International Journal of Biology, Pharmacy and Allied Sciences (IJBPAS)

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OPTICAL NATURAL SCIENCES OF CUS THIN LAYERS PRODUCED BY CBD METHOD

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ABSTRACT

Thin layers of Copper sulfide have been prepared by chemical bath deposition technique from different deposition times. The layers were grown on glass substrates. The deposition was performed in alkaline media at 50 °C and pH fixed on 10 constant values. Optical properties of Nano layers were studied by spectrophotometer analysis in VIS wavelength range. Natural optical properties were obtained by applying Kramers-Kronig relations on reflectivity curves. The optical band gap (Eg) , was evaluated from VIS absorption spectra and found to have a mean value of 1.933 eV. Changing deposition times affect on all optical properties.

Keywords: Copper sulfide; spectrophotometer; thin layer; optical properties.

INTRODUCTION

Copper sulfides (Cu_xS, x = 1–2) are significant binary compounds that attract much attention due to their wide range of applications in optical and electrical devices[1], such as photo thermal conversion[2], microwave shielding coatings[3], solar control coatings [4], dye-sensitized solar cells [5], potential nanometer-scale switch [6] , cathode materials in lithium rechargeable batteries and some chemical sensors [7]. Additionally, it has recently been reported that CuS can transform into a superconductor below the 1.6 K because of its metallic conduction behavior [8]. Optical properties of thin metal films are determined by spectrophotometric, interferometric, and spectro ellipsometric methods. Optical constants determined in such calculations are significantly different in various works and, in addition, differ

essentially from the corresponding optical constants of massive metals by their values. In this work we used Kramers-Kronig relations applying on reflectivity curve to calculate natural optical properties of Copper sulfide thin layers.

Experimental details

Copper sulfide layers were produced by chemical bath deposited on glass substrates. Prior to deposition, the platelets (50mm x 25mm x 1mm) were ultrasonically cleaned with acetone and then alcohol and dried. The details of the procedure are: amounts of $CuCl_2$ and thiourea and thioacetamide were separately prepared. Formed mixtures are thoroughly stirring for several minutes in order to dissolve the formed precipitate and solutions to become homogeneous. Then in obtaining solutions were added distilled water. These solutions were mixed in a beaker and stirred well for a few minutes. The deposition bath was continuously stirred and heated at 50ºC for 0.5, 1 and 1.5 hour as deposition times. The substrates were immersed into the deposition bath, by vertically suspending them around the stirrer. The substrates were taken out after 1hour as deposition time. Deposition parameters were: $[CuCl_2]$ = 0.01M, [thiourea]=0.03M; [thioacetamide]= 0.07 M; pH = 10; All

samples were annealed in air, at 250ºC for half hour. Table I shows the detail of deposited layers produced in this work. The optical constants of our samples were derived on the basis of standard Kramers–Kronig relations using computer techniques.

Table I: Details of produced CuS layers by CBD method.

Sample name	Deposition time
1	o.5 hour
2	1 hour
3	1.5 hour

RESULTS AND DISCUSSION

In this work Kramers-Kronig relations were used to calculate the phase angle θ (E) [9]:

$$\theta(E) = -\frac{E}{\pi}\int_0^{E_2}\frac{\ln R(E) - \ln R(E_0)}{E^2 - E_0^2}dE + \frac{1}{2\pi}\ln[\frac{R(E)}{R(E_2)}]\ln\frac{E_2 + E}{|E_2 - E|}$$
$$+ \frac{1}{\pi}\sum_{n=0}^{\infty}[4(\frac{E}{E_2})^{2n+1}](2n+1)$$

… (1)

Where E denotes the photon energy, E_2 the asymptotic limitation of the free-electron energy, and R(E) the reflectance. Hence, if E_2 is known, the θ (E) can be calculated. Then the real and imaginary parts of the refractive index were calculated, from which other parameters were obtained. Figure 1 show Reflectance curves of Copper sulfide thin layers produced in this work. Omaiyo optical curves as a reference are added to all optical curves for comparison. The general trend between our data and Omaiyo data are the same. As it can be seen from figure 1, by increasing the time of deposition, reflectivity

curves have increasing trend in general. That is because of configuration more complete layers by increasing deposition time. There is an intersection between optical curves that is because of formation complete layers from one hand and supper saturation property from other hand.

