Abstract

Recent interest in amorphous semiconductors is due to the feasibility of their application in magnetic, optical and structural media. Among them, one of the striking applications is to optical data storage media. The key requirements of optical data storage media include large recording density, high speed writing and erasing, an adequate number of overwrite cycles, a high signal to noise ratio and sufficient optical contrast between the two phases. The principle behind the phase change optical storage is based on a thermally induced reversible transformation between amorphous and crystalline phases of the film. In phase change optical recording, Ge\textsubscript{22}Sb\textsubscript{22}Te\textsubscript{56} (GST) is most widely used as the active medium for the rewriteable CD and DVD’s. Amorphous area embedded in crystalline surrounding acts as bit of information. A relatively highly intense laser pulse is used to write these amorphous spots by melt-quench process and low laser pulses are used for both erasing (crystallization) and reading respectively. Doping is one of most effective methods to improve the properties of phase change materials. So, efforts have been made to dope a small amount of other elements such as Co, Ti, Ag, Cr, O\textsubscript{2}, N\textsubscript{2}, Sn, Bi and In into Ge\textsubscript{2}Sb\textsubscript{2}Te\textsubscript{5} films to improve optical recording performance. In this work, we choose Pb/Sn/Bi/Se elements doping into Ge\textsubscript{22}Sb\textsubscript{22}Te\textsubscript{56} to prepare X:GST (X= Pb, Sn, Bi and Se ) films by thermal evaporation method. The transformation process of microstructure and optical properties of the X:GST films have been presented.

Two different methods for X:GST bulk preparation have been presented. First, by cooling the melted alloy rapidly by dropping the ampoule in ice cold water; second, by leaving the ampoule inside the furnace after switching it off (i.e. slow cooling inside the furnace). Pb substituted samples were prepared by rapid melt quenching, all other samples viz. Sn/Bi/Se:GST were prepared by furnace cooling. Bulk samples so obtained were used to prepare thin films by thermal evaporation technique. The structure, electrical properties and spectroscopic analysis have been performed on these films in view of their applications in the phase change memories.

Temperature dependent sheet resistance measurements were performed on the thin films to find out the phase transformation temperature. GST, exhibit two phase transformations; first, form amorphous to metastable FCC and second, from metastable FCC to stable HCP state. First, transformation temperature is observed for Pb substituted samples, which is found to increase with the Pb addition. Both first and second
transformation temperatures are observed for Sn, Bi and Se substituted samples. Higher substitution of Bi increases the room temperature conductivity and also lacks both abrupt transformations.

Thin films were annealed above the phase transformation temperatures. X-ray measurements were carried out to analyse the nature of the films. All the as-prepared films were found amorphous except for 4 and 6 at% of Bi. Also the lattice parameter increases with Pb/Sn addition. Although, much variation is not observed in lattice constant with Bi and Se substitution.

The values of optical band gap obtained for Pb$_x$Ge$_{22-x}$Sb$_2$Te$_{56}$ (x = 0, 1, 2, 3) thin films decreases with Pb addition. However, the changes are only marginal. Large increase in the optical band gap from 0.54 to 0.75 eV is observed as the content of Se increases from 2 to 4 at%. The small decrease in the optical band gap from 0.59 to 0.53 eV as the content of Bi increases to 2 at%.