International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2018): 7.426

Thermal Emmitance of Solar Energy Assisted Chemical Bath Deposited Cadmium Sulphide (CDS) Thin Films on Aluminium

Arekumo ThankGod[1], Marere Omamode[2]

[1]Department of Physics Federal University Otuoke, Bayelsa State, Nigeria
[2]Department of Science and Technology Delta State School of Marine Technology Burutu, Delta State, Nigeria

Abstract: ***The chemical bath deposition (CBD) method was used to deposit good quality thin films of cadmium sulphide (CdS) on aluminium at room temperature of 300k (27^{0}C) and deposition times ranging from 16hrs to 36hrs. The flat sample plate (8.2 x7.2 x0.1 cm^2) were cleaned by polishing them using emery paper and gamma polishing alumina. The plates were polished with distilled water and dried in air before usage. Thermal emmitances of the plates were measured before and after deposition using an instrument called thermocouple potentiometer. These plates were also weighed before and after deposition with an electronic weigh balance to determine the mass of plates. Six beakers each containing 25cm^3, 0.4M $CdCl_2.H_2o$, 16cm^3, 0.2M EDTA as a complexing agent, 12cm^3, 1.0M NaoH, 20cm^3, 0.8M $(NH_2)_2$ CS and 7.0cm^3 by volume of distilled water. The average value for the thermal emmitance of the polished plates is 0.15 ± 0.01 while that of the thermal emmitances of the coated plates varied from 0.151 to 0.176 depending on deposition time. The film thickness ranged from 2.38μm to 9.53μm depending on deposition time. The thermal emmitance value of the coated plates compare with those obtained for spectrally selective surface can be employed in solar energy applications such as heating of houses, solar incubators and drying of crops.***

Keywords: Thermal Emittance, Cadmium Sulphide, Thin Films, Surface Solar Energy Collectors

1. Introduction

Energy is the life wire of every human activity. The place of energy plays a crucial role in the sustenance of life and the existence of man. The civilization of the world today cannot do without energy. Life's quality depends greatly on the availability of energy. The globe's energy crisis made it clear to man that energy from nature is fast depleting and can no longer sustain the world energy needs (Hayes 1978). Due to this reason man has focused on alternative sources of energy which cannot be depleted, that is solar energy. Recent investigations have triggered intense interest in Cadmium Sulphide (CdS) thin films because of its applications in solar collectors, shielding of microwave coatings and as transducers (Berzoni J.T., (1998) Coating for solar collecter symposium: American Electroplaters society) Solar control coatings(2 G.A Chouldhury, and Schgal, II.K. (1993). Solar Energy, 30,291), absorber coatings (3 Daletsiki et al., (1997). Galiotekhnika,15,1) e.t.c. Solar wavelengths highest selective absorbtion between 0.3 and 2.5 μm and lowest thermal emittance wavelength between 3.0 to 30 μm(Gier G.T and Dunkle R.V., (2000). Selective spectral characteristics as an important factor in the efficiency of solar collectors, Trans. Conf. on the use of solar energy, II(Part 1,see A), 24).

The amount of energy radiated is proportional to the thermal emittance (ε) and the absorbed solar energy by a surface is equally proportional to the solar absorbance (μ) (Granziera F. (2002). Aluminium anodizer Pty Ltd., Metal Australasia, 211). Selective surfaces must be poor emitter of solar radiation energy and good absorber of solar radiation energy, the requirement for the percentage for selective surface are 10 % solar emittance and 90 % solar absorbance (McDaniel D.K., (2006). The sun our future energy source, Wiley, New York.).The spectral selectivity requirements are a function of flux concentration. Selective surfaces are essential due to their ability of retaining potential energy. The technique of chemical bath deposition is easy to use, cheap and convenient. It is a good method of the production of high quality semiconductor thin films (Sharma V.C and Hutchins, M.G., (2006) Radiative selectivity).