Figure 2 shows the real part of refractive index for layers produced in this work. By increasing time of deposition and formation of complete layers, fraction of voids decreases and denser layers produces, therefor real part of refractive index increases.

In figure 3 we depict the imaginary part of refractive index (k) for the layers produced in this work. Because of formation complete layers by increasing the time of deposition and decreasing the fraction of voids,

transmittance increases therefore absorbance decreases, extinction coefficient decreases.

Figures 4 and 5 show the real and imaginary parts of conductivity respectively. By increasing time of deposition, the ratio of copper metallic ions increases on substrate, therefor the real part of conductivity index and the imaginary part of conductivity index increases. The intersection between conductivity curves are discussed before. Also this intersection is a proof of wavelength correlation for optical constants.

We depict the natural optical band gap in figure 6. By increasing time of deposition and increasing the ratio of copper metallic ions increases on substrate, band gap decreases. The values of bang gap calculated 2.1 eV, 2 eV and 1.7 eV for 0.5 , 1 and 1.5 hours, respectively.
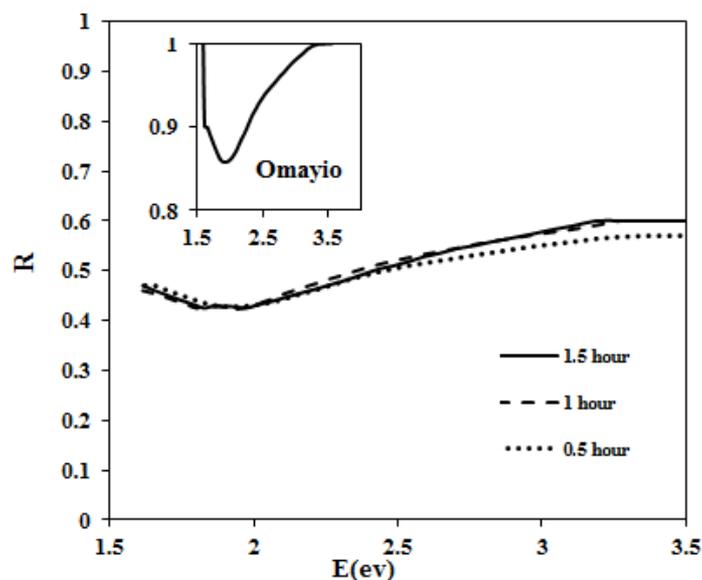

