ELECTRONIC PROPERTIES OF CRYSTALLINE Ge—METAL FILMS

by

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ABSTRACT

A detailed study of structural and electrical properties of crystalline and crystallized Ge and Ge-metal films has been undertaken (a) to investigate the solubility characteristics of metals in Ge-films, (b) to understand the pravelent conduction mechanisms in polycrystalline Ge films, (c) to study the electrical properties of Ge-metal alloy films and heterogeneous Ge-metal/compound films, and (d) to elucidate differences in the incorporation scheme of foreign atoms in amorphous and crystalline Ge matrix. Polycrystalline Ge and Ge-metal films with 0.5-10 at.% concentration of Al, Ga, Ag, Au, Cu and Fe have been prepared by codeposition onto glass/rock salt substrates held at 723 K and also by crystallization of amorphous films of the same materials on heating at 723 K. The metals have been chosen on the basis of their solubility in bulk Ge and compound forming tendency.

Crystalline and crystallized Ge films are polycrystalline with grain size $\sim$680 Å and $\sim$100 Å, respectively. Both the films show p-type behaviour and the corresponding acceptor level is found to be at $\sim$0.05 eV above the valence band. The mobility of the charge carriers has been analyzed in terms of various scattering mechanisms and grain boundary scattering has been found to be the dominant scattering mechanism.

Structural studies of crystalline and crystallized Ge-metal films show that the solubility of the metal is enhanced and metal segregation/compound formation is detected only at metal concentration $\gtrsim$5 at.%. The grain size dependence on metal

concentration is also dictated by the solubility conditions and compound forming tendency. Electron transport properties of these films are dependent on the granular structure of the films and the electronic nature of the metal incorporated. The addition of Al and Ga decreases the electrical resistivity and thermoelectric power (TEP). The carrier (hole) concentration increases rapidly and there is a gradual decrease in the Hall mobility. Silver affects these properties slightly in crystalline films but, in crystallized Ge-Ag films, strong effects are observed. There is a gradual decrease in the electrical resistivity and TEP with Au concentration in crystalline and crystallized Ge-Au films. The carrier concentration increases slowly and the Hall mobility shows a maximum. The carrier concentration in crystalline Ge-Cu and Ge-Fe films decreases slowly but shows an increase in the corresponding crystallized films. Hall mobility in crystalline films increases but shows a maximum in the crystallized films. In crystalline Ge-Cu films, the TEP decreases initially upto $\sim$2 at.% Cu and increases thereafter.

Alloying/doping effects on the electron transport properties of crystalline films are compared with those of the amorphous films. Whereas the formation of solid solution/ segregated metal or compound governs the transport properties in the crystalline films, impurity state introduced on alloying are responsible for the transport behaviour of amorphous films. The crystallized films show a behaviour which is intermediate between that of the amorphous and the crystalline films.

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