In the present research work, the investigation of thermal emittance and absorbance of cadmium sulphide (CdS) thin film was carried out using chemical bath deposition method at room temperature of 300 K (27^{o}C) and different deposition times for applications in solar energy collectors.

The rest of the paper is structured as follows: Section 2 presents information on materials and method used in the research. In section 3, apparatus parameter measurements are discussed while section 4 presents the results and discussion and conclusions are summarised in section 5.

2. Materials and Method

It is impractical to adopt and report all the deposition techniques available as they are too many to be accommodated in this paper. However, the chemical bath deposition (CBD) method is adopted I this study due to the wide application and low cost implication of the method. The materials for the CBD method are chemical bath, thermocouple potentiometer, six 400 ml beakers, aluminium plates and electronic balance.

2.1 Preparation of sample plates and deposition Bath Solution

The flat sample plate (8.2 x7.2 x0.1 cm^2) were cleaned by polishing them using different emery papers with grade 120 to 300 corresponding to the decreasing particle grain sizes and gamma polishing alumina of 0.05µm particle size until its smoothness were obtained. The polished sample plates were washed with distilled water and dried before usage.

Deposition bath solution mixed different solutions and volumes of reagents in 400ml glass beaker. The bath constituents for deposition of Cadmium Sulphide thin films were 0.4M of Cadmium Chloride ($CdCl_2$) H_2O, 0.2M of EDTA (Ethylene Diamine -Tetra- Acetate) as complexing agent in the preparation of this solution to slow down the reaction, 1.0M Sodium Hydroxide (NaoH), 0.8M of thiourea (H_2NCSNH_2) as sources of sulphide ions (S^{2-}).

Masses of the solute reagents were obtained using the expression [8 paper]:

$$V = \frac{200 \times W \times M}{p \times d} \tag{1}$$

where V is total volume of the solution, W is molecular weight, M is the molarity required, P is the percentage assay, d is the density and specific gravity.

Masses of the chemical reagents used in the preparation of the different molar solutions were obtained using the expression (Sharma, V.C. (2007). Effect of polishing treatment and thermal oxidation on the total hemispherical thermal emittance of austentic stainless steel, AISI 321, Energy, 7, 607.):

$$m = \frac{MWV}{1000} \tag{2}$$

where m is the required molar concentration of the solution, W is the molar mass of the chemical salt, M is molarity and V is the volume of distilled water required.

2.2 Film Deposition

Six 400 ml beaker containing different solutions of various molarities were measured in the beakers. The constituents of each deposition beakers were 25 ml 0.4 M CdS solution, 14 ml 0.2 M EDTA solution, 12 ml 1.0 M NaoH solution, 16 ml 0.8 M Thiourea (H_2NCSNH_2) solution, 10 ml of distilled water. The polished Aluminium sample plates were suspended vertically in each reaction bath. This was done at room temperature of 27^0c or 300k from 12.00pm to 4.00am for different deposition time range of 16 to 36 hours at 4hours interval. Deposited films of increasing good quality were obtained. The chemical reaction for Cadmium Sulphide (CdS) thin film is:

$CdCl_2.H_2O$ + EDTA + $(NH_2)_2CS$ + $2OH^-$ → CdS + CH_2N_2 + $2H_2O$ + EDTA + Cl_2

After deposition, the deposited thin films on the sample plates were rinsed and dried. Mass of each plate was measured before and after film deposition.

3. Measurements of Parameters

An electronic weighing balance was used to measure the mass of sample plates. The room temperature was measured with the help of a thermometer. Thermal emittance (ε) of the polished Aluminium sample plate was measured by a thermocouple potentiometer before and after deposition of Cadmium Sulphide (CdS) thin films. The potentiometer output was calibrated in millivolt (mV). Values of the thermal emittance were calculated from the equation (8 Sharma, V.C. (2007). Effect of polishing treatment and thermal oxidation on the total hemispherical thermal emittance of austentic stainless steel, AISI 321, Energy, 7, 607.):

$$\varepsilon = \frac{Vs}{Vb} \times 0.18 \tag{3}$$

where V_s and V_b are the potentiometer readings for sample surface and black standard surface respectively. The measurements were repeated and their mean values of thermal emittance ε obtained.

