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Morphological Characterization of Cus Thin Films by Atomic Force Microscopy

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Abstract: The aim of the study was to investigate the influence of solution concentration on the morphological properties of chemically deposited copper sulphide thin films. Atomic force microscopy studies of CuS thin films grown on microscope glass slides at different solution concentrations have been carried out from 0.05 to 0.2 M of copper sulfate, thiourea and tartaric acid solutions. Atomic force microscopy images revealed that the films deposited using 0.05 M of solution concentration had incomplete coverage of material over the surface of substrate. The thin films deposited using 0.1 M showed higher number of CuS with homogeneous surface. On the other hand, when the thin films were deposited with 0.2 M of solution concentration, the number of grains reduced with the bigger grain size could be observed.

Key words: Atomic force microscopy, chemical bath deposition, copper sulphide, thin films

INTRODUCTION

The study of the thin films has received a great deal of attention during the last few years due to their important semiconducting properties. Thin films can be used as optoelectronics devices, photovoltaic cells, solar selective coatings and laser materials. There are many techniques that can be used to prepare chalcogenide thin films such as chemical bath deposition (Gopakumar *et al*., 2010), electrodeposition (Kassim *et al*., 2010), molecular beam epitaxy (Gautier *et al*., 1998), successive ion layer adsorption and reaction method (Zhuge *et al*., 2009), close-spaced sublimation method (Armstrong *et al*., 2002), spray pyrolysis (Bedir *et al*., 2005) and plasma-enhanced chemical vapor deposition (Atif *et al*., 2006). Each deposition method has its own advantages and disadvantages. The chemical bath deposition method is preferred for its simplicity, inexpensive and capability to achieve large area coatings. Over the past several years, many researchers have prepared thin films such as FeS (Anuar *et al*., 2010), As_2S_3 (Mane *et al*., 2004), CdS (Moualkia *et al*., 2009), PbS (Larramendi *et al*., 2001), SnS (Guneri *et al*., 2010), In_2S_3 (Asenjo *et al*., 2010), ZnS (Anuar *et al*., 2010), $CuBiS_2$ (Sonawane *et al*., 2004) and $Cd_{0.5}Zn_{0.5}Se$ (Kale *et al*., 2007) using the chemical bath deposition technique.

In this study, we report for the first time the influence of solution concentration on the morphological properties of chemically deposited CuS thin films using atomic force microscopy in the presence of tartaric acid as complexing agent.

MATERIALS AND METHODS

This research was led to the laboratory of Faculty of Science, Universiti Putra Malaysia for the period of 3-1-2011 to 28-2-2011. All the chemicals used for the deposition were analytical grade reagents and all the solutions were prepared in deionised water (Alpha-Q Millipore). The copper sulphide thin films were prepared from an acidic bath containing aqueous solutions of copper sulphate, thiourea and tartaric acid. The microscope glass slide was used as the substrate for the chemical bath deposition of copper sulphide thin films. Before deposition, the microscope glass slide was degreased with ethanol for 15 min, then, ultrasonically cleaned with distilled water for another 15 min and dried in desiccators. Deposition of copper sulphide thin films was carried out at 70°C using following procedure. 25 mL of copper sulphate was complexed with 25 mL of tartaric acid. Then, 25 mL of thiourea was added slowly to the mixture. The cleaned glass slide was immersed vertically

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Table 1: Thickness and surface roughness of CuS thin films deposited at various solution concentrations

	Thickness (nm)	Roughness (nm)
0.05 M	277.9	24.19
0.1 M	115.6	13.30
0.2 M	2069.0	256.1

into the beaker. The deposition process was carried out by varying the solution concentrations (0.05, 0.1 and 0.2 M). During deposition process, the beaker was kept undisturbed at pH 3. After the completion of deposition (120 min), the glass slide was removed, washed several times with distilled water and dried in desiccators for further characterization.

