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Experimental Studies on $InBi_{95}Sb_{05}$ Single Crystal Growth Using Melt Growth Technique

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Abstract: *The Crystal $InBi_{95}Sb_{05}$ is successfully growth using Melt Growth Technique.The Crystal perfection can be said to be good Since Cleaved very easily. Thus it has been found out that InBi crystal converts from metallic conductor to a narrow gap semiconductor with addition of Sb.*
Index Terms: *single crystal, melt growth technique, Indium, Antimony, Bismuth*.

I. Introduction

To grow large single crystals of metals, alloys and semi-conductors, the most widely used methods is growth from melt. Crystal growth from melt carries maximum theoretical importance, also since it is directly the process of phase change from liquid to solid involving systematic aggregation of atoms or molecules into crystalline order from their random distribution in liquid state of the same substance.The basic principles of the crystal growth from melt are based on cooling of a liquid to solidification in a controlled manner. The process of solidification so controlled as to promote extension of single nucleus without producing new nuclei and with minimum of nuclei. Instability of the growing surface can be eliminated by avoiding extensive zone of super-cooling in the melt. Heat transport in the solidification process plays a vital role in the success of growth. Basically the method involves transfer of heat through the solid liquid interface.

II. Crystal Growth From Melt

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III. Crystal Growth Of $InBi_{95}Sb_{05}$

In the present work In-Bi-Sb alloy crystals containing 100 atomic % of In, 95 atomic % of Bi, 5 atomic % of Sb were grown from melt by zone melting method.The radii of In and Bi both fall within ±8% of the radius of Bi. (Sb 7.7% smaller and In 7.7% larger) Hence the alloy is expected to be a substitutional solid solution. And, just as the Bi-Sb is a continuous solid solution, the ternary alloy with In also may be a continuous solid solution. Thus expectedly there may not be any lattice distortion due to presence of Sb in InBi.

Further, InBi and InSb exist as equilibrium compounds. So Sb would substitute Bi in InBi. Indium, Bismuth and Antimony each of 99.999% purity were purchased from Nuclear Fuel Complex, Hyderabad India. The stoichiometric amounts($InBi_{95}Sb_{05}$: 2.55151 gm In, 4.4118 gm Bi and 0.13528 gm Sb) of the materials were weighed accurately up to 10 micro grams using a semi microbalance and filled in a quartz ampoule of about 8 cm in length and 1cm in diameter.

The quartz tube was then vacuum sealed at a pressure of about 0.8×10^{-5} torr and it was kept in alloy mixing furnace.

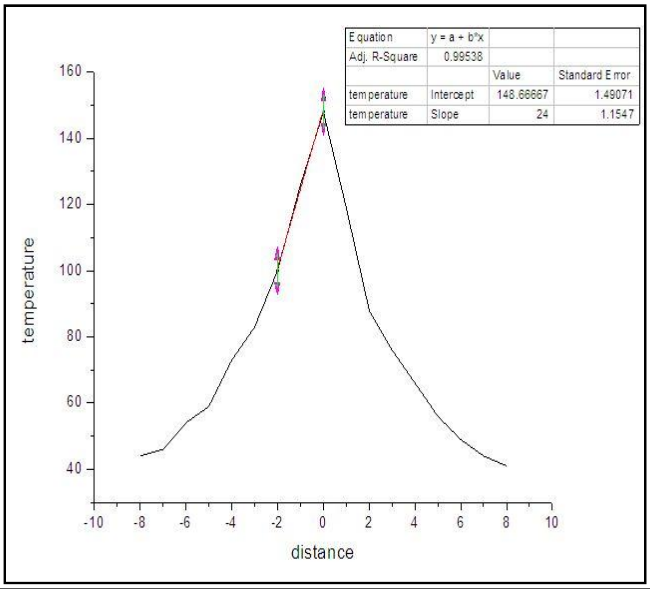
In this mixing unit, the material was mixed in the molten state for about 48 hours by rotating the tube at 2 rpm at 640^{0}C for thorough mixing. The rotation of the tube was stopped and the material was further kept in the molten state for further 24 hours in order to ensure homogenization and complete reaction in the molten charge. It was then slowly cooled to room temperature. This process usually produces fairly homogeneous compound. The ingot so prepared was subjected to growth by zone melting. It consists of resistance furnace with a cylindrical core of about 45 cm in length and 5 cm in diameter. A ceramic tube of 59 cm in length and 2 cm in diameter is passed through the cylindrical core. A uniform temperature zone of about 10-12 cm length is obtained inside this tube. The two ends of the tube are fitted to two brass sockets.

