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Growth features and band gap determination of InBiSb long wavelength infrared photo detectors

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Ternary (InBiSb) compound widely used as long wavelength infrared photo detectors. InBiSb crystal were grown by Bridgman technique with temperature gradient of 60 ˚C/cm and the growth velocity 0.5cm/hr.The different growth features were observed on top free surface of the InBiSb single crystal which is predominant of layers growth mechanism. Later on, the crystal pellets were used for FourierTransformInfraRed measurement in wavelength range 2.5-25µm which gives band gap of the bulk crystal. The results were discussed and reported in detail.

Key Words: Crystal growth, layer structure, energy gap

INTRODUCTION

InBiSb are widely used for the long wavelength infrared detector attain cut-off wavelength (8-12) µm [1-4]. Long wavelength photo detectors operating at room temperature widely used for many military and civilian applications [5]. III-V ternary is expected to be better than II-VI, HgCdTe system because it suffer from thermal instability and poor compositional uniformity over large area due to high Hg vapour pressure and weak Hg bond. InSb and several its solid solution offers range of well-developed infrared detector materials are used to detect 3-5µm wavelength [6]. Extension of cut-off wavelength λ_c beyond 8µm appears feasible if we incorporate Bi into InSb. A.M.Jean-Louis and C.Hamon [7] works on bulk crystals indicated that of Bi has equilibrium solubility of 2.2% in InSb which moves λ_c (77 K) from 5.5µm to 8.3µm (the 2.2% represents the maximum bulk solubility limit).The data indicate that a small increase (up to 3.5%) in solubility would yield material responsive to wavelengths close to 12µm. In this paper we are discuss about growth feature on top free surface of as-grown crystal which is responsible for growth mechanism. The infrared transmission measurements were performed using a FTIR with the spectral range of 2.5-25 µm.

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EXPERIMENTAL

For the growth of InBiSb a Bridgman-set-up is used. In this technique the raw materials InBi and Sb, of 5N (99.999%) purity were used for preparation of the compound. These materials are weighted in stoichiometric proportions and sealed under the vacuum of the order of 10^{-5} torr in quartz ampoule. [8]. InBiSb single crystals were grown under the temperature gradient of 60 °C/cm with the growth velocity of 0.5cm/hr. Using optical microscope, some interesting features observed on the top free surface of the as grown crystals were observed. For IR measurement, now solid sample is grind and mixed with KBr fine powder. This powder mixture is then placed in a mechanical dye to form a pellet, which can be placed in front of IR beam of the range of 2.5-25μm wavelength gives the absorption spectra. Using spectral analysis, the energy gap of the bulk material were discussed.

RESULTS AND DISCUSSION

In the present case, the striations were observed on the as grown top free surface of almost all the crystal. However it is noteworthy that their appearance is more conspicuous in the case of crystals grown by Bridgman method. A typical example is shown in fig-1. These are striation on the top free surface of as grown InBiSb single crystals at 0.5cm/h growth velocity. These striations were observed to be perpendicular to the crystal ingot axis. They are well spread over the surface of the crystal with concentric square in shape. They are parallel and nearly equally spaced indicating crystallographic associations. In this regard it is possible that some crystallographic plane like {111} may be responsible for these features. Stereographic method based on three trace analysis suggested by Reed – Hill[9] was employed to determine the direction of the edges and the indices of the planes responsible for these edges were obtained. It was found that the edges had the direction {110}, {101}, and {011} and the planes were of {111} family. This is because the layer growth mechanism has been dominance in these crystals. Fig-2 shows sharp undistributed edge lines of a surface ridge observed on the top free surface of the crystals. These lines are developed parallel to the growth axis. They are perpendicular to each other. From these observations it should be noted that the discrete substructures observed on the top free surface of the crystals.

The plot of $(\alpha h\nu)^2$ versus $h\nu$ were used to evaluate the optical band gap. Where α = absorption coefficient and $h\nu$ = photon energy. The plot is shown in fig.3 for the bulk material. The plot is observed to be straight line in the region of high absorption. The extrapolating of the linear portion to zero abscissa gives the band gap[10-11] for InBiSb crystal, which are plotted from analysis of FTIR absorption spectra of a given sample. From this we found that the direct band gap of the sample InBiSb was 0.1083 (~ 0.11) eV.

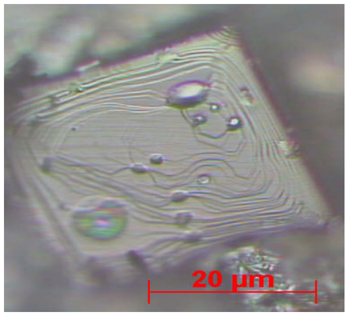

Fig-1 Layered Striations observed on the top free surface of InBiSb crystal

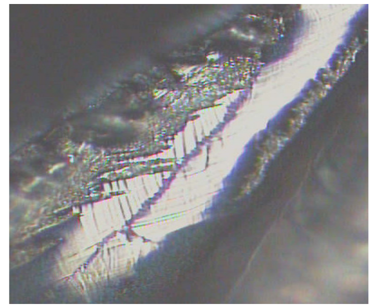

Fig-2 sharp undistributed edge lines of a surface ridge

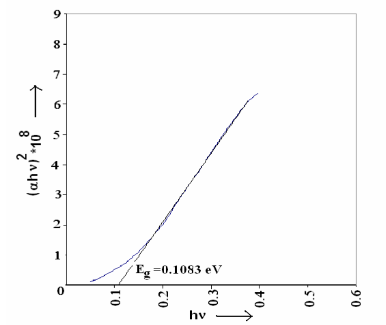

Fig-3 Plot of $(\alpha h\nu)^2$ v/s hν

Conclusions

A Growth feature represents the predominance of layer growth mechanism in the InBiSb crystals. The optical direct band-gap of the bulk material has been found to be nearly equal to 0.11eV.

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