CHAPTER - 4
GENERAL INFORMATION ON InBi
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The berthollide type intermetallic compound InBi was reported first time by Anosov et al\(^\text{(1)}\) in 1947 and subsequently by Giessen et al\(^\text{(2)}\) in 1967. It occurs at 50 at. % of each of the elements in the In-Bi system as indicated by the phase diagram in fig.1\(^\text{(2)}\). This equilibrium phase has a narrow homogeneity range\(^{(3,4)}\) and does not form any type of solid solutions with either Indium or Bismuth. Hence this alloy has been termed as a daltonide phase also (Makarov)\(^{(5,6)}\). One of the previous workers, Subinski\(^\text{(7)}\), has reported InBi as an “imaginary” chemical compound which does not exist in pure form and has always an excess of In or Bi. However, Giessen et al\(^\text{(2)}\) had performed quenching experiments to investigate metastable phases in the In-Bi system and revised the earlier reported phase diagram\(^{(3,4)}\). After number of trials, they found that InBi has a very sharp homogeneity range without any detectable stoichiometric deviation and can be considered as a true compound. Its melting point is 109.0 \(\pm\) 0.5°C\(^{(2,4)}\) and its density, 8.84 gm CC\(^{-1}\) (Makarov)\(^{(5,6)}\).

Structure of InBi:

InBi crystal has a tetragonal unit cell in the ditetragonal - bipyramidal point symmetry group (i.e. 4/mmm), having space group P4/nmm with \(a=b=5.000 \, \text{Å}\) and \(c=4.773 \, \text{Å}\), i.e. \(c/a = 0.9546\)\(^{(8)}\). The crystal structure of InBi (figure.2), contains two InBi molecules per unit cell with In position coordinates (0,0,0) and (1/2,1/2,0) and Bi coordinates (0, 1/2, Z) and (1/2, O, Z); where Z=0.393. The interatomic separations are as under:
Fig. 1
The positions of the bismuth atoms with respect to the c-axis are +1.876 Å and -1.876 Å, constituting two sublayers of Bi. Each In layer is in the first coordination with the bismuth layer; hence the closest spacing of atoms in the neighbouring bismuth layers is 3.68 Å, which is larger than the spacing of atoms in the adjacent layers of elemental Bi (i.e., 3.47 Å). Because of this, an easy cleavage exists between two bismuth sublayers along (001) plane. The slip systems of InBi single crystals are \{110\} [001], primary and \{100\} [001], secondary.

Electrophysical properties of InBi:

The intermetallic compound InBi behaves as a divalent metal and it is the most diamagnetic material with the magnetic susceptibility ~-50 emu/mole at room temperature. Its electrical resistivity is of the order of $10^{-4}$ ohm. cm. Its work function is about 4.15 eV and its Fermi energy is ~ 0.4 eV.

The linear compressibility of InBi is highly anisotropic, which was observed to be a factor of 10 greater in the c direction than in the c plane. At room temperature, the thermal expansion coefficients parallel and perpendicular to the c-axis are, $\alpha_\parallel \sim 80 \times 10^{-6}$ K$^{-1}$ and $\alpha_\perp \sim 60 \times 10^{-6}$ K$^{-1}$ with $\Delta \alpha \sim 140 \times 10^{-6}$ K$^{-1}$. The crystal expands along c-axis and contracts perpendicular to it with decreasing temperature. Hence this intermetallic compound InBi is even more anisotropic than the hexagonal selenium and tellurium.
The elastic stiffness constants of InBi at normal atmospheric pressure, were obtained by Fritz\(^{(17)}\) as under:

\[
c_{11} = 5.10, \quad c_{12} = 3.75, \quad c_{33} = 3.50, \quad c_{13} = 3.25, \quad c_{44} = 1.98 \quad \text{and} \quad c_{66} = 1.60,
\]

in units of \(10^{11}\) dyne cm\(^{-2}\). Thus InBi differs widely from the other III-V compounds like GaAs, InSb, GaP etc. in the structural and electrophysical properties.

Fletcher et al\(^{(18)}\) have reported Bi precipitates in the InBi crystals grown by the horizontal gradient freeze method. Lal et al\(^{(19)}\) have studied conductivity and Seeback isotropics and their temperature dependence in InBi. Leonov et al\(^{(20)}\) have studied the effects of annealing on creep of In-Bi and calculated diffusion coefficients. Powell\(^{(21)}\) has studied the tensile strength of [100] filamentary cleavage crystals of InBi. I-V characteristic curves of self oscillation characteristics of In-Bi system have also been studied in its superconducting phase by Chiang et al\(^{(22)}\). Anisotropy of carrier density and its composition dependence in Bi\(_{2-x}\)In\(_x\)Te\(_3\) has been studied by Kutasov et al\(^{(23)}\), Horak et al\(^{(24)}\) and Pancir et al\(^{(25)}\). Jansa et al\(^{(26)}\) have studied reflectivity and transmission of Bi\(_{2-x}\) In\(_x\)Te\(_3\) crystals in infrared region. Horak et al\(^{(27,28)}\) studied relation between structure, bonding and nature of point defects in layered crystals of In\(_x\)Bi\(_{2-x}\)Te\(_3\) single crystals. He has also reported work on electrical conductivity, Hall constant, concentration of antisite defects and free carriers. The preparation, characterization and photoelectrode behaviour of semiconducting polycrystalline InBi\(_2\)Te\(_4\) was studied by Subramanian et al\(^{(29)}\). It is interesting to note that because of the low melting point of InBi, it was selected as a member material for the study of the effect of absence of gravity on crystal growth in the experiments conducted by NASA on its APPOLLO flyback missions and skylab.
It can be seen from the above that the materials studied so far in In-Bi-Te system are all Te rich quasi binary or ternary alloys. There is no study reported on Indium rich alloys. Hence the present work on Te doped InBi crystals was undertaken.
REFERENCES


5. Makarov, E.S., Doklady AN ASSR, 59 (1948) 899.