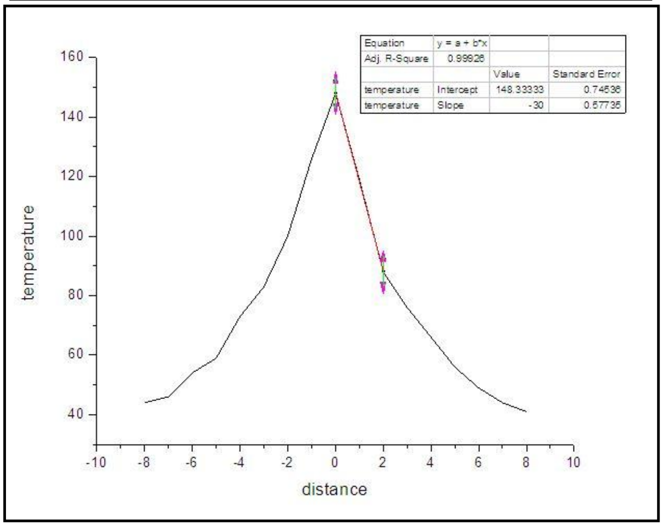
The sockets are pivoted on frictionless bearing for smooth motion without wobbling. The tube is rotated at 2 r.p.m. by an electrical motor. The ampoule containing the charge therefore is subjected to a rocking motion which would have stirring effect on the molten charge.

IV. Zone Melting Method

The apparatus consists of a long quartz tube about 103 cm in length and 2.5 cm in diameter. A ring or zone furnace is mounted on a trolley and the tube is passed through the furnace and clamped as its two ends. The motion of the furnace on trolley is controlled by a gear mechanism connected with a 0.5 H.P. Motor which moves the furnace at the rate of 0.6 cm/Hour. The vacuum sealed quartz tube containing the charge was then kept inside the long quartz tube. At a maximum temperature of$640℃$ in the furnace, an appropriate temperature gradient, viz, of about is obtainable at both the solid-liquid interfaces using this furnace. The 5 alternate pass of the furnace was given to the quartz ampoule.

V. Furnace Profile





Temperature gradient is $24℃/\mathrm{cm}$ on one solid-liquid interface and $30℃/\mathrm{cm}$ at the other interface. Molten-Zone length was 4-5 mm.

VI. single crystalline character of the crystals thus grown was asserted by Cleavage test as shown in photograph 1 and 2.

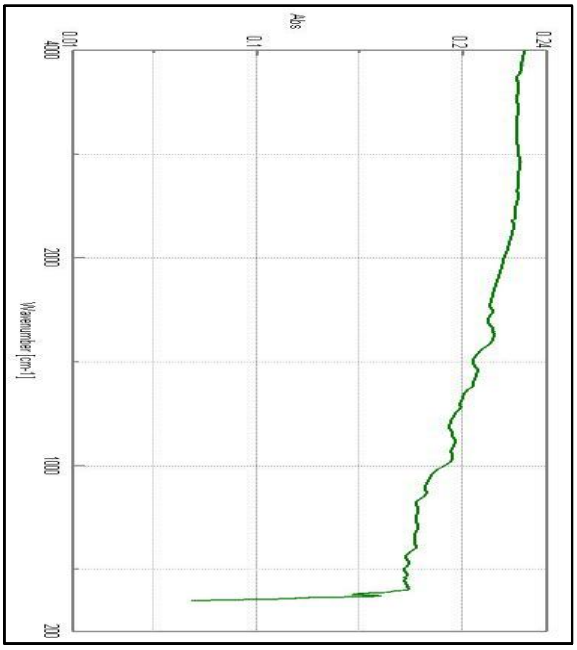
$InBi_{95}Sb_{05}$Single crystal grown during the project work

Photograph: 1

Photograph: 2

VII. Optical Band gap of $InBi_{95}Sb_{05}$

In this FTIR spectrometer a Sample is put in form of a pallet containing 95%KBr and 5% $InBi_{95}Sb_{05}$ and convert in to pallet by palletizer and finally we obtain the spectrum of Absorbance v/s wave number plot using FTIR as shown below.



From the figure we take corresponding values of Wave no. and Absorbance. By plotting a graph of hν v/s αhν*αhν as shown below and by extending the straight line we the band gap of$InBi_{95}Sb_{05}$.

VIII. Conclusion

By using FTIR spectroscopy of $InBi_{95}Sb_{05}$, the optical band gap was determined to be about 0.24 eV.Thus the InBi crystal converts from metallic conductor to a narrow gap semiconductor with addition of Sb.

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