Figure 1: The reflectance of Copper sulfide layers produced by CBD method at different deposition times.
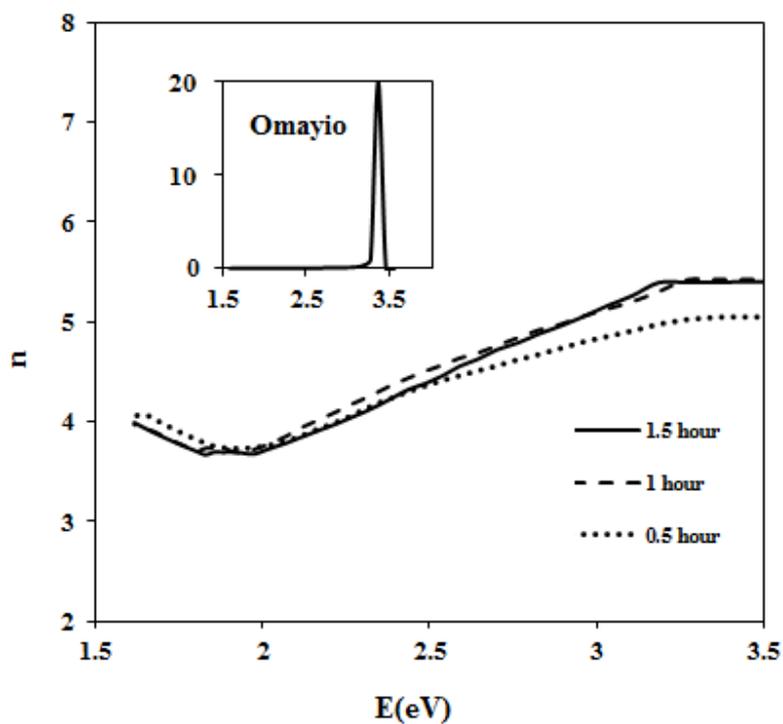
Figure 2: The real part of refractive index of Copper sulfide layers produced by CBD method at different deposition times.
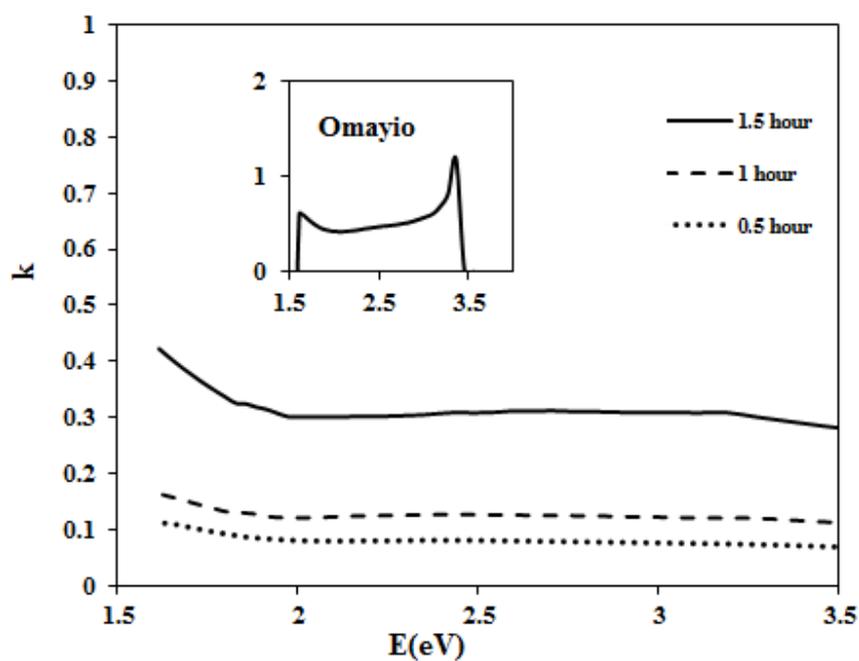

Figure 3: The imaginary part of refractive index of Copper sulfide layers produced by CBD method at different deposition times.
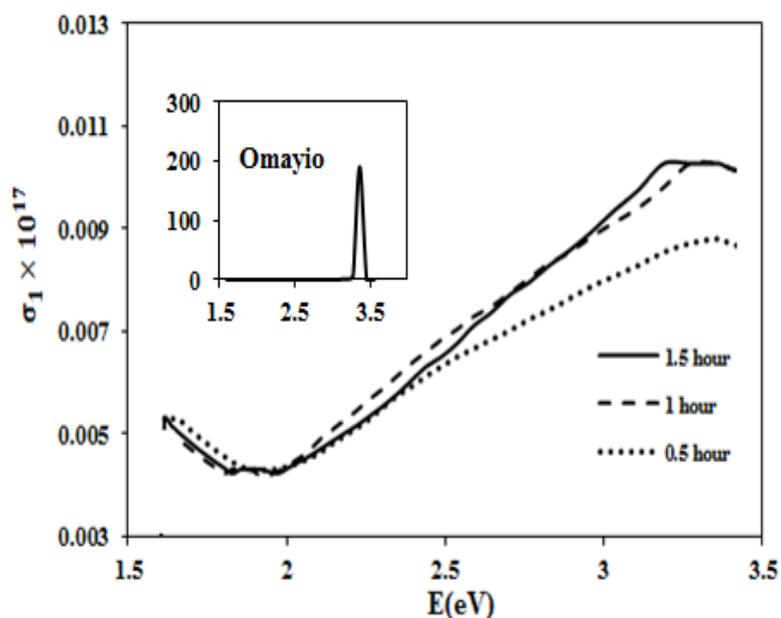
Figure 4: The real part of conductivity index of Copper sulfide layers produced by CBD method at different deposition times.
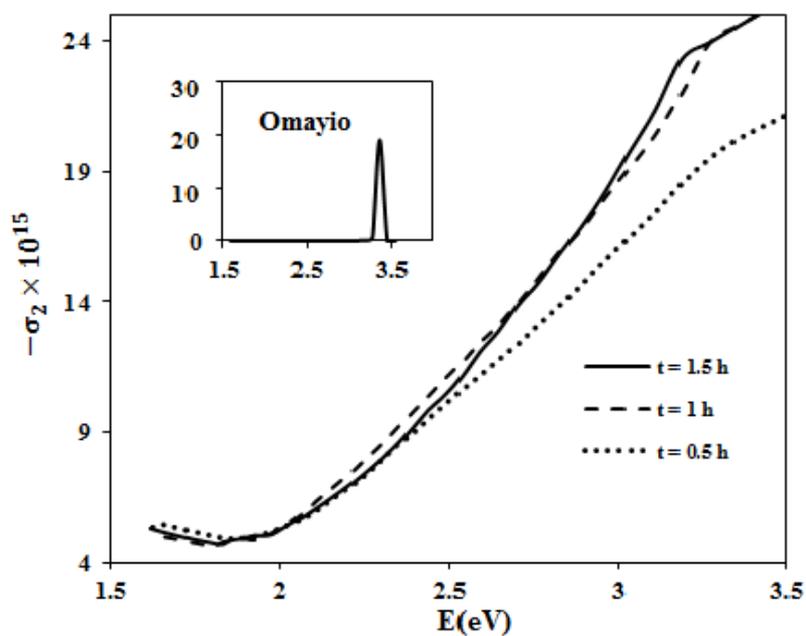

