optical and electrical proprties of chemically deposited culnsz thin films

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The study of thin films of materials in recent years has greatlyinterest of material scientists due to discovery of new device applications inindustry and medical science. CuInSZ was chosen because the constituentmaterials are plentiful and easily obtained in the required purities.In the present work, a brief account about the equipment and thetechniques employed for the production of CuInSZ thin films by twomethods (chemical bath deposition and thermal evaporation under highvacuum) . This is followed by describing the procedure of measuring thecharacteristics of the films obtained by the above techniques. The -techniquesemployed for estimating the film thickness, the microstructure andopto electronic properties were given. The effect of heat treatment on theseproperties and the theoretical calculation of the relative intensity of thediffraction lines of CuInSZ films were studied. A comparison of theexperimental , ASTM and calculated -relative intensities show littledifference.The chemical deposition technique give x ray powder diffraction ofCuInSZ single phase with chalcopyrite structure. The film -thicknessincreased by increasing the number of runs in fresh solution. The x raydiffractogram of these films show a difference between thin and thick films.Thin films still amorphous or composed of very fine grains up to - 500 I(•The heat treated of these films (heating temperature - 673 I() show apronounced diffraction peak corresponding to the (I1Z) plane besides (013),(004) and (OZO) planes. These results indicate that the crystallinity of thefilms has been improved by the annealing treatment. While thick films(more runs) show peak of low intensity from the second phases CUS, In2S3besides a strong (112) plane for CuInS2 when heated at - 573 k.’ • But at hightemperature (- 673 k.’), only CuInS2 planes appeared. It was noticed fromall the x-ray diffractogram that, - 500 I(was required for heat treatment tocomplete convert the amorphous film to polycrystalline structure. In therange _ 500-700 k.’ the compound was stable, while at higher temperature >700 k.’ the films showed considerable degradation . The surface morphologyof the CuInS2 films of different thicknesses was investigated using scanningelectron microscopy (SEM). It was noticed (from the plates of themorphology) that by increasing the film thickness and also the annealingtemperature, the uniform distribution of the grains was observed.In comparison, thermal evaporation technique was used to prepareCuInS2 films from the constituent elements. The x-ray diffraction of thepowder show single phase CuInS2 with chalcopyrite structure. The filmsprepared from this powder show amorphous structure up to - 473 k.’. At hightemperature of

heat treat - 673 k.’ reveal (112) plane besides other planes ofchalcopyrite CuInS2. The scanning electron microscopy of these films showthat, the as-deposited films of different thickness demonstrate a small grainsand non-uniform distribution. The heat treatment of these films at differenttemperatures show an accumulation of grains or the grains are inlarged.The optical density and the corresponding transmission spectrum ofCuInS2 films were recorded over the spectral range from 300 _. 900 nmusing double beam spectrophotometer. The values of the refractive index,n,, absorption index ,k, absorption coefficient, a, and the optical energygap, Eg, were calculated from the transmission data of CuInS2 films whichdeposited from chemical and thermal techniques. It appears from the figuresof the thermal deposited specimens (non-heated) that, the optical band gapEg is dependent on sample thickness. By heating the samples at 623 I(and700 1(, the value of Eg is around 1.52 eV, which is less than the energy gapvalue of the non-heated layers. -But the optical energy gap of the chemicallayers is 1.496 eV for heated and non heated thick films (5 run). Thesevalues are lower than the values reported for the evaporated thin films.Electrical properties of CuInS2 films prepared by chemicaldeposition and thermal evaporation techniques were studied using directcurrent (d.c) and alternating current (a.c). The (d.c) measurements ofchemically deposited films show that, the films has low resistance (R) atroom temperature (1’). The variation of , R versus lIT was not stable forthe first heating run of measurement. Cooling run of the first run was notreversed on the same curve, the film resistance was increased as ”1’”decreased and a complete reaction was existed. The energy gap [Eg _ 1.55eV] was calculated, and was found to decrease as the film thicknessincreases.In contrast, thermal as evaporated films show a high resistance atroom temperature, the decrease of resistance with increasing temperaturefor the first run in a stable behaviour with two slopes. The energy gapcalculated from the high temperature region (intrinsic), Eg_ 1.5 eV. Areduction in resistance with cooling was achieved, the stable curve with oneslope yield an activation energy Ed - 0.6 eV. The heat treatment of films atdifferent temperatures show no difference with the cooling run i.e theelectrical properties of the film was changed by heat treatment.A.C measurements was used to obtain several electrical constantsof the solids, also, the equivalent circuit of the samples . The impedance/Z*I was studied as a function of the frequency ” f”, this study showsdifference between thin and thick films. The equivalent circuit for thesesamples were postulated. The imaginary part and real part of IZ*I; Z” andZ’ was also studied. In the same way the relations were also differesbetween thin and thick films. from these relations, ” Rg” , ” Cg” (the grainor bulk resistance and capacitance); ”Rgb”, ” Cgb ” (the grain boundaryresistance and capacitance) and other parameters could be calculated.