

## STUDIES ON GROWTH AND CHARACTERIZATION OF MERCURY SELENIDE THIN FILMS PREPARED BY CHEMICAL BATH TECHNIQUE

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Mercury Selenide (HgSe) thin films were successfully grown from a solution bath containing Mercury chloride (HgCl<sub>2</sub>), Ammonia solution NH<sub>3</sub> with Triethanolamine (TEA) as a complexing agent, sodium-selenosulphite (Na<sub>2</sub> SeSO<sub>3</sub>) and water on glass slide using solution growth technique. The surface topographies were obtained by taking the photomicrographs of the films coated on the transparent glass slides with wide KPL-W10x/18 zeiss standard 14 photomicroscope with M35 4760 – 9901 camera at a magnification of x 200. The structural nature was obtained using X-ray diffraction (XRD) analysis. The band gap ranges between 1.55 and 1.68 eV.

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### 1. Introduction

Mercury selenide is an important class of material because of its electronic and optical properties and potential in infra red (IR) detection, electro-optic, opto-electronic and solar energy conversion devices [1, 2 and 3]. Other applications of thin films of medium band gap semiconductor include filters, mirrors, heterojunction devices and antireflection coatings [4, & 5]. An attempt is made in this work on their growth kinetics and the compositional behaviour of the structural and optical properties with the intension of using HgSe thin films in electrochemical conversion. Several techniques have been used in the deposition of thin films such as chemical vapour deposition (CVD), thermal evaporation [6], electron beam evaporation, and hot wall epitaxy (HWE) [7]. Most of the methods named above require sophisticated equipment and high technique such as those that involves vapour phase. The method of thin film deposition used in this work is known as solution growth technique (SGT) because of its simple, cost-effective and easy reproducible nature.

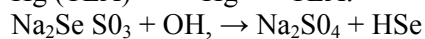
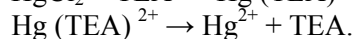
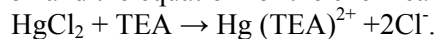
Pujari et al in 2002[8] reported a band gap range between 1.72 to 1.06 eV and an absorption coefficient of (10<sup>4</sup>-10<sup>5</sup> cm) with direct type transition of a grown HgSe. The purpose of this work is to obtain the optical and solid state properties of HgSe thin films, compare them with the existing ones and to find possible areas of their applications.

### 2. Experimental details

The thin films of HgSe were obtained by deposition of Hg<sup>2+</sup> and Se<sup>2-</sup> ions in a simple aqueous medium [9, and 10]. The apparatus includes the glass beaker, measuring cylinders, syringes, density bottles, stirring glass rods, microscopic glass slides, temperature regulating oven, electronic weighing balance, spatular, lab bench and electrical heater. The required chemical bath was formed with stock solution of 4ml of 1M sodium seleno-sulphite (Na<sub>2</sub>SeSO<sub>3</sub>), 5ml of 1M Mercury chloride (HgCl<sub>2</sub>), mixture of (5ml of 13.4M of Ammonia solution (NH<sub>3</sub>) and 10ml of 7.4M Triethanolamine (TEA) as buffer in this means that they act as complexing agent and PH regulator, in 40ml of double distilled water. The stock solution of Na<sub>2</sub>SeSO<sub>3</sub> was obtained by mixing selenium metal powder (5g) with anhydrous sodium sulphite (12g) in 200ml double

distilled water and heating at 90 °C for 1hr. The substrate is the plane glass slide (76mm x 13mm x 1mm) that was soaked in concentrated HCl for 12hrs and thoroughly washed in the detergent water with synthetic sponge, rinsed with clean water and dried in air. Four reaction baths were used for the experiments.

The dissociation relation and the equation for the chemical reactions are:



The solution in the reaction baths were properly stirred with a glass rod to ensure homogeneity. The glass substrates were then placed vertically inside the reaction baths using synthetic foam cover to shield the effect of impurities and support the slide in vertical position. The baths were placed in the temperature regulating oven set at 75°C for different deposition times ranging between 1hr and 1<sup>3</sup>/<sub>4</sub> hrs. The deposited samples were removed, rinsed with distilled water and dried in air.

Finally, the samples were annealed at different temperatures for 1 hr each. The samples include: annealed H<sub>10</sub> at dip time of 1 hour, H<sub>11</sub> annealed at 300°C with dip time of 1 <sup>1</sup>/<sub>4</sub> hrs; H<sub>17</sub> annealed at 100°C with dip time of 1 <sup>1</sup>/<sub>2</sub> hrs and H<sub>18</sub> annealed at 200°C and dip time of 1 <sup>3</sup>/<sub>4</sub> hrs. The structural characterization and surface morphology investigation were performed using Philips PW 1500 XRD and MD 10mini diffractometer with Cuka and diffracted beam monochromator. The band gaps were obtained using the transmittance and absorbance measurement from Unico-UV-2102PC spectrophotometer.