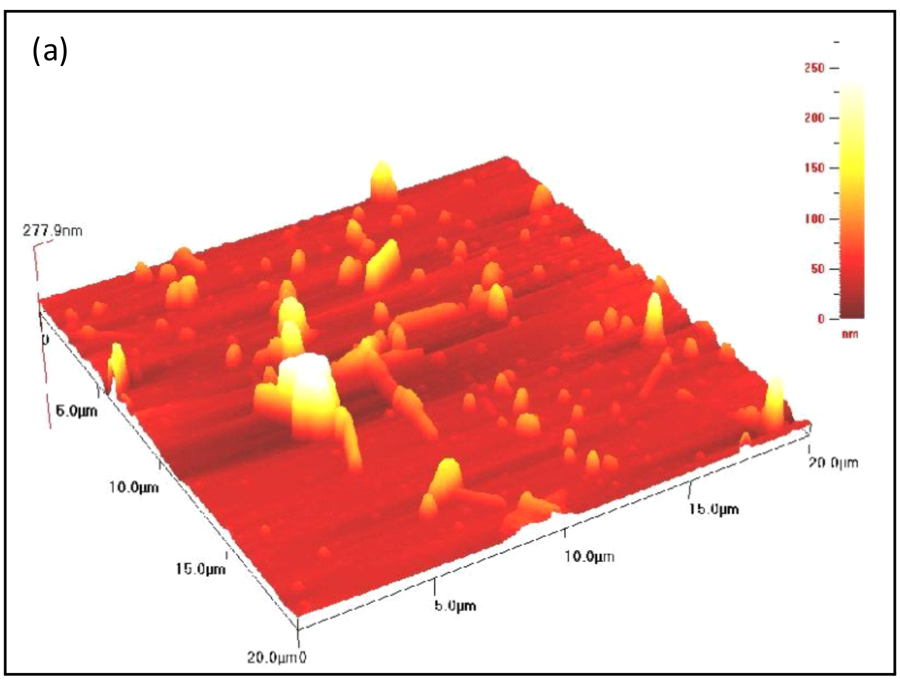
The surface morphology of the thin films was investigated using atomic force microscopy (Quesant Instrument Corporation, Q-Scope 250). It was operated in a contact mode with the Si_3N_4 cantilever. The value of root mean square roughness was calculated from the height values in the atomic force microscopy image using the commercial software.

RESULTS AND DISCUSSION

Figure 1a, b, c, 2a, b and c shows three-dimensional and two-dimensional of Atomic Force Microscopy (AFM) images of CuS thin films deposited at various solution concentrations, respectively. All the AFM images were measured over an area of 20 mm × 20 mm. The films thickness and surface roughness were investigated using atomic force microscopy images. The thickness and surface roughness values were listed as shown in Table 1. The Root Mean Square (RMS) roughness which is defined as the standard deviation of the surface height profile from the average height, is the most commonly reported measurement of surface roughness (Jiang *et al*., 2005).

Based on the Fig. 1a and 2a, the films prepared using 0.05 M of copper sulphate, thiourea and tartaric acid exhibit incomplete coverage of material over the surface of the substrate. This may be caused by insufficient amount of copper ions and sulfide ions during the deposition process. The thin films deposition process on a substrate depends chiefly on the formation of nucleation sites and subsequent growth of the thin films from this centre. The irregular shaped grains with the sizes about 0.5-1.0 mm are observed. The surface roughness is about 24.19 nm and is unavoidable due to the three-dimensional growth of films.

Further increment in the solution concentration to 0.1 M shows complete coverage of the material over the substrate compared to the films prepared at lower concentration. The surface is relatively uniform and devoid of any highly agglomerated features with the surface roughness and thickness is 13.30 and 115.6 nm, respectively. The grain sizes (0.5-0.7 mm) were almost



