Effect of deposition time and thermal emittance of copper sulphide thin films for use as a selective coating

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Abstract

Copper sulfide thin films were deposited on aluminum sample plates using simple and cost-effective electroless chemical bath deposition (ECBD) techniques at a fixed temperature of 303K and varying deposition time ranging from 16 to 36 hours. A thermocouple potentiometer was used to measure the thermal emittance of the coated sample plates. Our results show that the thermal emittance values range from 0.161 to 0.192, depending on the deposition time. Observed also is the film thickness, which varies from 3.00 to 6.00 µm. It was however, observed that the films deposited at low deposition time have low thermal emittance; hence films deposited at low deposition time can find applications in photothermal devices.

Keywords: ECBD, thin film, thermal emittance, deposition time, film thickness.

1. Introduction

The aim of this work is to grow copper sulphide thin films by solution growth method and determine the effect of variation of deposition time on the thermal emittance with a view to ascertaining the possible applications. A spectral selective coating is an important Requirement for efficient photo thermal converters. It is employed for effective conversion of solar energy into heat for various applications such as solar water heaters for hot water supplies in homes and hospitals, solar cookers, solar water distillation, Solar refrigerators, poultry production etc. (Ileoje, 1997; Okeke, 2002; Oparaku, 2007; Ilenikhena,2008). Chemical bath deposition is presently being used extensively due to its numerous advantages. The technique is a cost effective and reproducible method of producing compound semiconductor metal halides and chalcogenide thin films on both metallic and non-metallic substrates (Chopra and Das, 1983; Chandra et al., 1980; Brinker and Harrington, 1981; Cho et al., 1998; Okujagu and Okeke, 1997). It has also been applied in producing emerging materials for solar cells, solar collectors among others and is now being adopted by some industries (Ilenikhena and Okeke, 2002; 2004; Ezema and Okeke, 2003; Ilenikhena and Mordi, 2005). Its technology is based on slow release or controlled precipitation of the desired compound from its ions in a reaction bath. The

chemical bath deposition method could be improved by controlled addition of a second complexing agent with pH oppose to that of deposition bath constituents to enhance variation of deposition conditions at different pH values (Ilenikhena and Okeke, 2005; Ilenikhena, 2007; 2008)

2. Experimental procedure

The aluminum sample plate used has a thickness 0.1 cm and was cut into six measuring approximately 7.8 x 7.8 cm with a hand guillotine. The sample plate was polished with different sizes of emery paper and then cleansed with gamma polishing alumina to remove dirt to give a fine finishing. The bath solution contains 0.8 M of copper chloride dihydrate ($CuCl_2.2H_2O$), thiorea and distilled water, 1.0 M of sodium hydroxide (NaOH), 0.2 M of ethylene diamine tetra acetate (EDTA) which act as a complexing agent. The masses required were measured with an electronic weighing machine and their molarity calculated from equation (1)

$$M = \frac{mVW}{1000} \quad (1)$$

where V is the volume of the required solution, M is the molarity of the required solution, W is the molecular weight of the reagent and m is the mass of the reagent.

A 75 ml beaker was placed on a weighting balance, the required amount of copper chloride dihydrate ($CuCl_2.2H_2O$), sodium hydroxide (NaOH), thiorea, ethylene diamine tetra acetate (EDTA) and distilled water were measured. The prepared solution was stirred with glass rod this is to ensure uniform reaction. The bath constitution is displayed in table 1. The aluminum plates were then immersed in the solution mixture and left for the required time. The substrate (aluminum) was cleansed in distilled water, methanol, ethanol, acetone and distilled water before each deposition. After all the deposition the films were designated as A1, A2, A3, A4, A5 and A6 for easy identification.

Table 1: Bath constitution for the deposition of copper sulphide thin films on aluminum substrate at temperature 303K for different deposition time.

Thin films	Deposition time (hr)	Vol. of 0.8M $CuCl_2.H_2O$(ml)	Vol. of I.0M NaOH (ml)	Vol. of 0.8M Thiorea (ml)	Vol. of 0.2M EDTA (ml)	Vol. of 0.8M H_2O (ml)
A1	16	25	12	20	16	7
A2	20	22	12	18	14	14
A3	24	19	10	16	12	23
A4	28	16	10	14	10	30
A5	32	13	8	11	8	40
A6	36	10	8	10	6	46

The basic equations for the deposition of copper sulphide thin films is as follows

$$CuCl_2.2H_2O + EDTA \rightarrow [Cu(EDTA)]^{2+} + H_2O + 2Cl \quad (2)$$

$$[Cu(EDTA)]^{2+} \rightarrow Cu^{2+} + EDTA \quad (3)$$

$$(NH_2)_2\ CuS + OH^- \rightarrow CH_2N_2 + H_2O + HS^- \quad (4)$$

$$HS^- + OH^- \rightarrow CH_2N_2 + H_2O + S^{2-} \quad (5)$$

$$Cu^{2+} + S^{2-} \rightarrow CuS \quad (6)$$

3. Results and Discussion

3.1. Measurement of film thickness

The thickness of the films was evaluated using equation (7)

$$t = \frac{m}{2A\rho} \quad (7)$$

where t is the film thickness, m is the mass of the deposited films, A is the area of the coated aluminum substrate and ρ is the density of the copper sulphide films which is given as $4.7g/cm^3$. Figure 1 shows the variation of film thickness with deposition time. Our result shows that the deposition time has a great influence on the film thickness we observed that the film thickness increases as the deposition time increases. This increase of the film thickness with deposition time has been observed by Akhabue and Illenikhena, (2013)., Mosiori et al. (2016).

