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# THE BAND GAP STUDIES OF COPPER OXIDE THIN FILM

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**ABSTRACT**

The study of the material in thin film form has solved a number of fundamental problems, which could be solved by materials in the bulk form. The applications of thin films are numerous. Chemical bath deposition also known as solution growth it is a controlled precipitation of a solution of a compound on a glass substrate. This method is very advantageous The method is used to prepare Copper Oxide thin films. The structure, lattice constants and crystallite size are calculated using X-Ray Diffraction technique. Band gap of the film is studied by using UV-VIS-NIR spectrum. Surface morphology of deposited film is obtained by SEM study.

**KEY WORDS:** Thin film, Band gap, X – ray diffraction.

## 1. INTRODUCTION:

The thickness of a film determines the properties of the film. It is the very basic character of the film. In contrast, other important film attributes such as structure and chemical composition, where only characterized in the most rudimentary way until relatively recently. In some applications the actual film thickness, with in broad limits, is not particularly crucial to functions. The life period of an inner element is determined by the coating thickness and resistibility. Micro electronics require re-change of thickness of the films for the maintenance.

### CHEMICAL BATH DEPOSITION

Chemical bath deposition is the widely used for the preparation of thin films as it is accessible, simplest and the most economical one. CBD is a technique in which thin films are deposited on substrates immersed in dilute solutions containing metal ions and sulphide ions or selenide ions. This process usually uses a chelating agent to control the release of metal ions and sulphide ion to produce controlled homogeneous precipitation of the film on the solid substrate[1]. CBD is well suited for producing large area thin films. It does not require sophisticated instruments like vacuum system. The other starting chemicals are readily available and are cheap than the other techniques. The present CuO film is also prepared by chemical bath deposition.

### EXPERIMENTAL TECHNIQUES OF CHEMICAL BATH DEPOSITION:

The CuO thin film is prepared by the chemical bath deposition technique [3-4]. Recently large area and large scale applications of this technique to obtain doped and uncontaminated multi component semiconductor films of usual, peculiar and meta-stable structures have demanded the understanding of the physics and chemistry of the process involved[5].

Chemical bath deposition also known as solution growth is a controlled precipitation of a solution of a compound on a glass substrate. This method is very advantageous than CVD, MBE and Spray Pyrolysis. By varying the pH, temperature and concentration the thickness and deposition rate of the film can be varied. This process is very cheap. The solubility product (Ksp) determines the homogeneity and stoichiometry of the thin film.

### 1.3:Chemical aspects

According to the solubility product principle, in a saturated solution of a weakly soluble compound the product of the molecular concentrations of its ions (each concentration term being raised to a power equal to the number of ions of that kind as shown by the formula for the

compound) called the ionic product, a constant at a given temperature. If the ionic product (IP) exceeds the solubility product (SP), precipitation occurs[6]. When IP<SP, the solid phase will dissolve until the above relation is satisfied.

It is necessary to eliminate spontaneous precipitation in order to form a thin film by a controlled ion-by-ion reaction. This can be achieved by using a fairly stable complex of the metal ions which provide a controlled number of the free ions according to an equilibrium reaction of the type.

$$M(A)^{2-} \leftrightarrow M2^{+} + A$$

The concentration of the free metal ion at a particular temperature is given by

$$[M^{2+}][A]/ [\ M\ (A)^{2+}]=K_i$$

Where $K_i$ is known as instability constant of the complex ion. By choosing an appropriate complexing agent, the concentration of the metal ion is controlled by the concentration of the complexing agent and the solution temperature.

**PHYSICAL ASPECTS**

The substrates are immersed vertically in the reaction bath, which is stirred continuously with a magnetic stirrer. The temperature of the bath is monitored by a contact thermometer that forms a part of a feedback circuit controlling the heater to maintain a constant temperature. When the IP of the metal and chalcogenide film is formed on the substrate by an ion-by-ion condensation process.

The composition and temperature dependent of the various chemical reactions involved can be worked out thermodynamically. The experimental set up to obtain film deposition is shown schematically.

**KINETICS OF GROWTH**

The kinetics of growth of a thin film process is determined by the ion-by-ion deposition of the chalcogenide on nucleating sites on the immersed surfaces. Initially, the film growth rate is negligible because an incubation period is required for the formation of critical nuclei from a homogeneous system onto a clean surface[7]. Once nucleation occurs, the rate rises rapidly until the rate of deposition equals the rate of dissolution. i.e; IP=SP.

Also, when the substrates are suspended in the container before forming the complex in the solution, film thickness increases in a manner similar to that of the sensitized surface, thereby showing that the nuclei for the formation of the film are provided by the solution itself.