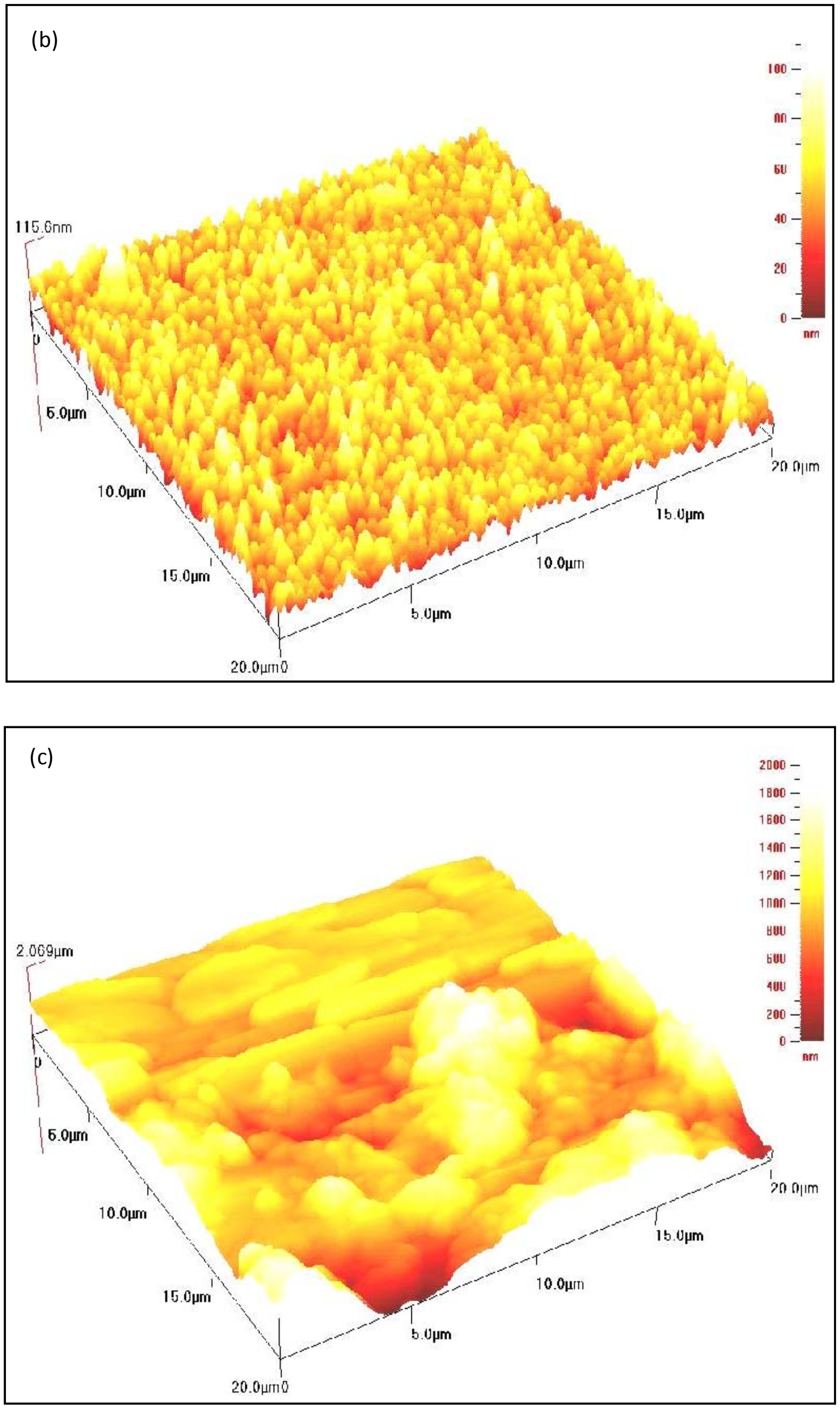
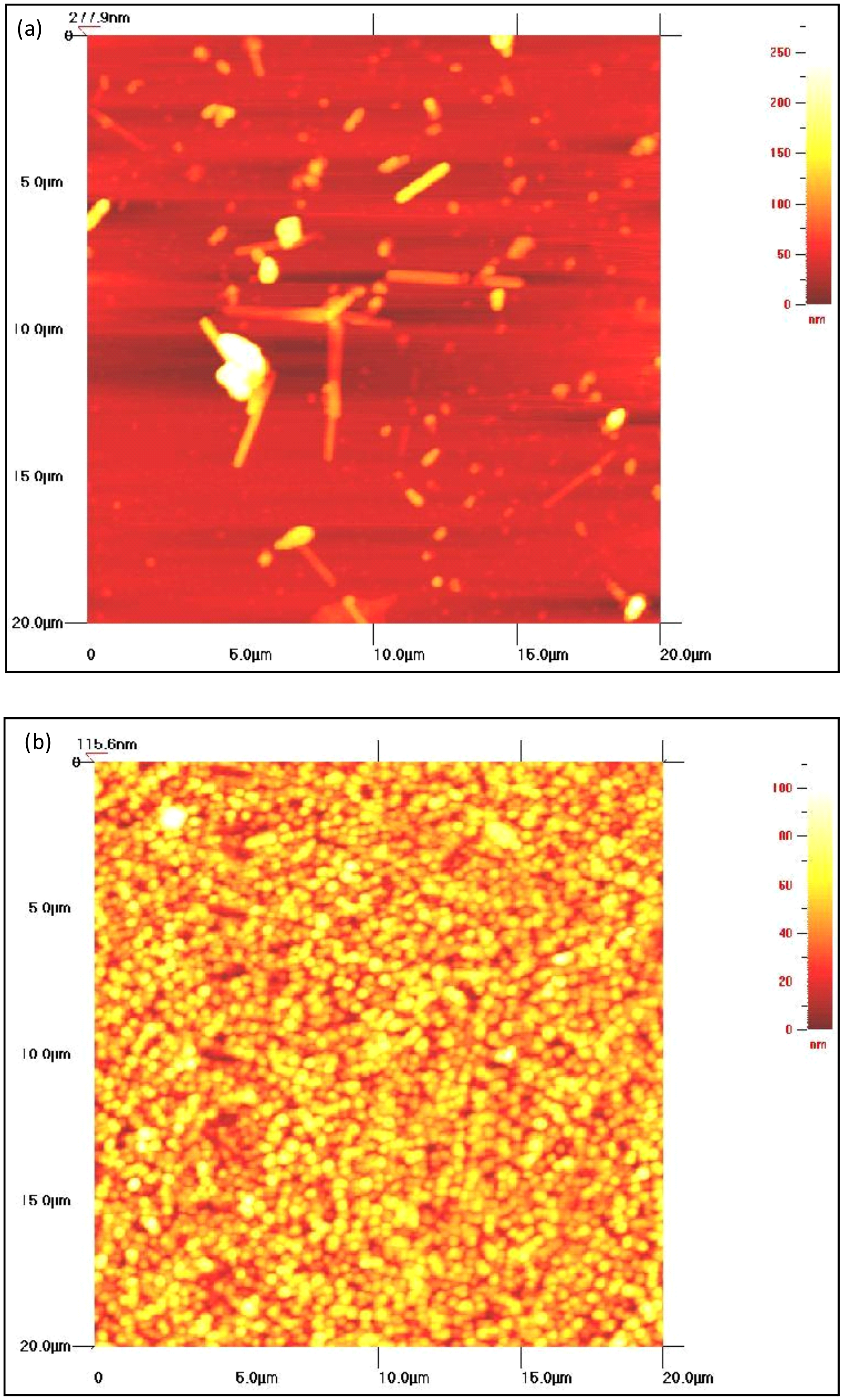