### 3. Results and discussion

The result from spectral characterization of HgSe films in the plot of absorbance Vs wavelength of HgSe shown in fig. 1a presents a near uniform absorbance across the spectra with the annealed sample (H<sub>10</sub>) having the least absorbance and the sample (H<sub>11</sub>) annealed at 300°C having the highest absorbance of 0.64 at 840 nm but decreases towards near IR region. However sample H<sub>17</sub> shows the highest absorbance of 0.7 from 920nm upward.

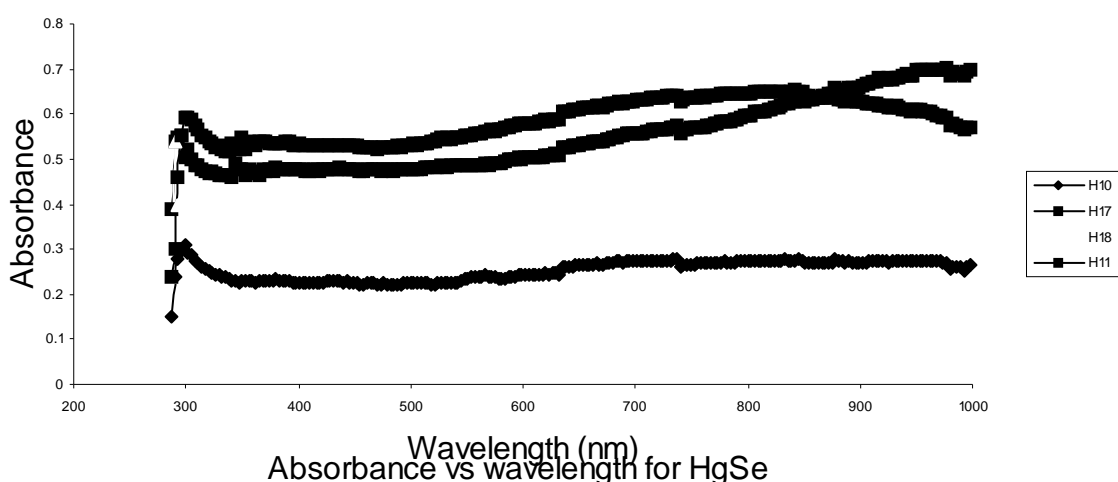


Fig. 1a

Fig 1b shows that absorbance is the reverse characteristic of transmittance where the as-deposited has the highest transmittance, the (H<sub>11</sub>) annealed at 300°C has the lowest transmittance. We conclude that annealing temperature is proportional to absorbance but inversely proportional to the

band gap. This has been reported by Erat et al, 2007[11] which stated that annealing, increases reorganization of the films, increases evaporation of absorbed water, cause decrease in the number of defect by filling of the voids in the film, increase in the grain size and decrease in band gap.