Film thickness was estimated from the equation according to (Sharma, V.C. (2007). Effect of polishing treatment and thermal oxidation on the total hemispherical thermal emittance of austentic stainless steel, AISI 321, Energy, 7, 607)

$$t = \frac{m}{2dA} \tag{4}$$

where m is the mass of Cadmium Sulphide (CdS) films deposited on a sample plate in grams, obtained from the difference between mass of each sample plate before and after film deposition. A is the area of the film on sample plate and d which is the density of the film deposited is $4.87g/cm^3$ for Cadmium Sulphide.

4. Result and Discussions

Tables 1.0 and 2.0 present thermal emittance values of polished aluminium sample plates and Coated Aluminium Sample Plates respectively. The change in Thermal Emittance of Polished Sample Plates after Cadmium Sulphide (CdS) Film Deposition and mass of the deposited cadmium sulphide on aluminium are presented in Tables 3.0 and 4.0 respectively while the film thickness values are shown in Table 5.0.

Table 1: Thermal Emittance of Polished Aluminium Sample Plates

Sample Plate S/N	Thermocouple Reading		Thermal Emittance of Polished Plate
	Black Body V_b=(mV) ±0.01	Polished Plates V_s= (mV) ± 0.01	
1	106	102	0.173
2	93	85	0.164
3	110	100	0.163
4	90	70	0.140
5	85	78	0.165
6	120	94	0.141

Table 2: Thermal Emittance of Coated Aluminium Sample Plates

Sample Plate S/N	Thermocouple Reading		Thermal Emittance of Coated Sample Plates ε±0.01	Deposition Time (hrs)
	Black Body V_b=(mV)±0.01	Coated Sample Plate V_s=(mV)±0.01		
1	105	103	0.176	16.00
2	91	84	0.166	20.00
3	94	87	0.167	24.00
4	98	86	0.157	28.00
5	90	84	0.168	32.00
6	88	74	0.151	36.00

Table 3: Change in Thermal Emittance of Polished Sample Plates after Cadmium Sulphide (CdS) Film Deposition

Sample Plate S/N	Thermal Emittance of Sample Plates		Change in Thermal Emittance ε ± 0.001	Deposition Time (hrs)
	Before Deposition $\varepsilon_1 \pm 0.01$	After Deposition $\varepsilon_2 \pm 0.01$		
1	0.173	0.176	0.003	16.00
2	0.164	0.166	0.002	20.00
3	0.63	0.167	0.004	24.00
4	0.14	0.157	0.017	30.00
5	0.165	0.168	0.003	32.00
6	0.141	0.151	0.010	36.00

Table 4: Mass of Deposited Cadmium Sulphide on Aluminium

Sample Plate S/N	Mass of Sample Plates		Change in Mass M_2-M_1 (g) ±0.01	Time of Deposition (hrs)
	Before deposition M_1(g)±0.01	After Deposition M_2(g) ±0.01		
1	18.14	18.18	0.04	16.00
2	19.20	19.27	0.07	20.00
3	19.30	19.40	0.10	24.00
4	19.40	19.52	0.12	28.00
5	19.50	19.65	0.15	32.00
6	19.60	19.76	0.16	36.00

Table 5: Film Thickness

Sample Plate S/N	Length (cm)	Breadth (cm)	Area (LxB) cm^2	Mass of Film (g)	Film Thickness (µm)x10^{-2}	Deposition Time (hrs)
1	8.20	2.10	17.22	0.04	2.38	16.00
2	8.20	2.30	18.86	0.07	3.81	20.00
3	8.20	2.10	17.22	0.10	5.96	24.00
4	8.20	2.20	18.04	0.12	6.82	28.00
5	8.20	2.10	18.04	0.15	8.53	32.00
6	8.20	2.10	17.22	0.17	9.53	36.00

