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Morphology Characterization of InSb Films and Correlation with Optical Properties

KEYWORDS: InSb morphology, optical properties, crystal growth, energy gap

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ABSTRACT *Polycrystalline InSb alloys have been prepared an evacuated quartz tube, the InSb films deposited by flash evaporation technique on different substrates like c-Si and glasses. Our experimental data showed that the crystal structure is transition from amorphous to crystalline phase with different stage depending on annealing temperature and film thickness.*

The values of energy gap increases from 0.15 eV to 0.18 eV with increasing Ta from 27 °C to 200 °C for thickness 0.5 μm and not sensitive for more 0.5μm . This variation is thought to be due to changes in degree of crystallinity and phase transition of the films structure.

Introduction:

In modern thin films technology for infrared detectors the main problem is to find a method of producing semiconductor films which exhibit similar electronic transport and structural properties to the bulk materials [1]. Numerous studied have been devoted to study of morphology and optical properties of crystalline InSb, because of their many application in devices e.g. semiconductor laser , infrared detectors, etc[2,3],on the other fewer studies have been devoted to a-III-V compound and as far as we know, no one has studied InSb in the amorphous form.

In this paper we reported the preparation and study of surface morphology and optical band gap of InSb films which deposited by flash evaporation , the previous work have been performed on crystalline InSb prepared by various techniques, r.f sputtering[5],molecular beam epitaxy [6]and flash evaporation [7]. The technique of flash evaporation and deposition of the compound III-V since the materials is evaporated quickly; the decomposition of the compound is minimized. Little information available on the morphology and optical properties of annealed films of InSb with different thickness deposited onto glass substrates [7,8]. The purpose of this paper is to present experimental results on surface morphology and optical properties of as deposited and annealed films of InSb obtained by using the technique of flash evaporation.

Experimental procedure:

InSb polycrystalline alloy have been prepared in an evacuated quarts tube by rotary stage pump, the tube were continuously rotated and rocked during the reaction to insure homogeneity. Alloy were reacted for (5h) at 550 °C and then quenched into cooled water, Fig(1) show XRD pattern of InSb alloy.

InSb films were prepared by flash evaporation in vacuum about 2*10-5 mbar using Balzars coating unit model BA 370 with an arrangement for flash evaporation, the thickness of the films in range (0.25-1)μm was measured by quartz crystal monitor and optical method . The details of the deposition system are given in ref.[9].

The substrates were corning glass and c- Si which are cleaned as described in ref.[7,9]. The surface morphology for as- deposited and annealed InSb films with different thickness have been examined by optical microscopy. The optical energy gap (E_g) was measured by using Lambda-9 Parkin-Elemer 330 Spectrometry, the value of Eg were deduced by fitting α (absorption coefficient) to the tauc relation:

$(\alpha h\nu)^r = B(h\nu - E_g)$

Where hν is photon energy and B is a constant depending on composition

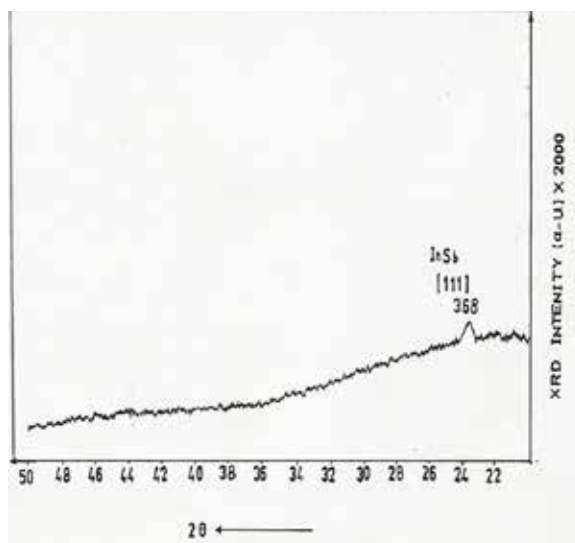

Fig..1 XRD of InSb alloy

Results and discussion:

I-Surface Morphology:

The optical micrograph of as-deposited InSb films exhibited a mirror surface as shown in fig.(2) for all samples with different thickness. These results are confirmed by XRD which reported by ref.[7] and agreement with previous studied observed by Masaaki et.al.[8]. These results appeared the amorphous or random orientation of InSb films and contain a small white spots may be act in precipitates, similar observation is shown by X.Liu et.al.[10].

Fig.(3) show the optical micrograph of InSb films annealed at T_a=100 °C with thickness 0.5 μm , from this figure we can see initial stage of recrystallization of large randomly oriented dendrites of InSb films as shown in ref.[10].

