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X-RAY DIFFRACTION STUDIES OF COBALT CHLORIDE DOPED GaAs & Ge MULTILAYER THIN FILMS

CHANDRA KUMAR DIXIT[1] & A. K SRIVASTAVA[2]

[1]Dept. of Physics, Feroze Gandhi Institute of Engineering & Technology, Raebareli, Uttar Pradesh, India

[2]Physical Research Laboratory, Kamla Nehru Institute of Physical and Social Sciences, Sultanpur, Uttar Pradesh, India

ABSTRACT

Germanium doped with cobalt chloride has been grown by electron beam evaporation, having the thickness of layers of gallium arsenide and germanium as 7nm, the two layers systems (thickness 14nm) have been prepared on different substrate temperatures (Ts= 273 K,300 K and 350 K) in the high vacuum 5×10^{5} torr. The X-ray diffraction study of the films represents amorphous nature of lower deposition temperature but polycrystalline at higher deposition temperature. The film deposited at lower temperature were annealed film also behaves polycrystalline as film deposited at higher substrate temperature.

KEYWORDS: Dielectric Properties, X-Ray

INTRODUCTION

We investigate the structure of doped GaAs and Ge multilayer's in both annealed and as deposited state. X-ray diffraction is used to determine the crystal structure of the layers. Prepared samples are sometimes amorphous and sometimes crystalline depending on evaporation rate, mainly doped on layer thickness less than about 10 atomic planes of each constituent per layer. Amorphous phase has also been observed in the case of GaAs/Ge multilayer, due to their thinner (7nm) layer thickness of each layer. This has also been observed in multilayer, due to their thinner (7nm) layer thickness of each layer. This has also been observed in multilayer's pairs, where the large atomic structure mismatch produces epitaxy between the layers. Absences of large range crystalline order are even observed at small layer thickness and low temperature, where at large thickness or at higher temperature the interface is crystalline[1-4].

In this paper we report some of our results as deposited and annealed effect of GaAs and Ge doped multilayer thin films. Which are prepared with equal numbers of closed packed planes of GaAs and Ge. Therefore these films are given a post deposition annealing treatment at different temperatures in a vacuum 5×10^{5} torr. X-ray diffraction is used to characterize the film (amorphous. Crystalline or polycrystalline).[5-7]

EXPERIMENTAL METHODOLOGY

Multilayer thin films samples consist alternate layers of cobalt chloride doped GaAs and Ge. The thickness of 14 nm was prepared by electron beam evaporation of GaAs and Ge, 99.999%, purity used on optically pyrex. plane photographic glass substrate of dimension 2.5cm×7.5cm×2mm, under the vacuum of reduced pressure (10^{6}torr). The films are prepared at different substrate temperatures. 273 K, 300 K, and 350 K. An ultrahigh cleaned graphite crucible was kept on water cooled platform the material was placed in the crucible to evaporate material. Power of the electron beam was carefully controlled and optimized so that the dissociation of the material in its constituent, before deposition could be prevented. In our case optimized beam power was 500 watt. Rate of deposition, calculated from the thickness and total time of deposition as $5A^{0}S^{-1}$. Tape water was circulated around the metal chamber (inside which vacuum was maintained),

to prevent excessive heating of substrate during the electron beam operation. Films of GaAs and Ge deposited at 300K temperature were annealed in vacuum at the temperature 373K, 473K and573K for one hour each to observe poly-crystallization of amorphous films.

X-ray diffraction was performed in symmetric reflection geometry when the scattering vector is perpendicular to the plane of the sample, and symmetric transmission geometry when the scattering vector lies in the plane of the sample. The later experiments were performed on sample deposited on kept on, whereas the performer were performed on both the oxide and kept on. Substrate with no difference observed between the samples on the two different substrate, in symmetric reflection geometry, the substrate of the sample is probed in the diffraction (Cu-Kα) of the growth. The layer structure, of these films were determined by x-ray diffraction. Large Angle (20^0-70^0 20) X-ray diffraction in the Bragg's Brentano geometry was used to characterize crystallinity respectively. Monochromatic Cu-Kα (λ=1.54 A^0) x-ray from a rotating anode generator was used[7].