Figure 5: The imaginary part of conductivity index of Copper sulfide layers produced by CBD method at different deposition times.
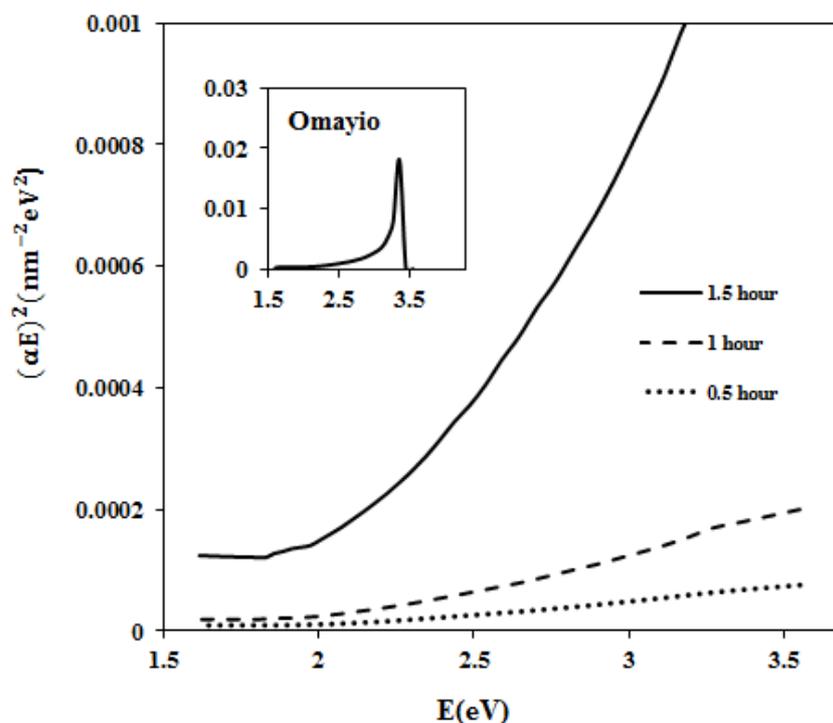
Figure 6: The values of band gap energy of Copper sulfide layers produced by CBD method at different deposition times.

CONCLUSION

Thin layers of Copper sulfide have been prepared by chemical bath deposition technique at different deposition times. The layers were grown on glass substrates. The deposition was performed in alkaline media at 50 °C and pH fixed on 10 constant value. Optical properties of Nano layers were studied by spectrophotometer analysis in VIS wavelength range. Natural optical properties were obtained by applying Kramers-Kronig relations on reflectivity curves. By increasing time of deposition for copper sulfide, reflectivity, real and imaginary parts of refractive index, real and imaginary parts of conductivity index, increased. The optical band gap (Eg) , was evaluated from VIS absorption spectra and found to have a mean value of 1.933 eV and by increasing time of deposition because of increasing the ratio of copper metallic ions on layers, band gap decreases. Changing deposition time affect on all optical properties.

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