The dependence of surface morphology on film thickness (0.5-1) μm as shown in fig.(4,a-b), the increase of thickness lead to formation of islands for thickness 0.5 μm. While for thickness 1μm the island disappear and formation continuous layer and appear a mosaic surface , similar results have been reported by ref.[8,10].

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Fig.(5) illustrate the optical micrograph for films annealed at T_a= (150-200) °C with thickness 1µm, we can see the surface have crystal at growth of a random aligned dendrites with Nano crystallites have a preferential crystallography orientation, this results indicated to form nearly a homogeneous surface and this data prove that the quality of surface morphology for InSb films is improvement with annealing. Similar to the case of a-GaAs films prepared by r.f sputtering reported by Baker et.al.[11].

II. Tauc energy gap E_T:
The optical energy gap E_T was determined from Tauc law (equation 1).

Tauc plots obtained from experimental data as shown in fig.(6) which are displayed in fig.(7) for as deposited and annealed films. From fig.(7) we can see the value of E_T increases from 0.15 eV to 0.185 eV for as- deposited and annealed temperature at T_a= 200 °C, this compares favorably with values obtained by others for InSb films prepeared by ref.[12,13]. This variation in E_T with T_a indicates to occur phase transition from amorphous to crystalline structures and E_T considerable the bulk value when the samples were crystallized.

The thickness dependence of E_T as shown in fig.(8) . It can be seen that the value of E_T increases with increases the thickness in the range 0.25 µm to 0.5 µm, but for more than the value of E_T become nearly constant and on the other word the Tauc energy is not too sensitive to large value of thickness. This behavior may be explained in term decreases or wrong bands and eliminated the associates states from the gap and improvement the surface morphology [11,13]. While for higher thickness the value of E_T is weakly dependent is because occurrence the stable in crystal structure which lead to form continuous surface morphology of layer, thus we are in agreement with report polished by Islam [14,15]. Finally our experimental data indicates to direct transition in optical gap for InSb films and the variation of $(\alpha h\nu)^{1/2}$ against (hν) offers the best fit to the optical absorption data.

Conclusions:
The experimental result show that the film deposited on c-Si and glass substrate at room temperature are amorphous surface and as-deposited films annealed at 100 ° C and 200 °C are a mosaic surface and initial stage of crystal growth contain nano crystallites have a nearly homogeneous surface .

The optical energy gap strongly dependence on annealing temperature and thickness this connected with change in crystalline of films, and the nature of transition in InSb films prepared by flash evaporation are direct.

