CHARACTERIZATION OF SPECTRAL SELECTIVITY OF COPPER SILVER SULPHIDE TERNARY THIN FILM

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Abstract: Spectral selective ternary thin films grown by the solution growth technique were found to have spectral properties which suggest their suitability for different applications in various solar energy devices. The films have the properties of screening off UV portion of the electromagnetic radiation by absorbing and reflecting and admittance of the visible and infrared radiation by transmission. These properties confirm the films good materials for coating poultry buildings, eye glasses coating, solar thermal conversion anti-reflection coating and solar cells fabrication. The direct band gap obtained is 2.3eV and indirect band gap is 1.1eV.

1. Introduction

Research into ways of improving the performance of solar energy devices have for sometime engaged the attention of some solar energy scientists around the world [1-6]. One area of such research is the use of materials’ surfaces to separate input solar radiation from radiation emitted by absorbing materials in order to obtain higher collection and working efficiencies [7]. Selective capabilities exist intrinsically in some materials, but such selectivity is usually inadequate for many solar energy applications. Tabor [1] noted that solar collection can be enhanced by using thin film coatings. It has been discovered that it is possible to control the amount of solar radiation admitted into building through window and door by coating them with some types of selective materials.

This type of spectral separation could be used to emphasize either solar heating or cooling effects in buildings depending on the temperature, lighting and energy needs of their interiors. Such effects could serve as complementary or alternative to the conventional heating and cooling (air conditioning) devices currently in use in homes, cars and offices. Sayigh [8] and Chopra and Das [9] have shown that it is possible to synthesize coatings which can be used to emphasize the desired heating or cooling effects in buildings from materials that are less expensive using simple production methods in this case solution growth technique (SGT).

The spectral properties which were computed for include absorbance (A), transmittance (T) and reflectance (R) using the expressions given in literatures by [10-44].

3. Experimental Detail and Materials

The chemical deposition of the copper silver sulphide ternary thin film onto the glass substrate was carried out by using a mixture of 1 M copper chloride, 0.1 M ethylenediaminetetraacetate (EDTA), 0.1 M silver nitrate, 7.4 M triethanolamine (TEA), 14 M ammonia, 1M thiourea, distilled water, microscopic glass slides in beaker.

Keywords: Spectral properties, CuAgS ternary thin films, Solution growth technique (SGT).
The chemical bath deposition technique was used to prepare the CuAgS ternary thin film on glass substrate (slide) which had been previously degreased in concentrated nitric acid (HNO₃) for 48 hours, cleaned in cold water with detergent, rinsed with distilled water and dried in air. The degreased-cleaned surface provides nucleation centre for growth of the film, hence yielding highly adhesive and uniformly deposited film.

The mixture was thoroughly stirred with a glass rod before the glass slide was vertically introduced into the beaker. The dip time of about 20 - 48 hours at pH between 9 and 11 was observed for the deposition process which took place at room temperature. The grown samples were removed from the reaction baths rinsed with distilled water and allowed to dry. They were then annealed at 423 K for 1 hour to obtain adherent transparent thin films.

During deposition, cations and anions in the deposition solution reacted to become neutral atoms which either precipitated spontaneously or vary slowly. Fast precipitation is an indication that thin films could not be formed on the substrate immersed in the solution. However, with the addition of NH₃ and EDTA, the reaction slowed down for thin film of neutral atom to be formed on the substrate. Sulphide ions were released by hydrolysis of thiourea. By the process of ion- by - ion exchange, CuAgS was deposited on the glass substrate in the form of transparent, uniform and adherent ternary thin film.

The film was characterized by measuring the absorbance and transmittance using UNICO UV-2102 PC Spectrophotometer. The spectral properties studied included the absorbance (A), transmittance (T) and reflectance (R). The step wise reactions involved in the complex ion formation and film deposition processes for CuAgS are:

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\begin{align*}
\text{CuCl}_2 \cdot 2\text{H}_2\text{O} + \text{EDTA} & \rightarrow [\text{Cu(EDTA)}]^+ + 2\text{Cl}^- \\
[\text{Cu(EDTA)}]^+ & \rightarrow \text{Cu}^+ + \text{EDTA}^2^- \\
\text{AgNO}_3 + \text{TEA} & \rightarrow [\text{Ag(TEA)}]^+ + \text{NO}_3^- \\
[\text{Ag(TEA)}]^+ & \rightarrow \text{Ag}^+ + \text{TEA} \\
(\text{NH}_2)_2\text{CS} + \text{OH} & \rightarrow (\text{NH}_2)_2\text{CO} + \text{HS}^- \\
\text{HS}^- + \text{OH}^- & \rightarrow \text{H}_2\text{O} + \text{S}^2^- \\
\text{Cu}^+ + \text{Ag}^+ + \text{S}^2^- & \rightarrow \text{CuAgS} 
\end{align*}
\]

4. Results and Discussion

The graphs of spectral absorbance, transmittance and reflectance versus wavelengths are presented in figures 1, 2 and 3 respectively. The absorbance increased sharply to a maximum value of 0.82 at 300 nm from a value of about 0.04 at 200 nm and thereafter decreased to a minimum value of 0.21 at 650 nm. This result indicates that the film has high absorbance at UV wavelength (0.2 < \(\lambda\) < 0.4µm) and low absorbance at visible (VIS) and infrared (IR) wavelengths (0.4 < \(\lambda\) < 1 µm) as shown in figure 1. While the transmittance as seen in figure 2, increased to a maximum value of about 0.61 % at 660 nm from a value of about 0.2% at 300 nm and thereafter decreased with wavelength. This means high transmittance at visible and infrared wavelength and low transmittance at UV wavelength. The reflectance as shown in figure 3, increased to a maximum value of 21 % at 480 nm from a value of about 17.5 % at 360 nm, it then decreased to a minimum value of 17.5 % at 680 nm before increasing with wavelength. This result indicates that reflectance is high in visible and infrared wavelengths and low at UV wavelength.
The film has high visible transmittance but absorb highly in the UV and near infrared (NIR) wavelengths. The shape of the spectral curve (fig.1) for this film shows that they can only allow visible radiation to be transmitted through the glazing system into the building if these films are used in coating the glazing.

These types of films are designated visibly transparent films (VTF) in this work. Also, because the film can be used to transmit solar radiation (0.3 um to about 1.0 um) into building but prevent thermal radiation out of the buildings through the glazing systems, if these films are used in coating them. The films can be called solar transmitting films (STF). Such films can also be used to anti-reflect solar radiation falling on and passing through solar collector glazing onto absorber plates in photo-thermal solar energy devices. This type of action would reduce the reflection of solar energy at the air - glass interface thereby causing high transmission of solar radiation into the device. These types of films are designated as solar anti-reflection films (SARF).

The optical properties considered revealed high absorbance and reflectance but low transmittance in the UV; low values of absorbance and reflectance accompanied but high transmittance in the VIS.
The variations observed from the three graphs may be due to variation in concentrations and impurities from the environment where the experiment is carried out.

5. Conclusion

New ternary thin films of copper silver sulphide have been grown on glass substrate using solution growth technique (SGT) and characterized using a spectrophotometer. From the results observed, it can be concluded that the ternary thin films have the properties of screening off UV portion of the electromagnetic radiation by absorbing and reflecting and admittance of the visible and infrared radiation by transmission. These properties confirm the films good materials for coating poultry buildings, eye glasses coating, solar thermal conversion, anti-reflection coating and solar cells fabrication.

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