Effect of Annealing on Structural Properties of $\text{In}_2\text{S}_3$ thin Film Prepared by PVD Method

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**ABSTRACT**

Indium Sulfide thin layers were produced by physical vapor deposition method on glass substrates at 70ºC and high vacuum condition and almost vertical deposition angle. Then produced layers were annealed at 400 ºC in presence of hydrogen gas. Crystalline structure were investigated by XRD and SEM analysis. By annealing process clusters produced and Columnar crystals configure on surface. Also crystal structure changes from tetragonal to cubic in presents of annealing process.

INTRODUCTION

$\text{In}_2\text{S}_3$ is an $n$-type semiconductor that belongs to the III–VI group of compounds. Depending upon synthesis temperature and pressure, it exists in three crystallographic phases such as $\alpha$, $\beta$, and $\gamma$. Among these phases, $\beta$-$\text{In}_2\text{S}_3$ is the most stable phase at room temperature. Amorphous $\text{In}_2\text{S}_3$ films on glass substrates have also been obtained by physical vapor deposition (PVD) [1], thermal evaporation [5] and rf sputtering [4].

Experimental part:

Indium sulphide layers were deposited on glass substrates (18*18*1 mm, cut from microscope slide) by using resistive evaporation method, from tungsten boats, at 70ºC temperature. The evaporation material was powder with 90% purity. An ETS 160 (vacuum evaporation system) coating plant with a base pressure of $10^{-5}$ mbar was used. Prior to deposition, glass substrates were ultrasonically cleaned in heated acetone first and then in ethanol. The substrate holder was a disk of 36.5 cm in diameter with adjustable height up to 45 cm and also adjustable holders for placing and kind of substrates, deposition angle was almost vertical. The structure of these films were studied by using a Philips XRD analysis and morphology was studied by SEM analysis.

RESULTS AND DISCUSSIONS

$\text{In}_2\text{S}_3$ thin layers were produced by physical vapor deposition method on glass substrates at 70 ºC.

Figure 1 shows the scanning electron microscopy of $\text{In}_2\text{S}_3$ glass thin layer produced by PVD method at 70ºC and high vacuum condition and almost vertical deposition angle. As it can be seen surface is full of tiny $\text{In}_2\text{S}_3$ grains with voids between them that is in agreement with zone 1 of structural zone model[6]. Figure 2
shows the scanning electron microscopy of In$_2$S$_3$/glass thin layer thin layer annealed at 400ºC in presence of hydrogen gas. As it can be seen grains coalescences and clusters of indium sulphide produced. Columnar crystals configure on surface that is in agreement with zone II of SZM, also that is a reason for zone II, that is in agreement with our results in figure 2.

Figure 3 shows the XRD pattern of In$_2$S$_3$/glass thin layer thin layer produced by PVD method at 70ºC and high vacuum condition and almost vertical deposition angle. As it can be seen there is only a small peak corresponding to (103) reflection observed in films, which is correspondence to tetragonal structure. The (311) reflection as preferred orientation which depends to cubic crystallite can be seen in In$_2$S$_3$/glass thin after annealing at 400 ºC in presence of hydrogen gas (fig3b).

Conclusions:

In$_2$S$_3$ thin films were produced by physical vapor deposition method on glass substrates at 70ºC and high vacuum condition and almost vertical deposition angle. Then deposited layer were annealed at 400 ºC in presence of hydrogen gas. Crystalline structure was investigated by XRD and SEM analysis. By annealing layers at 400 ºC In$_2$S$_3$ grains coalescences and clusters of indium sulphide produced. Columnar crystals configure on surface. Annealed layer exists in two crystallographic phases of $\alpha$ and $\beta$ corresponding to cubic and tetragonal structure.
Fig. 3: XRD pattern of $\text{In}_2\text{S}_3$ films produced by PVD method a) as-deposited, b) annealed at 400 °C.

REFERENCES