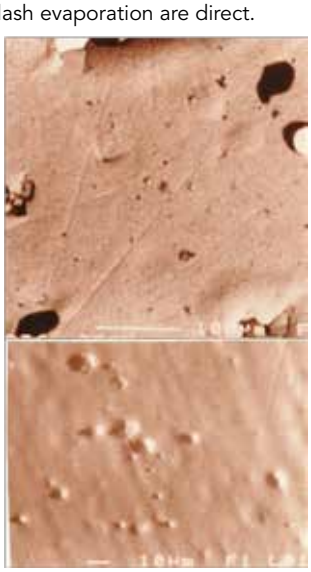

Fig.2: Optical micrograph of as-deposited InSb films

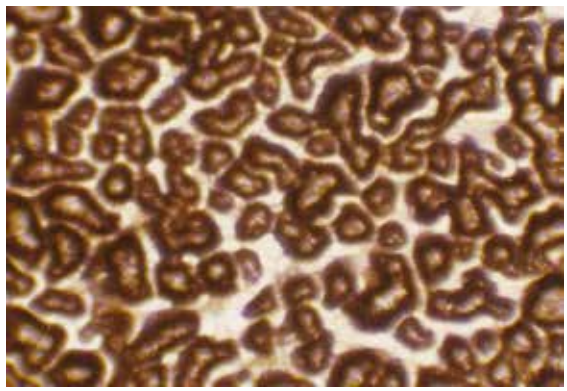

Fig.3: Optical micrograph of InSb films with T_a= 100 ° C

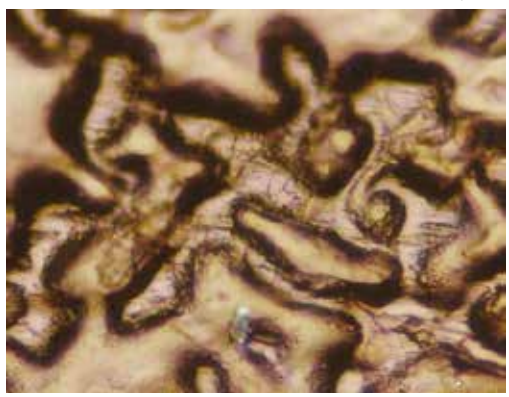

Fig.4(a): Optical micrograph for 1µm InSb films

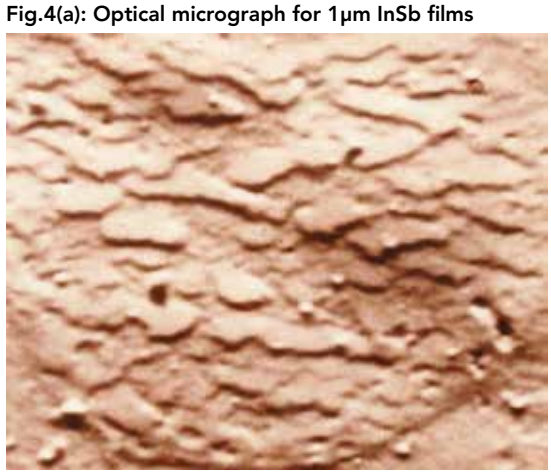

Fig.4(b): Optical micrograph for 0.5µm InSb films

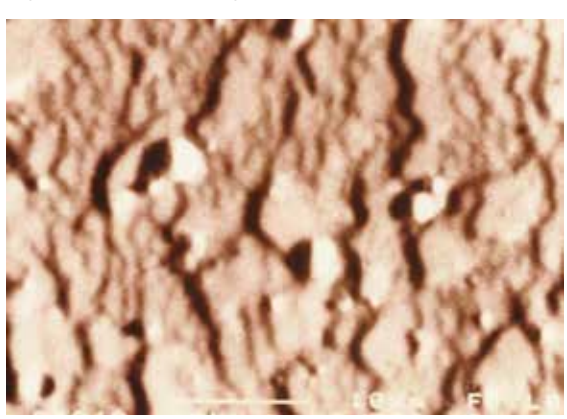

Fig.5: Optical micrograph for InSb films with T_a= 150 °C

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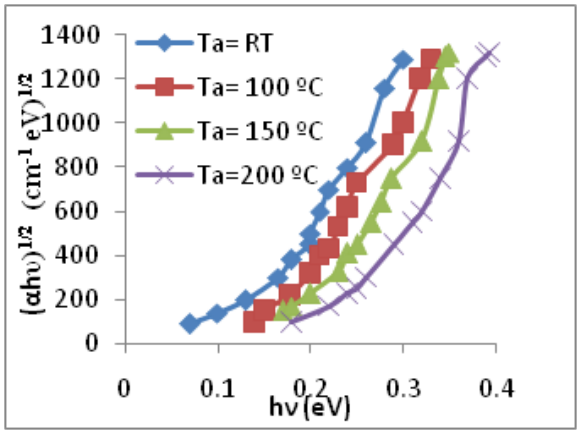

Fig.6: Tauc plots of InSb films with different T_a

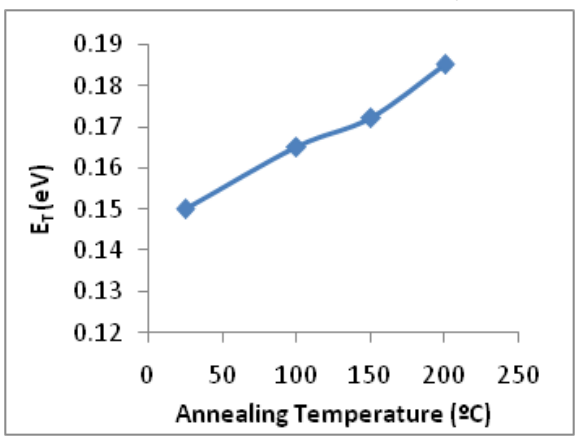

Fig.7: Variation of E_T with annealing temperature

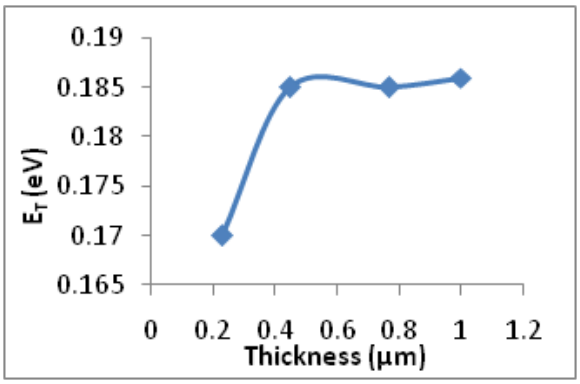

Fig.8: Variation of E_T with films thickness

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