The rate of deposition and the terminal thickness both depend on the number of nucleation centers, super saturation of the solution and stirring. The growth kinetics depends on the concentration of ions, their velocities, and nucleation and growth process on the immersed surfaces. The effect of various deposition conditions on these parameters is discussed in the subsequent sections.

**pH VALUE**

The addition of $OH^{-}$, i.e; increase in pH, makes the complex more stable, provide d the $OH^{-}$ ions take part in the formation of the complex. Thus the free, $M2^{+}$ion concentration is reduced, leading to a decrease in the deposition rate and on increase in the terminal thickness with increasing pH value.

## 2. EXPERIMENTAL DETAILS

In this study, the $Cu_2O$ thin films were prepared using the chemical bath deposition technique. The following constitutes the chemical bath system for optimum deposition: 30ml of 0.1M copper nitrate [Cu(NO3)2], 30ml of 0.1M Hydrazine (NH2NH2), and 6.5ml of 1M triethanolamine (TEA) which is the complexing agent.

Solutions for the deposition bath were made in 50ml beakers and 76mm x 26mm x 1mm commercial–quality glass microscope slides were used as the substrate. Before use, these glass slides were soaked in a solution of nitric acid and hydrochloric acid and then washed thoroughly with detergent and rinsed in distilled water. After transferring the solution to a beaker, the substrate was suspended vertically in the solution with the aid of a beaker cover. The addition of the 1M TEA to $CU(NO_3)_2$ solution resulted in a deep blue solution. The further addition of $NH_2NH_2$ to the solution resulted in a hissing sound which signaled the release of nitrogen gas and a rapid change in color, first to light blue and then to light yellow, reddish brown, and, finally, blue. The optimum growth period is in the range of 4-5 hours. The film deposited is either pure yellow or reddish brown but gradually turns yellow with time[8].

**STUDY OF CUO SURFACE MORPHOLOGY**

The scanning electron microscopic image of CuO thin film deposited at room temperature is shown in figure 1. It shows smooth uniform surface The SEM studies were carried out to study the morphology of the deposited film. The SEM photograph provides the nature of the surface that is uniformity, smoothness and cracks. The photographs are taken with the magnification of 10000X.

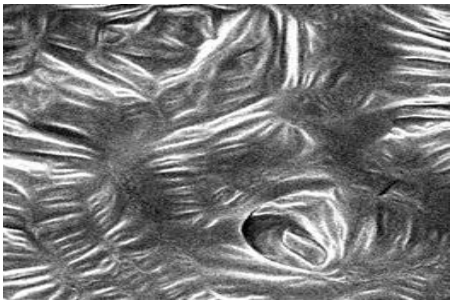

Figure 1. SEM image of CuO Film deposited on glass substrate at room temperature

**THIN FILM STRUCTURAL STUDIES**

The copper oxide thin film prepared by chemical path deposition at room temperature on a glass substrate was carried out using X-ray diffractometer.From the Diffract gram, it observed that the thin film is in crystalline in nature. The crystalline nature of the film may be improved further by increasing the substrate annealing temperature[3-7].

**ENERGY BAND GAP**

Figure 2 shows the graph of $(ahv)^{1/2}$ verses photon energy(hν) to find out the band gap energy .From the values of a and hν, $(ahv)^{1/2}$, can be calculated and hence (ahν) verses hν graph plotted. From the graph the band gap energy of CuO thin film is found to be 1.5ev.

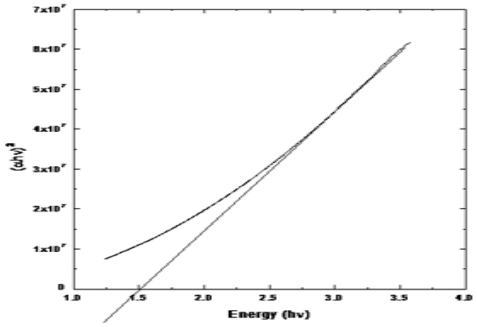


**Figure 2**: the graph of $(ahv)^{1/2}$ verses photon energy(hν)

The result obtained from my studies, encouraging and compares well with the values reported for the films prepared by other deposition techniques[9-10]. The result reveals that chemical bath deposition is conventional low cost technique to prepare CuO thin films suitable in solar thermal technology, particularly in antireflection coating.

**3.CONCLUSION:**

Thin film of CuO has been deposited on a glass substrate by chemical bath deposition method. The solution contains Barium chloride, potassium hydroxide and distilled water. CuO thin films are found to be uniform, smooth, and well adherent to the substrate. Structural study through XRD spectrum showed that CuO films are crystalline nature. The result reveals that chemical bath deposition is conventional low cost technique to prepare CuO thin films suitable in solar thermal technology, particularly in antireflection coating.

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