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Thermal Emmitance of Solar Energy Assisted Chemical Bath Deposited Zinc Sulphide (ZNS) Thin Films on Stainless Steel 430.

[1]Akinyemi P.,[1]Kolebaje O. T., [1]Adenodi R. A., [2]Abiodun C.I.

[1]Department of Physics, Adeyemi College of Education, Ondo, Nigeria.
[2]Department of Physics, University of Benin, Benin City, Edo State.

Abstract

The films of zinc sulphide (ZnS) were deposited on six polished sample plates of stainless steel 430 using improved chemical bath deposition (CBD) method technique at 32^0 to 38^o under intense solar radiation from 11.00am to 4.00pm respectively. The thermal emittance values of the polished and coated sample plates were determined before and after deposition of films respectively using thermocouple potentiometer. Average thermal emittance of polished samples plates is 0.174 ± 0.01. Thermal emittance values of deposited zinc sulphide (ZnS) thin film vary from 0.150 to 0.190 ± 0.01. Thickness of the deposited zinc sulphide (ZnS) thin films varies from 1.780 to 6.335 ± 0.01 μm. These values compared well with those obtained for selective absorbers using other deposition techniques. The chemical bath deposition techniques could be developed for deposition of the films at different temperatures with suitable deposition time to fabricate selective surfaces for solar energy applications.

Keywords:: Thermal Emittance, Chemically Deposited Zinc Sulphide Thin Films, Surface Solar Energy Colectors.

1.0 Introduction

Recent investigation have evoked considerable interest in Zinc Sulphide (ZnS) thin films because of its applications in so lar collectors, microwave shielding coatings and as sensors [1], Solar absorber coating [2], Solar control coating [3], Electro c onductive coating [4]. A spectral selective absorber has maximum absorption for solar wavelengths (0.3 to 2.5μm) and minim um emittance of thermal wavelengths (3.0 to 30.0μm) [8]. The quantity of radiation energy emitted is proportional to the ther mal emittance (ε) and the amount of solar energy absorbed by a surface is proportional to solar absorbance (α_s) [5]. Selective surface are poor emitter of thermal radiation and good absorber of solar radiation [9] (ε) is 20% while solar absorbance (α_s) is 90% [6]. The spectral selectivity requirement depends on the flux concentration and the

Converter surface operating temperature selective surface most have a proper spectral profile, and the properties at the su rface must resist elevated temperature. Spectral selective surface are of interest because of the potential energy saving capabil ities. The chemical bath deposition method is a simple, cheap, convenient and reproduction technique for producing high qual ity compound semiconductor thin films [7]. The present work reports the thermal emmitance of chemical bath deposition met hod Zinc Sulphide (ZnS) thin films on stainless steel 430 at room temperature of 300k and different deposition times for appli cation in solar energy collectors.

2.0 Experimental Studies

A plane sheet of stainless steel 430 series (75× 75×1mm^3) were polished using different emery papers of progressively decrea sing grain sizes and grade a polishing alumina of 0.05μm particles size until their mirror finishes were obtained. The polished sample plates were washed with distilled water, decreased with methylated spirit, rewashed with distilled water and dried.

3.0 Preparation of Deposition Bath Solution

Deposition bath solution was a mixture of different solution and volumes of reagent in 400ml glass beakers. The bath constitu ents for deposition of zinc sulphide thin films where zinc chloride ($ZnCl_2$) as source of zinc ions (Zn^{2+}), ethylene diamine tetr a-acetate (EDTA) as complexing agent, sodium hydroxide (NaOH) and thiourea (H_2NCSNH_2) as source of sulphide ions (S^{2-}) .

The mass of chemical reagents for the various molar solutions was calculated from the expression

Corresponding author: **AkinyemiPelumi**,E-mail: pelumi4mor@yahoo.com,Tel.: +2348065275295

$$m=M\times W\times V/1000 \quad (1)$$

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

4.0 Film Deposition

Six-400ml beakers containing different solutions of various molarities were measured in beakers. The constituents of each de position beaker were 25ml 0.8m ZnS solution, 16ml, 0.2m EDTA solution, 12ml, 1.0m NaOH solution, 0.8m thiourea solutio n and 7ml of distilled water. A polished stainless steel 430 sample plate was suspended vertically in each reaction bath. The b aths exposed to intense solar radiation from 11.am to 4.00pm at 32 to 38^0C for different deposition times range of 2.5 to 5hou rs at 30mins interval. The chemical reaction for deposition of zinc chloride (ZnS) thin films is:

$$ZnCl_2+ EDTA + (NH_2)_2CS+20H^-\rightarrow ZnS^{\downarrow}+ CH_2N_2+2H_2O+EDTA+Cl_2 \quad (2)$$

After deposition, the deposited thin films on the samples plates were raised and dried. Mass of each sample plate was measur ed before and after film deposition.