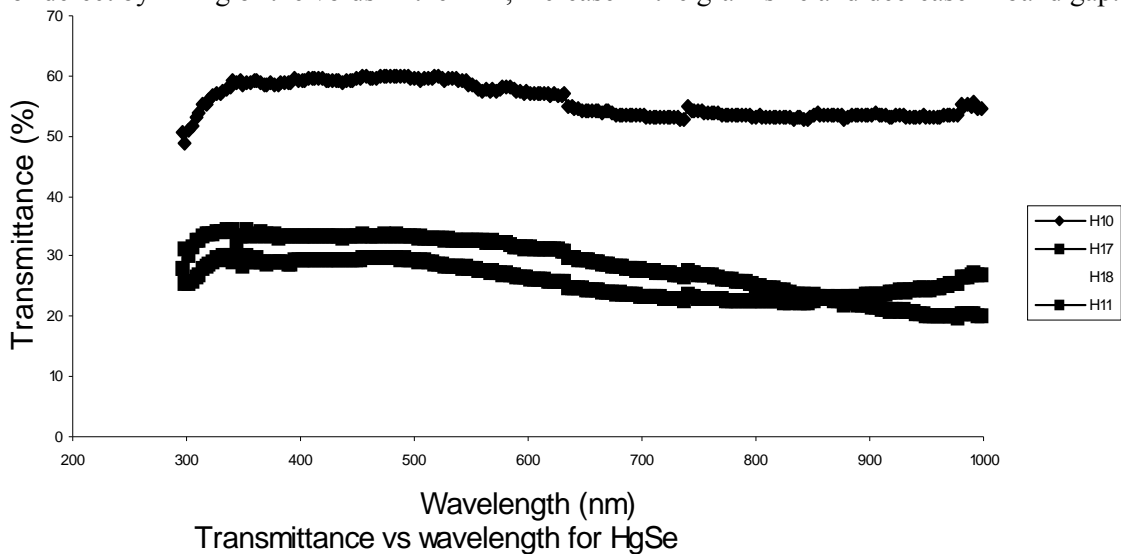


Fig. 1b

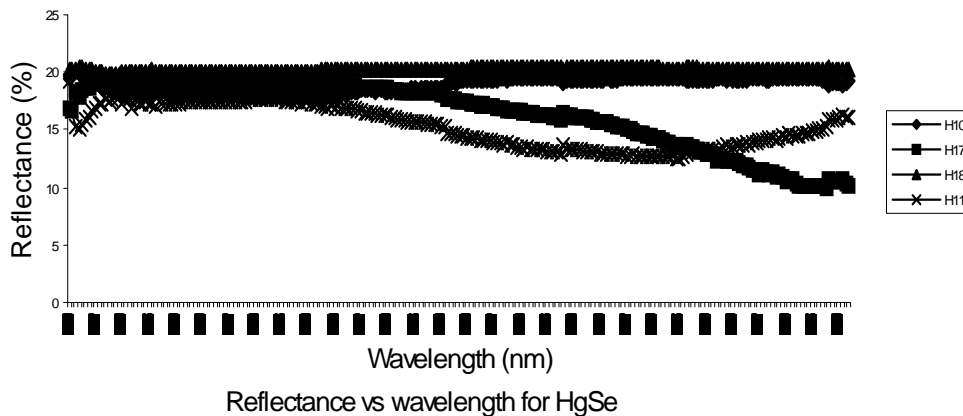


Fig. 1c

It was also observed from fig 2 that the band edge sharpness reduces with annealing temperature. It was also shown that band gap increases with dip time. They almost generally have low uniform reflectance of about 20% across the spectra though sample H<sub>11</sub> and H<sub>17</sub> decreases more toward near IR. They have band gap of: H<sub>(10)</sub> 1.68 eV, H<sub>(11)</sub> 1.55eV, H<sub>(17)</sub> 1.58eV and H<sub>(18)</sub> 1.57 eV shown in fig 2. This shows that the band gap decreases with annealing temperature but increases with dipping time.

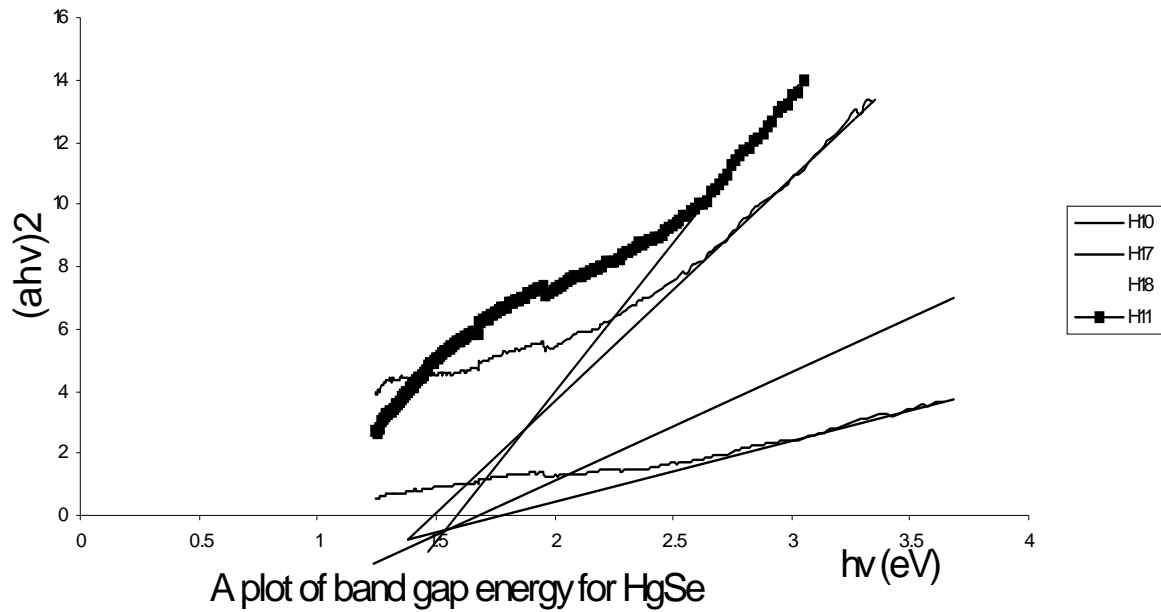


Fig. 2

Fig 4 shows a typical X RD pattern display of HgSe. The peaks at  $2\theta$  values were observed around 19.75, 25.64, 28.20 and 63.42. The existence of identifiable peaks in the diffractograms suggests that the films are not amorphous but crystal in nature. From analysis, sample  $H_{11}$  has a near uniform distribution of peaks which suggest a pure crystal with uniformly distributed particles. A close observation of the optical micrographs (Fig3) of HgSe show a uniform structure and darkening of the colour as the annealing temperature increases.

