Abstract

Recently there has been extensive interest in infrared detectors operating in the 8-12μm wavelength region where minimum atmospheric absorption is present. The atmosphere has clear transmission windows in the MWIR and LWIR bands, making it very attractive for terrestrial applications. Covering the near infrared (IR) region becomes important for military as well as for industrial control, medical diagnostics and other civilian needs.

Usually the more developed III-V materials are preferred over group II-VI low band gap semiconductors and play major role in development of detector technology. This is because group III-V semiconductors exhibit very useful and tunable physical properties. Study of Sb based semiconductors has been very much carried out by researchers. InSb, among the III-V semiconductors, has sufficiently narrow band gap suitable for the said application. It crystallizes into the zinc-blende structure. It has a band gap 0.18 eV and its melting point is ≈ 527 °C. By doping Bi in InSb the band gap can be reduced by fair margin. This would make single crystals of $InSb_{1-x}Bi_x$ useful in various detectors. Hence the band gap of single crystals of $InSb_{1-x}Bi_x$ was taken up in this study.

Chapter 1 gives a general introduction to the basic background of the present work and importance of the thermoelectric materials and their applications. A brief survey of earlier work reported on growth and micro hardness of the crystals (InSb in particular) is given. It also includes reports on optical and electronic properties of these materials.

Chapter 2 deals with the experimental techniques used in the present work. The techniques include the crystal growth, thin film preparation, thermoelectric power measurement, optical microscopy, hardness measurement, optical band gap and I-V characteristics measurements.

Chapter 3 deals with the results of growth of $InSb_{1-x}Bi_x$ single crystals. The crystals were grown using Bridgman-Stockbarger method. Various methods of crystal growth in general and of crystal growth from melt in particular have been discussed. Fairly large good quality crystals of $InSb1_{-x}Bi_x$ were obtained with the Bridgman-Stockbarger technique. EDAX analysis shows that the crystals obtained were stoichiometric and homogenous. The X-ray diffractrometry indicates substitution of Sb by Bi in the InSb structure. The thermoelectric power and the band gap of crystals were evaluated. The band gap obtained of $InSb_{1-x}Bi_x$ crystals was about 0.16eV (direct band gap). There are no observable indirect transitions in the crystals.

Chapter 4 deals with hardness studies on $InSb_{1-x}Bi_x$ crystals. The variation of hardness with applied load has been studied in detail. Particularly, the observed complex low load dependence of hardness has been explored. The results indicate that the hardness peaks obtained in the low load range may be explained in terms deformation induced coherent regions. Micro hardness is a load dependent quantity and the variation is quite prominent in the low load ranges, while only for sufficient high applied loads it becomes virtually independent of load. The peaks observed in H_v versus load (P) plots may be explained in terms of deformation induced coherent regions. The indentor penetration through surface region work hardens the crystal and due to work hardening, as the penetration progresses with increasing load, the crystal hardness increases. Only in the interior of the crystal the work hardening saturation prevents hardness from increasing and saturates the hardness to true bulk value. The Mayer index is not truly constant but may be different in various load ranges.

Chapter 5 discusses the results on optical band gap of $InSb_{1-x}Bi_x$ Crystals and thin films. This also includes the effect of film thickness on optical band gap. The results are discussed invoking the size effect operative in the thickness range used. At smaller thickness the band gap is larger than the bulk values. The film thickness dependence of the band gap of $InSb_{1-x}Bi_x$ indicates the optical transition to be governed by quantum size effect within the thickness range studied. To study the behaviour of grown thin films of $InSb_{1-x}Bi_x$ under different light conditions, the I-V characteristics were carried out. The behaviour in dark and illuminating condition were also studied. It is observed that current increases in fairly good amount in the illuminating condition compare to the dark condition. The I-V characteristics and photo-response results were obtained for the $InSb_{1-x}Bi_x$ thin films.