Fig. 1: Three-dimensional atomic force microscopy images of CuS thin films deposited at various solution concentrations. (a) 0.05 M (b) 0.1 M (c) 0.2 M


(a)
277.9nm
0
5.0µm
10.0µm
15.0µm
20.0µm
0
5.0µm
10.0µm
15.0µm
20.0µm
250
200
150
100
50
0
nm
(b)
115.6nm
0
5.0µm
10.0µm
15.0µm
20.0µm
0
5.0µm
10.0µm
15.0µm
20.0µm
100
80
60
40
20
0
nm

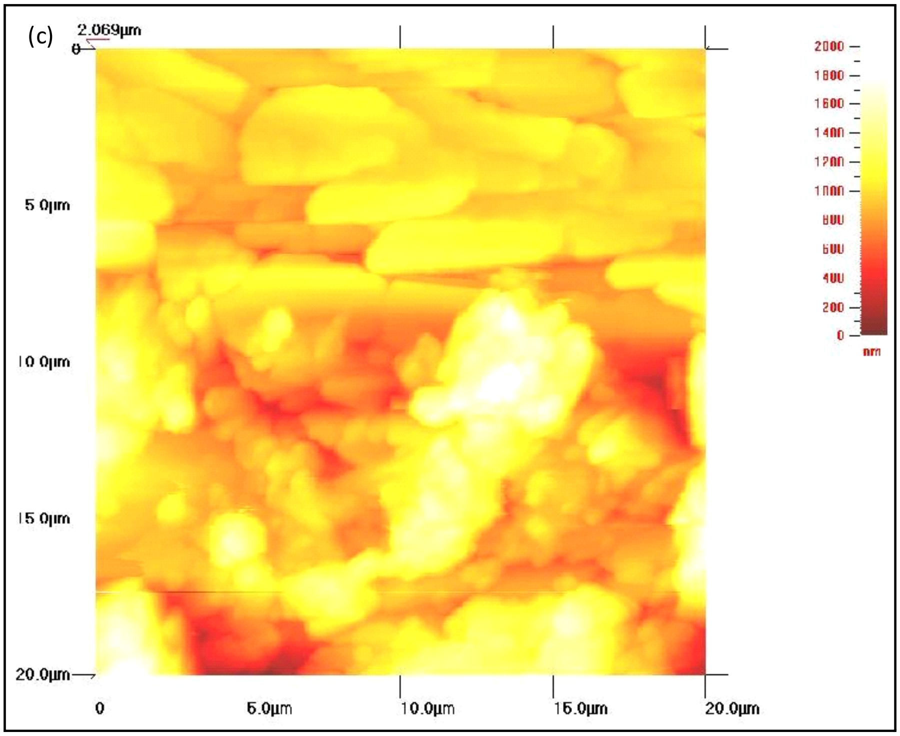


Fig. 2: Two-dimensional atomic force microscopy images of CuS thin films deposited at various solution concentrations. (a) 0.05 M (b) 0.1 M (c) 0.2 M

similar to each other. However, in contrast to this, for the films deposited using 0.2 M, highly irregular agglomerated features are observed with surface roughness and thickness is 256.1 and 2069 nm, respectively. The number of grains has been reduced and larger grain sizes (1.5-2.5 mm) could be observed as shown in Fig, 1c and 2c.

CONCLUSION

CuS thin films have been successfully deposited by chemical bath deposition method.

from the AFM results, the film thickness and surface roughness reduced as the solution concentration was increased from 0.05 to 0.1 M. However, both values increased when the solution concentration was further increased to 0.2 M. The surface morphology of the films deposited using 0.1 M was observed quite uniform and well covered on the substrate than other samples.

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