactions in an aqueous electrolyte solution with the help of applied voltage, e.g. this is the process of using electrical current to coat an electrically conductive object with a relatively thin layer of metal. This method is relevant to deposition of nanostructured materials include metal oxides and chalcogenides.

Electrodeposition is relatively cheap and can be performed at low temperatures which will minimize interdiffusion of materials in the case of a multilayered thin film preparation.

The film thickness can be controlled by monitoring the amount of charge delivered, whereas the deposition rate can be followed by the variation of the current with time.

The composition and defect chemistry can be controlled by the magnitude of the applied potential, which can be used to deposit nonequilibrium phases. Pulsing or cycling the applied current or potential in a solution containing a mixture of precursors allows the production of a multilayered material.
The potential during the pulse will determine the species deposited whilst the thickness of individual layers is determined by the charge passed. Alternatively, the substrate can be transferred periodically from one electrolytic cell to another.
The final films can range in thickness from a few nanometers to tens of microns and can be deposited onto large specimen areas of complex shape, making the process highly suitable for industrial use.

3. Electrospinning method

A large number of advanced techniques have been employed to fabricate 1-D nanostructure, but electrospinning seems to be the simplest and most versatile method. Electrospinning is a broadly used technique for electrostatic fiber formation. In this method electrical force is utilized to produce polymer fibers with diameters ranging from few nanometers to several micrometers using polymer solutions of both natural and synthetic polymers. It is the process by which continuous nanofibers are produced with high surface area-to-volume ratio.

Electrospinning process parameters

Solution Parameters– viscosity, conductivity, molecular weight, molecular weight distribution, surface tension, polymer structure, solution properties.

Process Parameters– applied electric field, tip to collector distance, feeding or flow rate, hydrostatic pressure in the capillary, plate movement

Ambient Parameters– humidity and temperature of the surroundings, solution temperature, air flow rate.

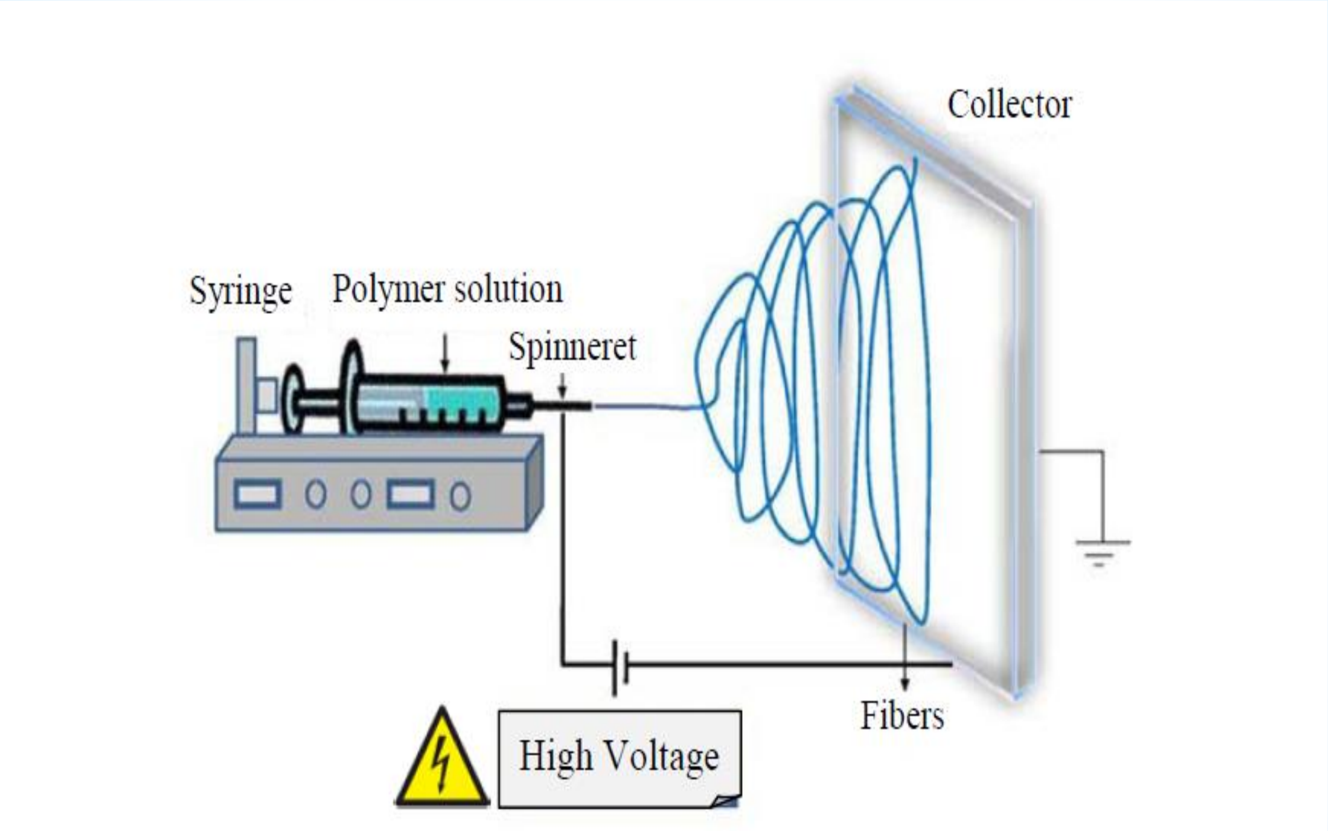

Fig.Λ: Schematic diagram of an electrospinning process