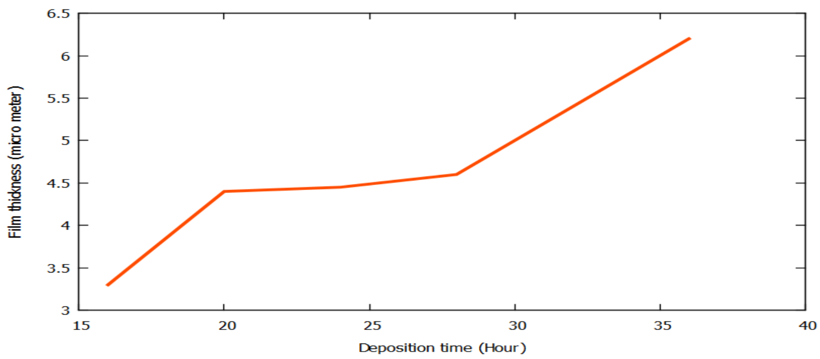

Figure 1. Variation of film thickness with deposition time

3.2. Thermal emittance of the film

The thermal emittance of the films was measured using a thermocouple potentiometer. A black body was used as a reference for measurement whose emissivity was used as a control for the substrate. An electric pressing iron was used to supply heat at an interval of 30 seconds. The emissivity of the substrate was measured from equation (8)

$$\varepsilon_s = \frac{V_s}{V_b} x \varepsilon_b \quad (8)$$

where ε_s, is the emissivity of the substrate, V_s is the thermocouple reading of the substrate, ε_b is the emissivity of the black body and V_b is the thermocouple reading of the black body. Figures 2 and 3 shows the plot of thermal emittance against deposition time and film thickness respectively. We observed that the films deposited at low deposition time have low thermal emittance and thickness whose values are 0.161 ± 0.050 and 3.30 ± 0.010 respectively these values obtained compare well with that obtained in literature [REF].

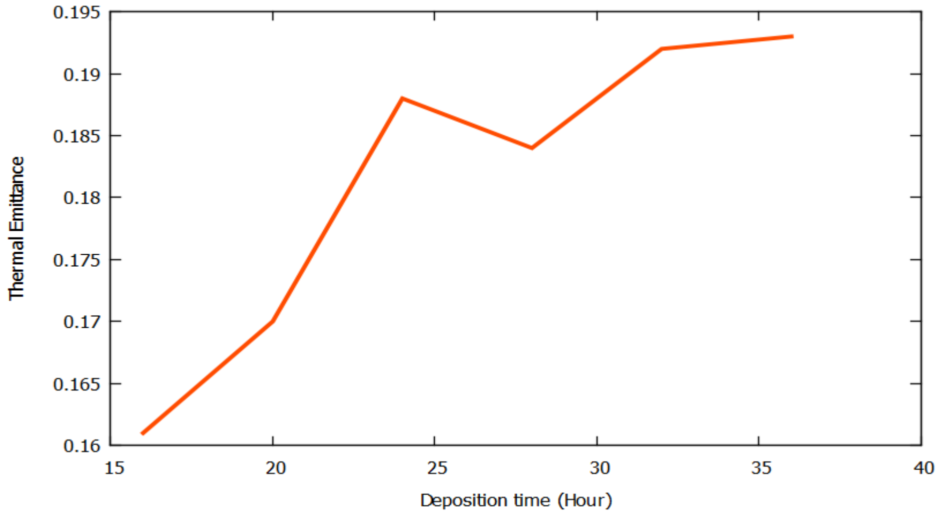

Figure 2. Variation of thermal emittance with deposition time

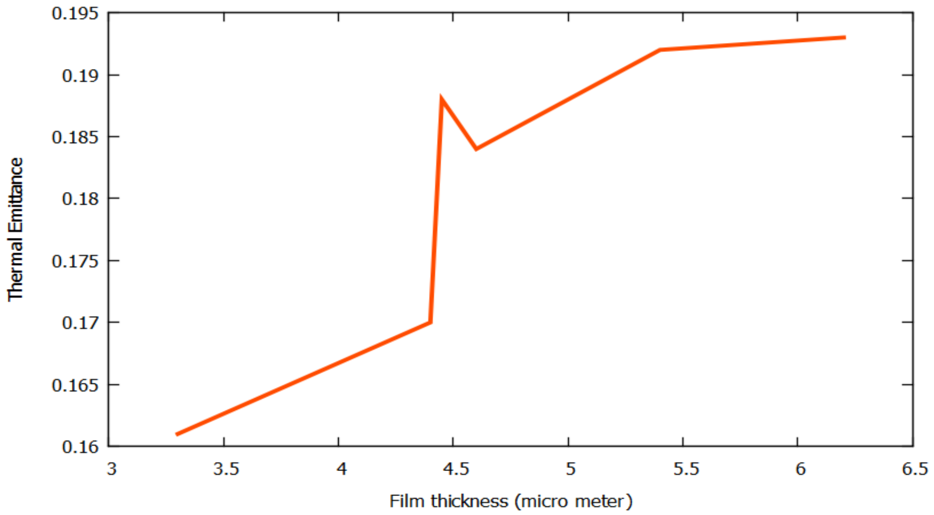

Figure 3. Variation of thermal emittance with film thickness

4. Conclusion

Thin films of copper sulphide have been successfully deposited using the electroless chemical bath deposition (ECBD) techniques at different deposition time. We observed from our results that the thermal emittance and film thickness increases with deposition time hence we conclude that the films deposited at low deposition time can be used in photothermic devices.

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