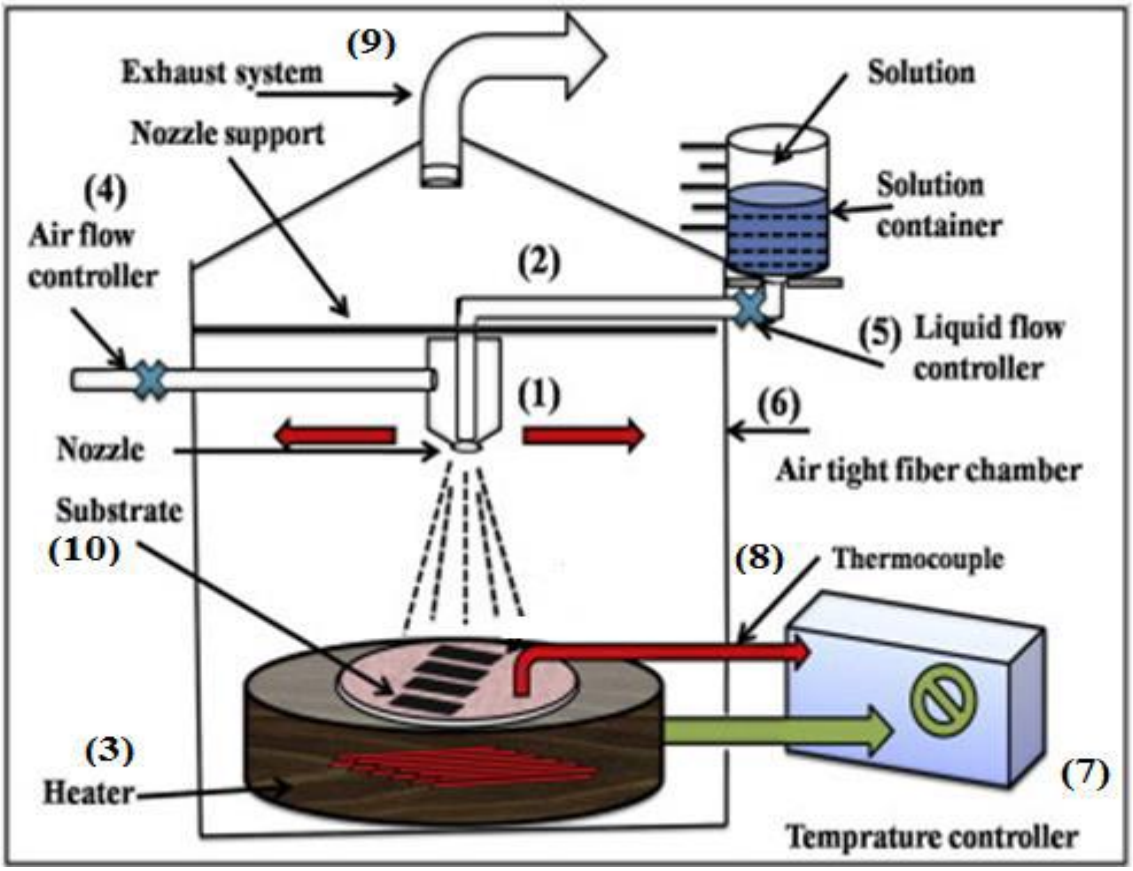
Thin films

Lecture (2)

Chemical Spray Pyrolysis Technique (CSP):

Chemical spray pyrolysis is one of principle methods to produce large area and uniform coating. Spray pyrolysis has proved to be simple and inexpensive .Besides the simple experimental arrangement, high growth rate and mass production capability for large area coatings make them useful for industrial as well as solar cell applications. By using this technique one can control the film morphology and particle size in the nanometer range .The prime requisite for obtaining good quality thin film is the optimization of preparative conditions via, Substrate temperature, spray rate, concentration of solution etc. Spray pyrolysis is a processing technique used to prepare oxide films, ceramic coatings and powders. It has also been used for several years in glass industries and solar cell production. Spray pyrolysis includes a thermally stimulated chemical reaction between fine droplets of different chemical species. In this technique, a solution containing soluble salts of the constituent atoms of the compound is sprayed on a heated surface as tiny droplets by a nozzle atomizer with the help of a carrier gas.The droplets start decomposition to form a film on the substrate surface, when they reach the substrate. The hot surface maintains the required thermal energy for the decomposition and recombination. The carrier gas sometimes plays an active role in the pyrolytic process.

The chemical spray pyrolysis system includes the nozzle, solution container, heater, air flow controller, liquid flow controller, airtight fiber chamber, temperature controller, thermocouple, (exhaust system, nozzle support) and substrate as shown in the following figure.



1. Spray Nozzle :

   Spray pyrolysis was fixed on a certain height by means of a holder which itself fixed on a metal rod, in such a way that the height of the apparatus above the surface of the electrical heater can be controlled. In addition to the position of the apparatus it can also be controlled because the end of the capillary tube in which the solution coming out should be in a perpendicular position on the substrate.

   2. Heater:

   This heater is used to heat the substrate to the required temperature. The temperature controller (or the heat limit) controls the temperature with the help of special thermocouple. The temperature is registered by digital read out; the range of the heater temperature is (1-500) ^{0}C with accuracy of ±10 ^{0}C.

3. Thermocouple:

The thermocouple consists of a sensitive thermal probe which is in contact with the surface of the substrate; and connected to a digital counter showing the temperature degree (in centigrade).

4. The Spray Controller Unit:

This part contains the timer which controls the spray time.

5. Air Compressor

Preparation of thin films:

The basic steps in the process of the films preparation are:

1) The solutions must be mixed according to the films components, before starting the deposition.

2) After getting different amounts of solutions according to the ratio and volume requirement, put them in the magnetic stirrer to be sure that solutions were mixed properly.

3) After cleaning the substrates, place on the flat plate heater surface, which is electrically controlled , and leave solutions for about 10 minutes so as to allow their temperature to reach a certain temperature.

4) Then the solution must be put in sprayer container.

5) After that, start the deposition process with a certain deposition time.

6) When the fine droplets arrive at the substrate, the solid compounds react to become a new chemical compound. The atomization of the solution into a spray of fine droplets is carried out by the spray nozzle, with the help of compressed air as carrier gas.

7) After the spray process is completed, the heater will be shut down and the samples are left on the surface of the hot plate to reach the room temperature, then the substrates can be raised.

8) Finally, characterize the structural, optical and electrical properties for films.

Note: To measure the thickness of thin films by weighting Method through this law

$$t = \frac{m_2 - m_1}{\rho_{total} \times A}$$

Advantages of Chemical Spray Pyrolysis

- Low cost (inexpensive apparatus).
- Does not require high quality targets or vacuum at any stage: a major advantage when scaled up for industrial applications.
- Simplicity and good productivity .
- Easy control of composition, deposition rate, film thickness and microstructure by changing the spray parameters. It eliminates the major problems of chemical methods such as sol-gel which produces films of limited thickness.
- Can produce films on less robust materials, with virtually no limitation on substrate material , dimension or the surface.
- Technological capability for mass production.
- Easy preparation of multi-layer films with composition gradient through the thickness by changing composition of the spray solution during the spray process.
- Offers opportunity to obtain reliable fundamental data because of well-formed film surfaces. The resulting films are quite compact, uniform without any side effects from substrate.

Despite the many advantages, there are also some disadvantages to this method including:

- Spray nozzle might get cluttered after long usage .
- Film quality highly dependent on droplet size and spray nozzle.

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