Fig: 3 Photomicrograph of  $H_{(10)}$ 

The photomicrographs were shown to have uniform structure and the XRD shown in Fig.4 below indicates that the colour of the thin films were blue-grey metallic. The spectroscopic analysis taken at 25°C showed that it is an orthorhombic opaque mineral at 19 reflections in pattern. At angle  $2\theta$  of  $25.165^\circ$ , it showed an atomic distribution of (hkl) III and at  $29.141^\circ$  of  $2\theta$ , (hkl) of 2,0,0. From XRD pulses, it was shown that both sample  $H_{(10)}$  and  $H_{(11)}$  were shown to be stable crystals with  $H_{(10)}$  having an average peak value of 4.15 at the range of  $20.50^\circ - 20.76^\circ$  and 2.9 at  $64.20^\circ$  °C while sample  $H_{(11)}$  has an average peak value of 1.20 at  $2\theta$  range of  $20.5-47.0$  and 2.10 at  $60.70-68.40$  range of  $2\theta$ .

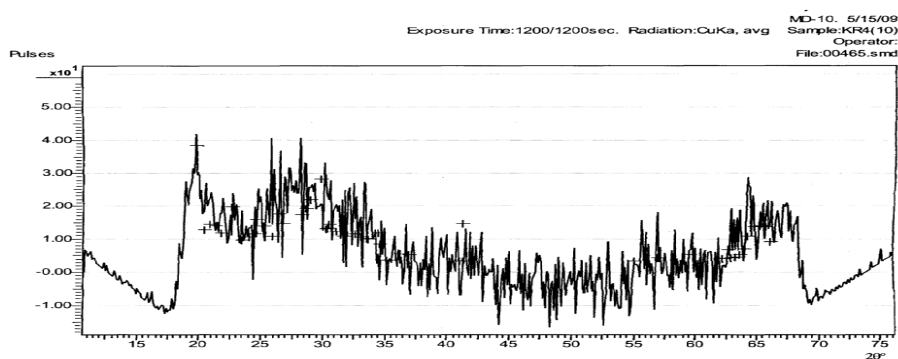


Fig: 4a XRB PATTERN OF H(10)

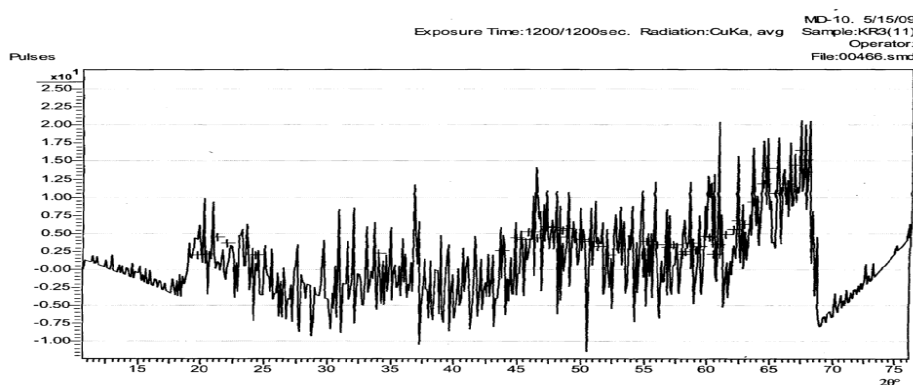


Fig: 4b XRB PATTERN OF H(11)

Table 1

S/NO	HgSe films	Band gap hv (eV)	Deposition temperature (°C)	Annealing temperature (°C)	Dipping time (hr)
1.	H (10)	1.68	75	0	1 <sup>3/4</sup>
2.	H (11)	1.55	75	300	1
3.	H (17)	1.58	75	100	1 <sup>1/2</sup>
4.	H (18)	1.57	75	200	1 <sup>1/4</sup>

#### 4. Conclusion

The deposition of HgSe thin films have been successfully carried out in alkaline medium using solution Growth technique. They had a near uniform absorbance throughout the spectrum, low reflectance and good transmittance. With the above characteristics, the films would be useful in coating of poultry walls and roof and would save the money that would have been used to pay for electricity or buy fuels for plant and kerosene needed to warm the chicks. It would be very useful in the fabrication of anti-reflection coating for vehicles and window coating for solar cells.

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