RADIATION INDUCED OPTICAL AND LITHOGRAPHIC EFFECTS IN CHALCOGENIDE GLASSES

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ABSTRACT

A quantitative study of radiation (e.g. photons, electrons and ions) induced effects in optical and electrical properties, physical thickness, far Infra Red (IR) and Urbach tail parameters and microlithographic effects in normal and obliquely deposited As-X (X = S, Se, Te), X-Ge and As-X-Ge films has been undertaken. The obliquely deposited films have been chosen because these exhibit enhanced radiation induced effects compared to the normal ones. The large irreversible photoinduced films have been attributed predominantly to photoinduced volume contraction and increased strength of electron-phonon coupling. The existence of the lone pair band on top of the valence band has been established as a necessary condition for the occurrence of photoeffects. The enhancement of photoeffects on addition of Ge in obliquely deposited (80^{o}) films is primarily due to the highly porous columnar microstructure and hence a large density deficit. However, the reduced effects in normal (0^{o}) films are due to the formation of three dimensional rigid network structures. The changes in optical and mobility gaps indicate that the reversible changes are associated with the changes/ modifications in the localized states at the band edges.

Large photocontraction upto 12% in Se-Ge and upto 19% in S-Ge films has been observed. Conditions necessary for the occurrence of large photocontraction are indicated

to be : ability to form a glass, high bond ionicity, strong electron-phonon coupling, low density of the bulk material and a large density difference between the bulk and the thin film. The effect of ionizing radiations (energetic electrons and ions) has also been investigated. Large densification effects upto 39% with He^+ ions and upto 23% with electrons have been observed.

A correlation of the Urbach tail features with composition, angle of deposition, photoinduced edge shift, average coordination number and photoinduced volume contraction has been established. The far IR spectra reveal that bond angle variations are the dominant features of the photostructural transformation rather than the bond stretching variations. The far IR and Urbach tail studies suggest that the strength of electron-phonon coupling is enhanced in Ge-based films having a very porous columnar microstructure. Further, the coupling is maximum at the best glass forming composition of the chalcogenide.

The major electrochemical changes produced by contraction have been utilized for high resolution submicron lithography, reprography and optical image storage. A correlation has been established between the thickness contraction and the lithographic parameters. A high contrast of 8.3 and sensitivity $\sim 1.4 \times 10^{-5}$ C/cm^2 as a negative resist have been obtained on He^+ irradiation of $Ag_2Se/Se_{75}Ge_{25}$ films.

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