Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy 150 (2015) 111–119

Contents lists available at ScienceDirect

Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy

journal homepage: www.elsevier.com/locate/saa

Using different chemical methods for deposition of copper selenide thin films and comparison of their characterization

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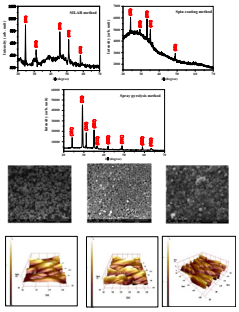
HIGHLIGHTS

- Cu_3Se_2 thin films have been grown on glass substrate using three chemical methods.
- There are a lot of methods have been used for investigation of characteristics properties of films.
- We focus on different growth effect upon optical parameters of Cu_3Se_2 films.
- We want to investigate the best features of Cu_3Se_2 thin films used in optoelectronic devices.
- We want to observe the best favorable chemical deposition method for fabrication Cu_3Se_2 thin film.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 7 October 2014
Received in revised form 16 April 2015
Accepted 4 May 2015
Available online 12 May 2015

Keywords:
Copper selenide
Nanostructure
Spray pyrolysis
Spin coating
SILAR method

ABSTRACT

Different chemical methods such as Successive Ionic Layer Adsorption and Reaction (SILAR), spin coating and spray pyrolysis methods were used to deposite of copper selenide thin films on the glass substrates. The films were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), atomic force microscopy (AFM), energy dispersive X-ray analysis (EDX) spectroscopy and UV–vis spectrophotometry. The XRD and SEM studies showed that all the films exhibit polycrystalline nature and crystallinity of copper selenide thin films prepared with spray pyrolysis greater than spin coating and SILAR methods. From SEM and AFM images, it was observed copper selenide films were uniform on the glass substrates without any visible cracks or pores. The EDX spectra showed that the expected elements exist in the thin films. Optical absorption studies showed that the band gaps of copper selenide thin films were in the range 2.84–2.93 eV depending on different chemical methods. The refractive index (n), optical static and high frequency dielectric constants (ε_0, ε_∞) values were calculated by using the energy bandgap values for each deposition method. The obtained results from different chemical methods revealed that the spray pyrolysis technique is the best chemical deposition method to fabricate copper selenide thin films. This absolute advantage was lead to play key roles on performance and efficiency electrochromic and photovoltaic devices.

Introduction

Surfaces and interfaces play critical roles in nanostructured materials because of their very high specific surface areas. The

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http://dx.doi.org/10.1016/j.saa.2015.05.002
1386-1425/

