Abstract

The semiconductor and thermoelectric materials have been the two most promising research areas in the last century for physicists and the electronic industry. The advancements in science and technology of materials have made it much simpler to create and enhance new materials. Semiconductors always offer wide scope of research due to their various applications because of their characteristics. This enables tayloring the functionality of various devices based on these materials.

There is a good amount of work done to develop materials for Infrared (IR) detectors using narrow gap semiconductors. The materials in this study correspond to the group III-V compounds which have narrow band gaps. A large number of researchers worldwide are working on group III-V semiconductors especially on semiconductors with a small band gap. In recent years, growth of III-IV group pseudo binary crystals has increasingly become a subject of significant research in view of demands of IR technology. Various narrow band gap materials are not only good IR detectors but are also useful for thermoelectric devices. Materials including n-type $Bi_2(Te, Se)_3$ and p-type $(Bi, Sb)_2Te_3$ have emerged to be subject of improving their figure of merit (ZT) values through structural and compositional modifications.

Among the pseudo binaries of interest, in the present case, $InBi_{1-x}Te_x$(x = 0, 0.05, 0.10 and 0.15) have been the least studied in this respect and in view of demands of IR technology. As a detector material InBi/InSb system is nonhazardous and suitable for narrow band gap applications as in IR optical devices.

Chapter 1 gives a general introduction to the basic background of the present work and importance of the optoelectrical materials and thermoelectric materials and their applications. It also includes reports on optical, electronic and mechanical properties of these materials. Thus based on literature survey, this chapter describes the present status of research work going on in the field of crystal growth and characterization of these and the like materials. This chapter also explains the objectives of present research problem.

Chapter 2 deals with the experimental techniques used in the present work. The techniques include the crystal growth, XRD, EDAX, FESEM, FTIR, thermoelectric power measurement, optical microscopy, hardness tests, optical band gap and Hall Effect measurements.

Chapter 3 deals with the results of growth of $InBi_{1-x}Te_x$(x = 0, 0.05, 0.10 and 0.15) crystals. Various methods of crystal growth in general and of crystal growth from melt in particular have been discussed. Fairly large good quality crystals of $InBi_{1-x}Te_x$ (x = 0, 0.05, 0.10 and 0.15) were obtained with the zone melting method at growth rate of 0.3cm/hr and temperature gradient around 45˚C/cm. In this growth technique, the growth velocity was varied also and it was found that increase in growth velocity decreases the crystal perfection. Hence the growth velocity was optimized to yield good quality crystals useful for characterizations. EDAX analysis shows that the crystals obtained were stoichiometric and homogenous. The X-ray diffractrometry indicates substitution of Te by Bi in the InBi structure. Using FESEM Color mapping of $InBi_{1-x}Te_x$(x = 0, 0.05, 0.10 and 0.15) crystals has been studied.

Chapter 4 This chapter includes study of optical properties of $InBi_{1-x}Te_x$ (x = 0.05, 0.10 & 0.15) crystals using absorption spectra obtained using FTIR spectrometer. The value of optical band gap is calculated from the plots of $(\alpha h\nu)^{1/2}$ vs. hν for all crystals. This chapter discusses the results of optical band gap of crystals of $InBi_{1-x}Te_x$ (x = 0.05, 0.10 & 0.15). The band gap obtained of $InBi_{1-x}Te_x$ (x = 0.05, 0.10 & 0.15) crystals was about 0.2 eV (direct band gap). There are no observable indirect transitions in the crystals. Thermoelectric power has been measured and described in this chapter. Transport properties, namely, Hall coefficient, mobility and carrier concentration have been measured using Hall Effect under different applied magnetic fields. The results obtained from the study of $InBi1_{-x}Te_x$ (x = 0.05, 0.10 & 0.15) crystals are presented here.

Chapter 5 deals with hardness studies on $InBi_{1-x}Te_x$ (x = 0, 0.05, 0.10 & 0.15) 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. The hardness values of $InBi_{1-x}Te_x$ (x = 0, 0.05, 0.10 & 0.15) single crystals have been obtained on average about 115 MPa. Microhardness is a load dependent quantity and the variation is quite prominent in the low load range, 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 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 in the applied load-indentation diagonal length is not truly constant but is found to be different in various load ranges. Though there is applied load dependence of hardness observed but the bulk hardness is found to be quite independent of the applied load. In the cold-worked crystals, the load independent hardness value significantly increases in the case of the as-cleaved samples. In the annealed sample, the load independent hardness value is less than that of the as-cleaved sample. The annealing treatment very significantly improves perfection of all the crystals.

Future Scopes:

This chapter gives an overall view of the possible future work that may be carried out on the crystals.