Journal of Alloys and Compounds 631 (2015) 303–314

Contents lists available at ScienceDirect

Journal of Alloys and Compounds

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

Morphology reliance of cobalt sulfide thin films: A chemo-thermo-mechanical perception

S.S. Kamble [a], A. Sikora [b], S.T. Pawar [a], R.C. Kambale [c], N.N. Maldar [d], L.P. Deshmukh [a,*]

[a] Thin Film & Solar Studies Research Laboratory, Solapur University, Solapur 413 255, M.S., India
[b] Electrotechnical Institute, Division of Electrotechnology & Materials Science, ul. M Skłodowskiej-Curie 55/61, 50-369 Wroclaw, Poland
[c] Department of Physics, University of Pune, Ganeshkhind, Pune 411 007, M.S., India
[d] School of Chemical Sciences, Solapur University, Solapur 413 255, M.S., India

ARTICLE INFO

Article history:
Received 19 November 2014
Accepted 15 January 2015
Available online 23 January 2015

Keywords:
Dilute magnetic semiconductor
CoS
XRD
EDAX
Magnetic force microscopy
Optical band gap

ABSTRACT

We report onto the morphology dependency of CoS thin films by studying the role of mechanical agitation, thermal assistance and deposition duration in an aqueous alkaline bath (pH = 9 ± 0.1). The deposition of CoS thin films was carried out at different mechanical stirring rates, deposition temperatures and times. As-optimized CoS thin film were of polycrystalline nature and exhibited hexagonal crystal structure. Co^{2+} rich nature (≈85%) of optimistically grown thin film was detected. Complex multifaceted webbed network of as-grown elongated and threaded into each other CoS crystals was observed through a scanning electron microscope. Surface morphology was further studied by means of an atomic force microscopy. Existence of magnetic domains was marked in the magnetic force microscopy. As-grown CoS thin films were having transmission index of 0.5 with a band gap of ≈1.59 eV.

1. Introduction

Thin film technique is predominantly known in the context of commercial escalation of surface coatings. In the realm of technological applications of microelectronics, understanding of the fundamental growth process and control over microstructure are most substantial for fine-tuning of the thin film properties and inclusive functionality for the proposed application [1–5]. In particular, deposition from an alkaline bath has grossed a part of an intensively studied method for the synthesis of various semiconductor thin films, largely because of its number of advantages such as low cost, relatively low processing temperature, easy deposition over complex shaped surfaces and modest chorological instrumentation over the former thin film deposition methods [1–3,6–9]. This chemical route includes the continuous immersion of the substrates in distinctly prepared reaction bath to deposit the different species on the substrates at the optimized growth conditions. Here, thin film growth can be accomplished by two different mechanisms: (i) ion-by-ion growth, wherein the deposition process involves the ion-by-ion condensation at the nucleation sites on the immersed substrates and (ii) cluster-by-cluster growth, wherein growth takes place by coagulation of nuclei, giving thin, uniform and adherent films. Though there are studies on the role of preparation parameters, many aspects of chemical depositions (such as, growth kinetics and morphological adaptations) owing to variations in the number of deposition parameters (such as mechanical agitation and thermal assistance) in a number of systems are still faint in understanding.

Cobalt sulfide is a technically important semiconductor material with many potential applications in optical filters, thermal sensors, solar selective coatings, PV – detectors including solar cells, optical waveguides and as a DMS material [5,8,10–12]. Owing to its imperative role as magnetic semiconductor, many efforts have been dedicated to the morphology tailored growth of cobalt sulfides in the form of micro/nano-particles, wires, tubes and in thin film form. In this preliminary brief communication, for the first time, we report our observations on the morphology adaptation of CoS thin film by a modified chemical deposition designed and set in our laboratory. The studies have been made on the growth influencing parameters mainly, mechanical agitation, thermal assistance and deposition period.

2. Methods and measurements

2.1. CoS thin film deposition

CoS thin film layers were synthesized onto the spectroscopic grade glass substrates in an aqueous alkaline medium (pH = 9.0 ± 0.1) [8]. For the synthesis, 10 ml (1 M) $CoSO_4$ solution was taken in a 250 ml beaker, to this 4 ml AR grade

* Corresponding author. Tel.: +91 9850697974.
E-mail address: laldeshmukh@gmail.com (L.P. Deshmukh).

