Ion irradiation induced porosity in Germanium

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Ion irradiation of crystal germanium (c-Ge) results in the formation of a porous surface, and sometimes buried porous layer. The controlled fabrication of such porous structures has potential applications in lighting, gas detection and catalytic applications. In the present work, we employ a combination of complimentary characterisation techniques to better understand the crystalline-to-porous transformation in Germanium as a function of implantation conditions (fluence and temperature).

Post-implantation optical profiling indicated that significant swelling of the irradiated layer occurs (up to 400 nm), consistent with the formation of a porous surface layer. The optical result also showed evidence of a four stage swelling process with clear plateaus and sharp inclines with ion dose for pure Ge, whereas in $Ge_{0.8}$ $Si_{0.2}$ alloy, which has 80% of Ge shows two different stages of swelling (up to 100 nm) , which indicate the creation of volume expansion associated with porous structure. It has been observed by utilizing Raman spectroscopy that the structural properties of the porous layers were also heavily dependent on the ion fluence and temperature as evidenced by changes in the position and width of the characteristic phonon bands. Scanning electron microscopy (SEM) is also applied to study the morphology (pore size, areal density ….etc) as a function of ion fluence and temperature. Investigation has done on the pore shape and depth damage distribution by using Transition electron microscopy (TEM). Positron annihilation lifetime spectroscopy (PALS) and small angle x-ray scattering (SAXS) measurements provided further evidence of an implant temperature-dependent pore morphology extending to depths ~7 times the projected range of the incident ions.