5.0 Measurements

The emittance (ε) of the polished stainless steel 430 series sample plate were measured by thermocouple potentiometer befor e and after deposition of zinc sulphide (ZnS) thin films. The potentiometer output was obtained in mill volt (mV) and calibrat ed by black standard surface. Values of the thermal emittance were calculated from the formula:

$$\varepsilon= V_S/V_b\times 0.18 \quad (3)$$

Where, $V_b$and V_S were potentiometer readings for black standard surface and sample surface respectively. The measurements were repeated and their mean values of ε obtained.

6.0 Measurement of Thickness

Film thickness was calculated from the formula:

$$t= m/2dA \quad (4)$$

Where, m is the mass of zinc sulphide (ZnS) films deposited on a sample plate, obtained from the difference in mass of each sample plate before and after film deposition. A is the area of the film on sample plate and $d=4.10g/cm^3$ for zinc Sulphide thi n film.

7.0 Discussion

The results of thermal emittance of polished stainless steel 430 sample plates and deposited Zinc Sulphide thin films at 32^0 to 38^oC under intense solar radiation from 11.00am to 4.00pm increases rapidly from 0.15 to 0.19 with a near constant value of 0.17±0.01 as shown in Table 1. Table 2 and fig 2 show that thermal emittance of deposited zinc sulphide (ZnS) thin films inc reases rapidly due to higher film thickness as a result of increase in rate of film deposition with increase in temperature under solar radiation. Average thermal emittance of polished sample plates is 0.17 ± 0.01. This value compares well with the therm al emittance values of 0.13 to 0.17 ± 0.01 for polished stainless steel AISI 321 using abrasives of different grain size [10] .Th e coating help to modify the microstructure and composition of the absorber so as to provide high absorbance for the wavelen gth range 0.3-2.0 μm [9]. The corresponding values of 0.17±0.01 film thickness vary from 1.78 to 6.36 μm and produced at d eposition time 2.30 to 5.0 hours under intensity solar radiation. The selective surface with poor film thickness cannot withsta nd adverse weather condition while those with high film thickness and thermal emittance cannot retain much heat [10].

This technique of deposition could be used at both high and low temperature with suitable deposition time to produce selectiv e absorbers for solar thermal applications. The thickness of such film produced could be hardened to withstand adverse weath er conditions while at the same time retaining low thermal emittance. Such selective absorbers could retain enough heat for a pplications in solar crop dryers, solar cooker, solar water heater, solar distillation, solar thermal refrigeration etc. [9].

Table 1: Thermal emittance of zinc sulphide thin films produced on stainless steel 430 sample plates at 32 to 38^{0}C under int ense solar radiation from 11:00am to 4:00pm for deposition time of 2.3 to 5 hours

Sample Plate S/N	**Surface treatment**	**Deposition Time (hrs)**	**Thermocouple reading Blackplate sample surface V_s=(mV) ±0.01 V_b=(mV) ±0.01**		**Thermal Emittance ε= ± 0.01**
	Polished and uncoated		110	92	0.151
1	Polished and uncoated	2.30	110	100	0.164
2	Polished and uncoated	3.00	110	102	0.167
3	Polished and uncoated	3.30	110	106	0.173
4	Polished and uncoated	4.00	110.00	107	0.175
5	Polished and uncoated	4.30	110	109	0.178
6	Polished and uncoated	5.00	110	115	0.188

Table2: Thickness of zinc sulphide (ZnS) thin films produced on stainless steel 430 at 32 to 38^{0}C under intense solar radiatio n from 11:00am to 4:00pm for deposition time of 2.3 to 5 hours.

Sample Plate S/N	**Surface treatment**	**Deposition Time (hrs)**	**Mass of deposited (ZnS) film m(g) ±0.01**	**Area of film A(cm) ±0.01**	**Film thickness t(μm) ±0.01**	**Thermal Emittance**
1	Polished and coated	2.30	0.02	13.68	1.780	0.15
2	Polished and coated	3.00	0.03	12.75	2.860	0.16
3	Polished and coated	3.30	0.05	11.84	5.150	0.17
4	Polished and coated	4.00	0.04	11.25	5.396	0.17
5	Polished and coated	4.30	0.01	12.75	5.739	0.18
6	Polished and coated	5.00	0.06	11.55	6.335	0.19

