THERMOELECTRIC POWER OF SOME TETRAHEDRALLY COORDINATED AMORPHOUS SEMICONDUCTORS

by

SUDHIR KUMAR BARTHWAL

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Thesis Supervisor:

Professor K.L. Chopra
Thin Films and Materials Science Laboratory
Department of Physics
Indian Institute of Technology, Delhi
New Delhi-110029

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S.K. Barthwal

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(SUDHIR KUMAR BARTHWAL)
I.I.T. NEW DELHI
INDIA

ABSTRACT

The temperature dependence of the thermoelectric power (TEP) and the corresponding conductivity of evaporated amorphous (a-) Ge, Ge_xTe_{1-x}, InSb and GaAs films have been studied as a function of such deposition parameters as technique of deposition, boat temperature during flash evaporation, nature and temperature of substrate, rate and angle of deposition, presence of different gas ambients during deposition, post-deposition annealing treatments, etc., and in case of Ge, also as a function of the source of polycrystalline Ge sample as well as impurities (Sb, Al, Au and Fe). Electron microscopy and electron diffraction studies of as-deposited, annealed and crystallized films have also been carried out in an effort to correlate the changes in the electrical properties with those of the microstructure.

The characteristic behaviour of the TEP of a-Ge films is a small (several μV/K) negative value at low temperatures (below $\sim$ 300 K), followed by an inversion of sign above room temperature and thereafter, a rapid rise with temperature. Whereas the low temperature behaviour of the TEP is not significantly affected, the inversion temperature and the high temperature behaviour are markedly affected by changes in the deposition parameters and post-deposition treatments. Small ($\lesssim$ 1 at.%) concentration of impurities have no effect on the low temperature behaviour but significant changes are observed in the high temperature behaviour. The sign of the TEP depends upon the concentration of impurities and is not necessarily

correlated with the electronic nature of the impurities. The characteristic behaviour of the conductivity is a continuously decreasing activation energy with decreasing temperature. The changes in the conductivity behaviour due to changes in the deposition parameters are much smaller as compared to the changes in the TEP.

In the case of a-Ge_xTe_{1-x} films, a gradual modification in the TEP and conductivity behaviour of a-Ge is observed on addition of Te. The TEP becomes increasingly positive with increasing Te concentration. At high enough concentrations, segregation of Te occurs and TEP becomes very small. The TEP of a-$Ge_{0.5}Te_{0.5}$ films remains positive and varies inversely with temperature in the range 250-400 K. In sharp contrast to a-Ge films, the TEP and conductivity are not affected significantly by various deposition parameters and post-deposition treatments. These results are understood in terms of the microstructure and the associated void structure of the films, as revealed by our electron microscopy studies.

The TEP and conductivity of a-InSb and a-GaAs films are strongly dependent on various deposition parameters, especially boat temperature. The conductivity behaviour shows a continuous variation with boat and substrate temperature whereas the TEP shows wide and anomalous variations in sign and temperature dependence. The conductivity data of these films show a continuously decreasing activation energy with decreasing temperature (similar to a-Ge films). The results are understood in terms of the electron microscopy studies of these films.

The TEP and conductivity behaviour of the presently studied amorphous semiconductors can be understood in terms of conduction in an asymmetrical energy-band diagram whose tailing and localization features and shape of the density-of-states curve are very sensitive to deposition parameters and post-deposition treatments, and are attributable to changes in the microstructure and the associated voids and dangling bonds.

CONTENTS

Page