http://dx.doi.org/10.1016/j.jallcom.2015.01.097
0925-8388/

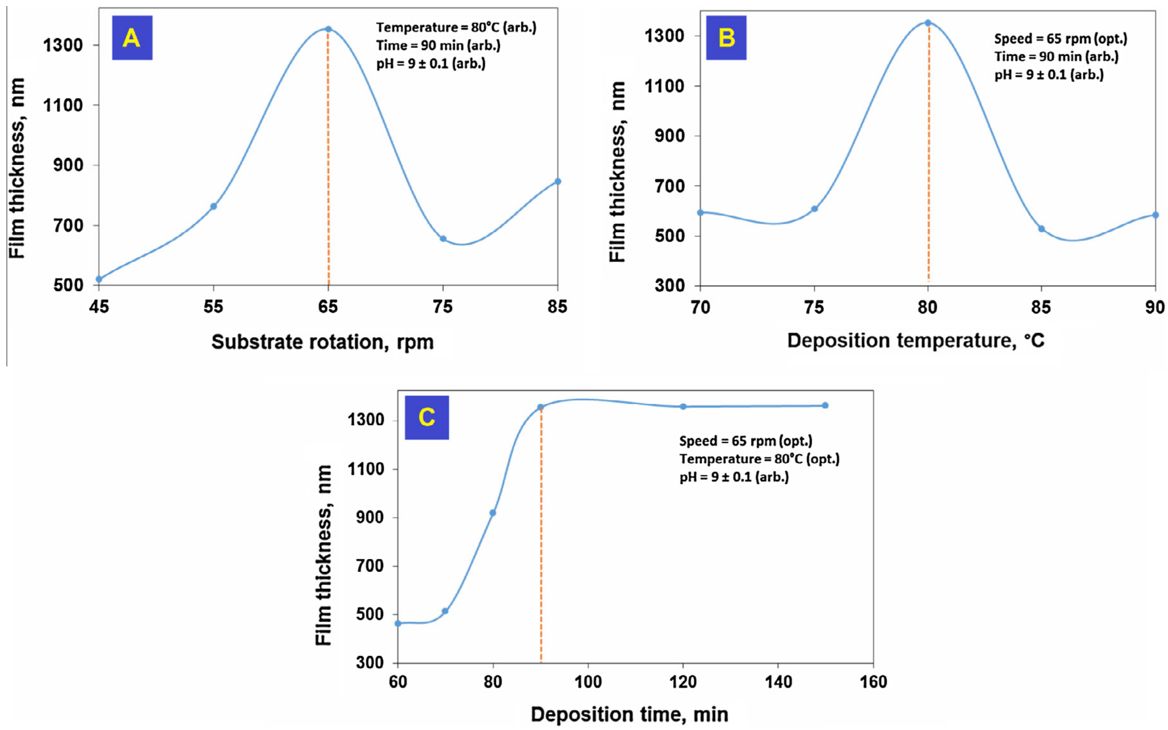

Fig. 1. Variation in terminal layer thickness with (A) speed of substrate rotation, (B) deposition temperature and (C) deposition time.

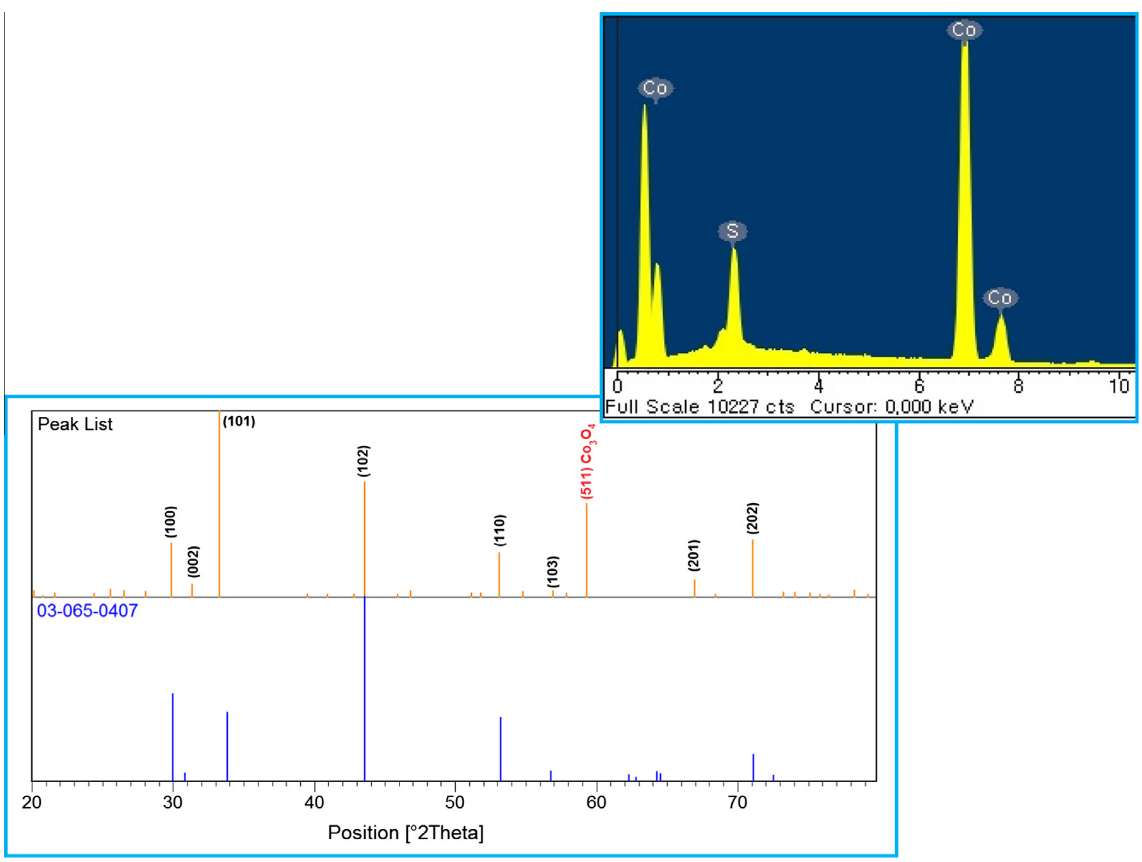

Fig. 2. X-ray diffractogram (Inset: EDAX analysis) for optimized CoS thin film sample (65 rpm, 80 °C and 90 min).