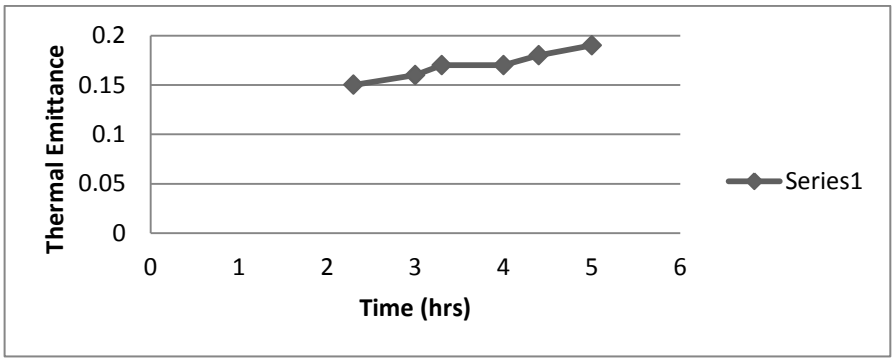

Figure 1: Variation of thermal emittance with time

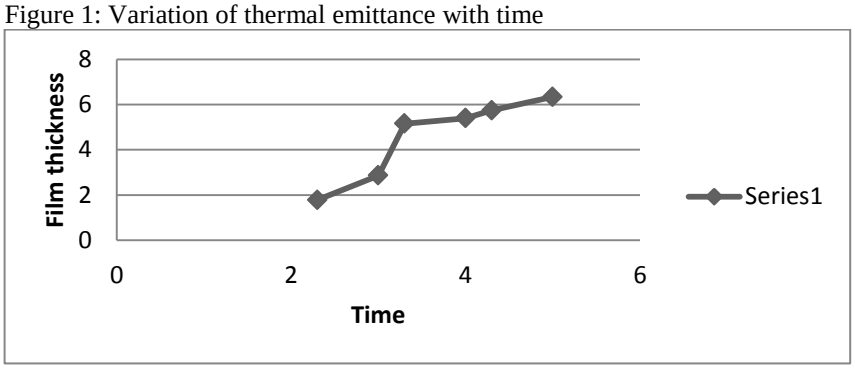

Figure 2: Variation of film thickness with time

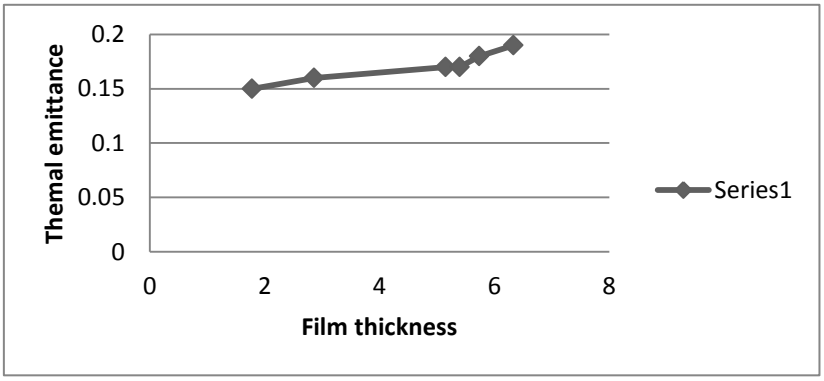

Figure 3: Variation of thermal Emittance with film thickness

8.0 Conclusion

Zinc sulphide (ZnS) thin films were deposited on polished stainless steel 430 sample plates using chemical bath method at dif ferent deposition time. Zinc sulphide (ZnS) were produced at 32^{o}C to 38 ^{o}C under intense solar radiation from 11.am to 4.00p m for 2.30 to 5.00hours. The average thermal emittance of the polished stainless steel 430 sample plates is 0.17±0.01. The va lues compares well favourably with thermal emittance value of 0.13 to 0.17μm ±0.01 for polished stainless steel AISI 321 [8] .The thermal emittance of the coated sample plates increases slowly depending on deposition time from 0.15to 0.19μm ± 0.0 1 for chemically oxidized stainless steel AISI 321 for use in solar energy application [9]. The masses of the deposited zinc sul pide thin films vary from 0.01 to 0.06g depending on deposition times and thickness of the deposited thin films vary from 1.7 8 to 6.36μm depending on deposition time. The values of thermal emmittance obtained at both low and high temperatures for the deposited zinc sulphide thin films compare favorably with obtained for selective surfaces used in solar energy collectors. The chemical bath deposition technique could be employed at low and high temperatures with suitable deposition time to fabr icate selective absorbers for solar energy collection.

REFERENCES

[1] Berzoni J.T., (1998). Coating for Solar collectors symposium; American Electroplaters society, G.A

[2] Chouldhury, C. and schgal, II.K. (1993). Solar Energy, 30, 291.

[3] Daletsiki et al., (1997). Galiotekhnika,15, 1.

[4] Gier, G.T. and Dunkle, R.V., (2000). Selective spectral characteristics as an important Factor in the Efficiency of sol ar collectors, Trans. Conf. on the use of solar energy, II(Part 1, See A), 24.

[5] Granziera, F. (2002). Coloured stainless steels, Aluminum Anodizer Pty Ltd., metal Australasia, 211.

[6] McDaniel, D.K., (2006). The sum our future energy source, Wiley, New York.

[7] Sharma, V.C and Hutchins, M.G., (2006). Radiative Selectivity and the Oxidation of Stainless Steels Proc ISES, Altlanta, G.A., 3, 1940.

[8] Sarma, 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

[9] Sharma, V.C., Sharma, A. and IIenikhena P.A.,(2007) Energy, 13(10), 749-754.

[10] Smith, G.B. and Ignatiev, A., (2007). Sol. Energy matter. 2, 461.