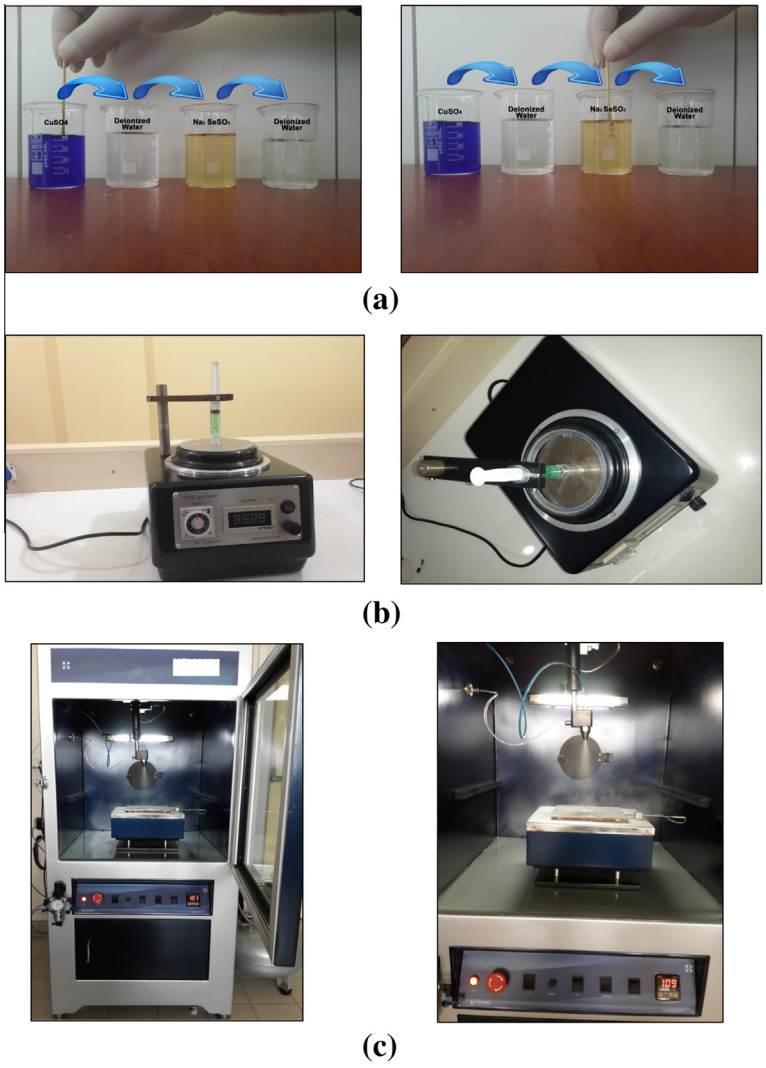

Fig. 1. The images of sample preparation methods: (a) SILAR method, (b) spin coating method, (c) spray pyrolysis method.

chemical and physical properties of such materials are different than the bulk materials [1]. Extensive attention has been paid to the preparation and characterization of metal selenides in the field of electronics and electro-optical devices. To study the fabrication and characterization of these metal selenides in the form of thin films, intensive research has been performed in the past [2–7]. The interest for copper selenide semiconducting thin film is motivated by its applications in solar cell technology [8–12]. Various methods for preparation of Cu_xSe thin films (where $x = 1$, 2 or between 1 and 2), such as vacuum evaporation [13], electrodeposition [14], sol–gel [15], solid-state [16], microwave [17] and ultrasonic synthesis [18] have been reported. The complexity of composition of copper selenide has always lead to the search for more chemically stable forms with better electronic properties and the deposition of thin films from a solution attracts the attention of researchers. Because such methods have a low-cost setup and has the ability to deposit large area layers.

Using different methods for growth of thin films would result different efficiencies for electrochromic and photovoltaic devices. Each method has advantages or for fabrication thin films: The SILAR method, introduced by Nicolau [19] is an alternative method which thin films of compound semiconductors can be deposited by dipping substrate into the aqueous solutions of containing ions for each component. During the SILAR method growth of thin films occur only heterogeneously on the solid-solution interface, due to the intermediate rinsing step between the cation and anion immersions. The SILAR method does not require high quality substrates and it does not require vacuum at any stage. The deposition rate and the thickness of the film can be easily controlled over a wide range by changing the deposition cycles. It offers extremely easy way to dope films; there are virtually no restrictions on substrate material, dimensions or its surface [20,21].

Spin coating is a procedure used to apply uniform thin films onto flat substrates. It has been used for several decades for the growth of thin films. A typical process involves depositing water of a fluid resin onto the center of a substrate and then spinning the substrate at high speeds. The spin coating is considered as one of the most advantageous techniques due to its effectiveness, versatility, and practicality. Importantly, it does not require a vacuum system since the process can be carried out at atmospheric conditions [22,23].

The spray pyrolysis is based on the preparation of solutions of some salts of the material whose films is to be prepared. Beside of its simple fabrication, spray pyrolysis technique also has the following proven advantages: (i) easy to control the size of particles, (ii) possibility of processing high purity powders and (iii) high stability of chemical stoichiometry. Compared with other techniques, spray pyrolysis has the best potential to control the deposition of microstructures because of the flexibility in processing parameters and their impact on film structure [24,25].