A Review of Synthesis of Binary Chalcogenide: ZnSe and its Film Deposition Techniques

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ABSTRACT
Chalcogenide materials are well-known for their unique optical properties such as infrared transparency, high refractive index, and optical nonlinearity. The most renowned binary zinc selenide (ZnSe) system, a member of the Chalcogenide family has a direct energy gap in the visible region. Due to its large potential and capability zinc selenide has a variety of applications and is an attraction for worldwide researchers. This paper provides insight into the methods of synthesis of amorphous zinc selenide bulk samples, polycrystalline zinc selenide bulk samples, zinc selenide nanocrystals. The most possible techniques for the deposition of zinc selenide thin films are also emphasised.

KEYWORDS: Chalcogenide, Infrared transparency, Optical properties, Bulk samples, Nanocrystals.

INTRODUCTION

Zinc selenide, a high refractive index binary chalcogenide has applications in protective and anti-reflection coatings [1]. Zinc selenide has a wide space in the field of research due to its noteworthy optical parameters, chemical and thermal stability, and eco-friendly applications. Fabrication and investigation of zinc selenide thin films becomes important technologically due to their linear and non-linear optical properties. ZnSe can be synthesised in both, amorphous and crystalline phases since elemental and stoichiometric chalcogenides are glasses and have a corresponding crystalline phase with the same composition. Chalcogenides have reversible amorphous-to-crystal phase transition [2]. Both glasses and crystals are of great interest because of their noble properties. Zinc selenide can be synthesised with the help of many methods. Zinc selenide crystals can have cubic zinc blend or wurtzite structures [3].

BULK ZnSe SYNTHESIS

Bulk zinc selenide is prepared by the melt quench technique. The calculated amount of zinc and selenium according to their atomic percentage is placed in quartz ampoule. Vacuum sealed ampoule is kept in the furnace at high temperature (approx. 1073 K) for 24 hours with maintaining other parameters during the process. The ampoule is cooled quickly into ice-cooled water. Amorphous zinc selenide is now prepared [4]. If the melt is cooled slowly zinc selenide solidify in the crystalline phase

DEPOSITION TECHNIQUES

There are many reported physical and chemical, in-situ -and off-site procedures for the synthesis of nanoscale ZnSe (Nanoparticles and nano thickness films). Some of them are chemical bath deposition, sol-gel method, Pulsed Laser Ablation technique, co-precipitation method , Molecular beam epitaxy (MBE), RF/DC magnetron sputtering, atomic layer deposition, thermal evaporation, electron beam and pulsed laser deposition are important deposition techniques. Many different techniques are being reported by researchers for the deposition of thin films for a variety of applications. Important ones are mentioned in the present paper.

CHEMICAL BATH DEPOSITION

Zinc selenide nanocrystalline thin films can be prepared with the assistance of the Chemical Bath Deposition method. Zinc ions and selenium ions are released slowly in the reaction solution containing zinc sulphate, sodium selenosulphate, ammonia, hydrazine hydrate and de-ionised water. With controlled parameters and controlled process, nanocrystalline films are deposited on the glass substrate [5].

ELECTRODEPOSITION

Thin films can be deposited with the help of the electrodeposition technique. Good quality polycrystalline films are produced for large, desired thickness. Morphology and stoichiometry of films can be improved by controlling electrical and electrolyte parameters. Zinc selenide thin films can be organised by co-deposition electrically on the conducting glass plate substrate coated with the fluorine doped SnO_2. Three electrode arrangement (substrate- electrode, graphite, rod – counter electrode and saturated calomel electrode -as reference electrode) is prepared for deposition of films. Detailed cyclic voltametric knowledge is employed to select a constant potential for deposition of films [6].

CLOSE-SPACED VACUUM SUBLIMATION

Structural and optical quality films can be deposited on the glass substrate by the Close-Spaced Vacuum Sublimation (CSVS) methodology. Evaporation takes place at 1073 K. Substrate temperature ranges from 373 K to 873 K. Time of evaporation is less (1- 2 minutes) for optical and electro-physical studies. The time of evaporation is seven minutes for morphological and structural studies [7].

CHEMICAL METHOD

Zinc selenide films can be prepared from an aqueous alkaline solution on a glass substrate [8]. ZnSe nanocrystals can be synthesised using SiO_2-Al_20_3- Na_20- K_20-B_20_3 glass system and ZnSe as raw material. The mixture of raw material is prepared and heated up to 1500°C to melt the mixture in an Alumina crucible for the duration of 1.5 hours. Quenched glass is prepared by cooling the melt quickly to room temperature and annealing at 450°C is done for one hour. Additional heat treatments are required for ZnSe nanocrystals [9].

THERMAL EVAPORATION

The thermal evaporation method is one of the most suitable procedures to prepare thin films of zinc selenide. Zinc selenide thin films on the glass substrate can be prepared at room temperature under a high vacuum with optimised deposition parameters i.e., target material (ZnSe powder), substrate temperature, a substrate to target distance, current, deposition time, deposition rate, pressure in the chamber [10].

ELECTRON BEAM DEPOSITION

The electron evaporation technique is applicable to deposit thin films on the glass substrate. The electron beam is focused to fall on the zinc selenide target sample. The target sample is kept in the copper Crucible. Vaporised target material condenses on the substrate in high vacuum with other specific deposition parameters to prepare reliable thin films [11].

PULSED LASER DEPOSITION

The Pulsed laser deposition method is employed to design high-quality thin films of zinc selenide for optoelectronic devices. Zinc selenide thin films can be deposited on glass substrates at room temperature. Employing target materials as ZnSe pellet with specific deposition parameters i.e., vacuum, substrate temperature, target to substrate distance, deposition time, target rotation, pulse duration, pulse repetition frequency. Nd: YAG laser source is employed for ablation of zinc selenide target [12].Synthesis of ZnSe nanocrystals can be done by the Pulsed laser ablation technique. In this procedure, the laser beam focuses on the bulk ZnSe target through the liquid medium and form zinc ions and selenium ions and neutral atoms on the target. On cooling, zinc, and selenium form nanocrystals of ZnSe. Downsizing zinc selenide crystals by PLA technique enriches their linear and nonlinear optical properties. Films of synthesized ZnSe nanocrystals on the glass slide is drop casted for further structural, morphological, linear, and nonlinear optical analysis [13].

SPUTTERING

Sputtering (assisted with chemical vapour deposition) is a technique for depositing films of single as well as multi composition materials. It is the most versatile approach for the deposition of films for optical and electrical data storage and can be operated to deposit polycrystalline as well as amorphous thin films of zinc selenide.

CHEMICAL VAPOUR DEPOSITION

Chemical vapour deposition (CVD) is an efficient method to prepare Chalcogenide thin film. Plasma enhanced chemical vapour deposition (PECVD) [14] and metal-organic chemical vapour deposition techniques [15] can be acclimated to lessen the temperature of the process. Amorphous and polycrystalline zinc selenide thin films can be deposited using chemical vapour deposition (CVD) techniques.

SPIN COATING

Spin coating (solution-based process) can be employed to deposit Chalcogenide thin films [16]. Zinc selenide thin films can be deposited using spin–coating techniques.

CONCLUSION

In recent years a substantial improvement in physical and chemical strategies has taken place for the fabrication of films of numerous materials for a variety of applications in different fields. Low-temperature epitaxial growth techniques(MBE and MOCVD) produce high-quality zinc selenide thin films. RF magnetron sputtering (RF power) is employed to deposit zinc selenide films. Electrodeposition has proven as an economical and reliable technique.

Many top-down and bottom-up approaches with some modification can be employed to deposit thin films of zinc selenide.

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