SUMMARY

The study of thin films of materials in recent years has greatly interest of material scientists due to discovery of new device applications in industry and medical science. $CuInS_2$ was chosen because the constituent materials are plentiful and easily obtained in the required purities.

In the present work, a brief account about the equipment and the techniques employed for the production of $CuInS_2$ thin films by two methods (chemical bath deposition and thermal evaporation under high vacuum) . This is followed by describing the procedure of measuring the characteristics of the films obtained by the above techniques. The techniques employed for estimating the film thickness, the microstructure and opto-electronic properties were given. The effect of heat treatment on these properties and the theoretical calculation of the relative intensity of the diffraction lines of $CuInS_2$ films were studied. A comparison of the experimental , ASTM and calculated relative intensities show little difference.

The chemical deposition technique give x-ray powder diffraction of $CuInS_2$ single phase with chalcopyrite structure. The film thickness increased by increasing the number of runs in fresh solution. The x-ray diffractogram of these films show a difference between thin and thick films. Thin films still amorphous or composed of very fine grains up to ~ 500 K . The heat treated of these films (heating temperature ~ 673 K) show a pronounced diffraction peak corresponding to the (112) plane besides (013), (004) and (020) planes. These results indicate that the crystallinity of the

films has been improved by the annealing treatment. While thick films (more runs) show peak of low intensity from the second phases CuS, In_2S_3 besides a strong (112) plane for $CuInS_2$ when heated at ~ 573 K . But at high temperature (~ 673 K), only $CuInS_2$ planes appeared. It was noticed from all the x-ray diffractogram that , ~ 500 K was required for heat treatment to complete convert the amorphous film to polycrystalline structure. In the range ~ 500-700 K the compound was stable, while at higher temperature > 700 K the films showed considerable degradation . The surface morphology of the $CuInS_2$ films of different thicknesses was investigated using scanning electron microscopy (SEM). It was noticed (from the plates of the morphology) that by increasing the film thickness and also the annealing temperature, the uniform distribution of the grains was observed.

In comparison, thermal evaporation technique was used to prepare $CuInS_2$ films from the constituent elements. The x-ray diffraction of the powder show single phase $CuInS_2$ with chalcopyrite structure. The films prepared from this powder show amorphous structure up to ~ 473 K. At high temperature of heat treat ~ 673 K reveal (112) plane besides other planes of chalcopyrite $CuInS_2$. The scanning electron microscopy of these films show that, the as-deposited films of different thickness demonstrate a small grains and non-uniform distribution. The heat treatment of these films at different temperatures show an accumulation of grains or the grains are inlarged.

The optical density and the corresponding transmission spectrum of $CuInS_2$ films were recorded over the spectral range from 300 — 900 nm using double beam spectrophotometer. The values of the refractive index,n, , absorption index , k, absorption coefficient, α, and the optical energy gap, E_g, were calculated from the transmission data of $CuInS_2$ films which deposited from chemical and thermal techniques. It appears from the figures of the thermal deposited specimens (non-heated) that, the optical band gap E_g is dependent on sample thickness. By heating the samples at 623 K and 700 K, the value of E_g is around 1.52 eV, which is less than the energy gap value of the non-heated layers. But the optical energy gap of the chemical layers is 1.496 eV for heated and non-heated thick films (5 run). These values are lower than the values reported for the evaporated thin films.

Electrical properties of $CuInS_2$ films prepared by chemical deposition and thermal evaporation techniques were studied using direct current (d.c) and alternating current (a.c). The (d.c) measurements of chemically deposited films show that, the films has low resistance (R) at room temperature (T). The variation of , R versus 1/T was not stable for the first heating run of measurement. Cooling run of the first run was not reversed on the same curve, the film resistance was increased as "T" decreased and a complete reaction was existed. The energy gap [$Eg \sim 1.55$ eV] was calculated, and was found to decrease as the film thickness increases.

In contrast, thermal as evaporated films show a high resistance at room temperature, the decrease of resistance with increasing temperature for the first run in a stable behaviour with two slopes. The energy gap calculated from the high temperature region (intrinsic), $E_g \sim 1.5$ eV. A reduction in resistance with cooling was achieved, the stable curve with one slope yield an activation energy $E_a \sim 0.6$ eV. The heat treatment of films at different temperatures show no difference with the cooling run i.e the electrical properties of the film was changed by heat treatment.

A.C measurements was used to obtain several electrical constants of the solids, also, the equivalent circuit of the samples . The impedance |Z*| was studied as a function of the frequency " f", this study shows difference between thin and thick films. The equivalent circuit for these samples were postulated. The imaginary part and real part of |Z*|; Z`` and Z` was also studied. In the same way the relations were also differes between thin and thick films. From these relations , " R_g" , " C_g" (the grain or bulk resistance and capacitance); "R_{gb}", " C_{gb} " (the grain boundary resistance and capacitance) and other parameters could be calculated.