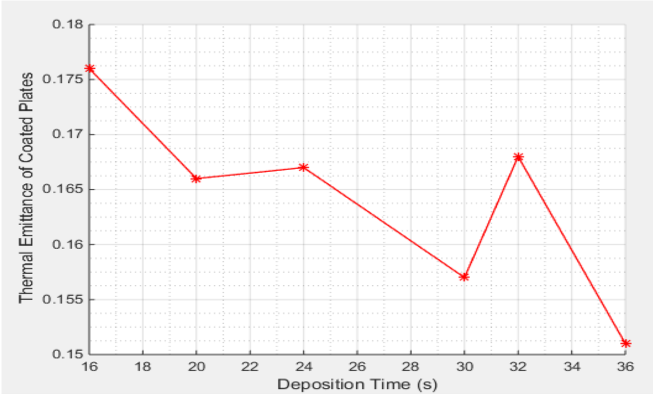

Figure 1: Thermal Emittance of Coated Sample Plates with Deposition Time

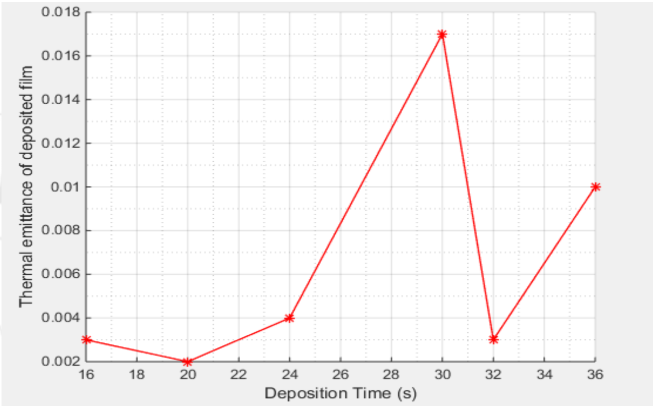

Figure 2: Change in Thermal Emittance of Deposition Film with Deposition Time

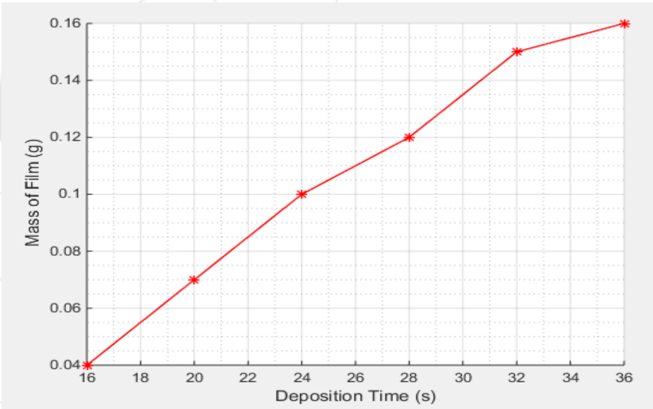

Figure 3: Change in Mass of Deposition Film with Deposition Time

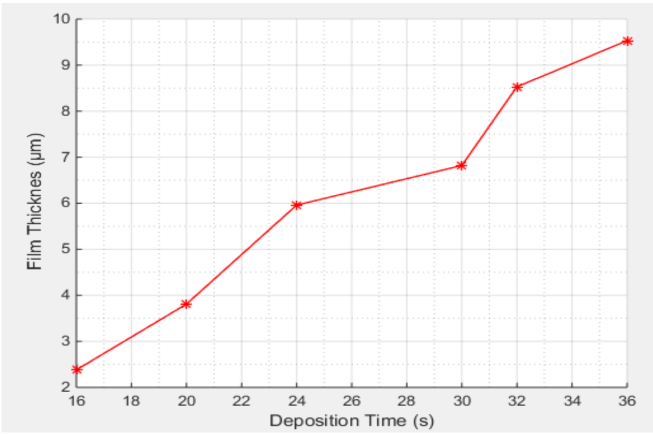

Figure 4: Change in Film Thickness with Deposition Time

The result of the thermal emittance of polished aluminium sample plates and deposited Cadmium Sulphide thin films at room temperature of 300K (27^0) from 12.00pm to 4.00am and different deposition times at intervals of 4 hours are presented in Table 2.0 and Figure 1.0. The emittance values rapidly increase from 0.15 to 0.17 with a near constant value of 0.16 ± 0.01. These values compared well with the thermal emittance values of 0.18±0.01 for chemically oxidized stainless steel AISI 321 and aluminium plates (Sharma, V.C and Hutchins, M.G. (2006). Radioactive selectivity and the oxidation of stainless steels, Proc ISES, Altlanta, G.A., 3, 1940.). From Table 2.0 and figure 1.0, the thermal emittance of coated sample plates with Cadmium Sulphide (CdS) thin films increases and gives good deposition within the deposition times of 20 hours to 32 hours. Table 3.0 and figure 2.0 depict that the change in thermal emittance of deposited thin films increases with the deposition time at about 30 hours to 36 hours and decreases with the deposition time at 16 hours to 20 hours. Table 4.0 and figure 3.0 show that the mass of thin films on the aluminium sample plates increases at each deposition time, that is, the change in mass of thin films progressively changes with the increase in deposition time. Table 5.0 and figure 4.0 indicated that film thickness increases with the progressive increase in deposition time. The thickness of such film produced could be hardened to withstand adverse weather conditions while at the same time retaining low thermal emittance.

This technique of deposition could be used at both high and low temperatures with a suitable deposition time to produce selective absorbers for solar thermal applications.

5. Conclusion

