# STRUCTURE AND TRANSPORT BEHAVIOUR OF OBLIQUELY DEPOSITED AMORPHOUS GERMANIUM FILMS

*by*

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## ABSTRACT

The structure and growth of amorphous Ge films deposited at an angle of incidence ranging from $0^{\circ}$ to $80^{\circ}$ have been studied by electronmicroscopy and electron diffraction as a function of the film thickness, deposition temperature, deposition rate, and annealing temperature. Like crystalline films, the growth of amorphous films proceeds via random nucleation centres and is controlled by the small but finite adatom mobility. The small adatom mobility results in the formation of a large concentration of vacancies, vacancy clusters, voids, and associated dangling bonds in a-Ge films. The adatom mobility is enhanced by the elevated deposition temperatures and oblique incidence of vapour and, consequently, the concentration of vacancy clusters and voids decreases. The formation of columns and the decoration of structural defects (associated with the cleaved NaCl single crystal substrate ) during the growth of a-Ge films are a direct consequence of the enhanced adatom mobility. The observed thickness dependence of the resistivity and the variation of density, crystallization temperature, and short range order with the deposition parameters are in accord with the structural model as deduced from our observations of the growth behaviour of a-Ge films. The marked structural changes in a-Ge films on deposition at an angle of incidence result in significant changes in their physical, electrical, and optical properties.

The presence of a microstructure, different from that of room temperature deposited normal-incidence film, in obliquely

deposited, high temperature deposited, and annealed films and the associated low concentration of dangling bonds and voids result in the decrease of electrical conductivity, density of localized states at the Fermi level and band edges, low frequency refractive index, extinction coefficient and absorption at low energies and in the increase of activation energy (at and below room temperature), thermoelectric power, and optical gap. The high temperature activation energy value of 0.55 eV remains constant irrespective of the sample history. A relatively sharp absorption edge at $\sim$0.56 eV is observed for room temperature deposited normal incidence film. Oblique and/or high temperature deposition and annealing result in the sharpening of the absorption edge with an associated shift towards higher energies. Oblique and/or high temperature deposition also seems to stabilize the amorphous structure against further ageing and annealing treatments. The results of our electrical and optical studies can be understood on the basis of the proposed asymmetrical energy-band model.