RESULTS AND DISCUSSIONS

Multilayer structure has been determined by a large angle (20^0-70^0 20 λ=1.54 A^0) x-ray diffraction patterns. To study the effect of substrate temperature, the x-ray diffraction measurements have been carried out on multilayer film deposited at 273K, 300K, and 350K of 14nm thickness respectively and is shown in Fig.1. The films are found to be sometimes amorphous and sometimes crystalline, perhaps depending on the substrate temperature of the film. When they are deposited at less than 300K as shown in fig. spectrum is amorphous. Thinner film tended to amorphous at lower temperature. This statement is further supported by the observation different workers [8-11]. Film deposited at 350 K is found to be crystalline in nature along the peak intensity direction as shown in Fig. 1.We see that films deposited at higher temperature have better crystallinity. The intensity for the various plane were estimated by measuring peak heights directly on diffractometer chart as shown.

To study the annealing effect on the crystalline properties of the multilayer film it was performed in vacuum (5×10^{-3}) for one each hour. The annealing is carried out from as deposited to 573 K in steps of 100K.It is conspicuous from Fig.2. That the structural properties of the film deposited at 300 K. Films annealed, at as deposited to 373K show amorphous structure as shown in fig. On increasing the annealing the temperature up to 473 K, some peaks are observed. Again increasing annealing temperature to 573 K peak intensity increase as shown in Fig.2. and shows a clear polycrystalline GaAs/Ge multilayer film.

CONCLUSIONS

GaAs multilayer thin film has been successfully fabricated using electron beam deposition technique on photographic pyrex glass substrate at different substrate temperature (T_S) and of different thickness. The multilayer thin films have been annealed in vacuum (5×10^{-5} torr) for 1 hr as deposited to 373 K, 473K, and 573K respectively. Further systematic x-ray diffraction investigations give more information about the dislocation densities, especially their time dependence. The layer structure has been confined by large angle 20^0-70^0 20 x-ray diffraction studies.

The studies show that the film thickness of 14nm and deposition temperature at 350 K gives better polycrystalline nature. It is also concluded from x-ray diffraction studies that the crystalline of the film increases film thickness. The annealing study shows that stoichiometry of the film changes at low temperature. Hence crystallinity also increases with annealing temperature.

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APPENDICES

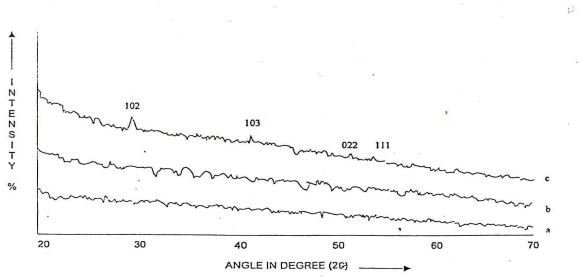

Fig.1: X-Ray Diffraction Pattern of Cobalt Chloride Doped GaAs and Ge Multilayer Thin Film of Thickness 14nm Deposited at Different Substrate Temperature (T_S): (a) T_s=273 K (b) Ts= 300K and c Ts=350 K

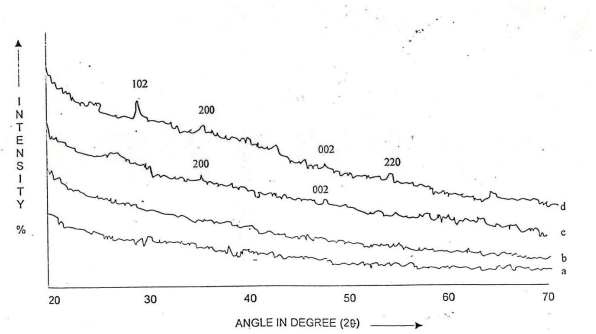

Fig.2: X-Ray Diffraction Pattern of GaAs and Ge Multilayer Thin Film of Thickness 14nm Deposited at 300K, Annealed One Hour in Vacuum 5×10^{-5} torr at Different Temperature (T_S): (a) T_s=373 K (b) Ts= 473K and c Ts=573 K