Cadmium Sulphide (CdS) thin films were deposited on polished aluminium sample plate. The chemical bath deposition technique was used with different deposition time at room temperature of 300k (27^0) to produce Cadmium thin films of selective surfaces of thermal emittance properties from 12.00pm to 4.00am at intervals of 4 hours. The average thermal emittance of polished aluminium sample plates is 0.15 ± 0.01. These values match conveniently with thermal emittance values of 0.13 to 0.17 ± 0.01 for polished aluminium.

The thermal emittance of coated aluminium sample plates appreciated gradually from 0.15 to 0.17 ± 0.01 with increase in deposition time. The masses of the deposited Cadmium Sulphide (CdS) thin films ranged from 0.04g to 0.16g as deposition time increases. The thickness of the deposited thin films varied from 2.38µm to 9.53µm as deposition time increases. The values of thermal emittance obtained in this study are very substantial for selective surfaces used in solar energy collectors. This technique of deposition could be used at both high and low temperatures with a suitable deposition time to produce selective absorbers for solar thermal applications The selective absorbers could be employed in poultry production for construction of solar chicks' brooders to provide heat to very young chicks which have no insulating feathers against adverse cold weathers condition during the day. This could also help to reduce high cost of energy consumption through the use of lamps stoves, electric bulbs and heaters.

References

[1] Hayes 1978
[2] Berzoni J.T., (1998) Coating for solar collector symposium: American Electroplaters society
[3] G.A Chouldhury, and Schgal, II.K. (1993). Solar Energy, 30,291
[4] Daletsiki et al., (1997). Galiotekhnika, 15, 1
[5] Gier G.T and Dunkle R.V., (2000). Selective spectral characteristics as an important factor in the efficiency of solar collectors, Trans. Conf. on the use of solar energy, II(Part 1,see A), 24
[6] Granziera F. (2002). Aluminium anodizer Pty Ltd., Metal Australasia, 211
[7] McDaniel D.K., (2006). The sun our future energy source, Wiley, New York
[8] Sharma V.C and Hutchins, M.G., (2006) Radiative selectivity