Abstract

Laser-induced surface, structural and electrical modifications of Germanium (Ge) in dry (vacuum and hydrogen) and wet (de-ionized water and ethanol) environments have been investigated. Single crystal Ge (100) has been exposed by KrF excimer laser with wavelength of 248 nm and repetition rate of 20 Hz at four different fluences. Surface modifications of irradiated Ge were investigated by Scanning Electron Microscope (SEM). Structural modifications were explored by employing FTIR spectroscopy and Raman spectroscopy. Four probe technique was used for the measurement of electrical conductivity of the irradiated Ge samples. In order to explore the effect of dry environment, Ge targets were exposed at four various fluences ranging from 4.5 J cm^{-2} to 6 J cm^{-2}. SEM analysis exhibits the formation of Laser-Induced Periodic Surface Structures (LIPSS), cones and micro-bumps in both dry environments of vacuum and hydrogen. The periodicity of LIPSS or ripples varies from 38 μm to 60 μm in case of vacuum whereas in case of hydrogen environment, the periodicity varies from 20 μm to 45 μm. The difference in number of ripples and periodicity as well as in shape and size of cones and bumps in vacuum and hydrogen is explained on the basis of confinement and shielding effect of plasma. FTIR spectroscopy reveals that C-H stretching vibration band is formed for two moderate fluences (5 J cm^{-2} and 5.5 J cm^{-2}) in case of ablation in hydrogen. Raman spectroscopy shows that no new bands are formed in case of ablation in both environments. However, a slight Raman shift is observed which is attributed to laser-induced stresses. The electrical conductivity of the irradiated Ge increases with increasing fluence and is also dependent upon the environment as well as grown structures. To explore the effect of wet environments, Ge targets were explored at four different fluences ranging from 0.64 J cm^{-2} to 0.85 J cm^{-2}. SEM analysis reveals the formation of cavities, cracks and ripples in case of ablation in de-ionized water whereas, the formation of cavities, ridges and pores is observed in case of ablation in ethanol. FTIR spectroscopy shows that C-H stretching vibration band is identified in case of ethanol at two moderate fluences of 0.71 J cm^{-2} and 0.78 J cm^{-2}. Raman spectroscopy reveals that only Ge-Ge band is formed at 300 cm^{-1} in both environmental conditions. The electrical conductivity of the irradiated Ge has been increased as compared to un-irradiated Ge. However, it was observed that conductivity decreases with increasing laser fluence and also shows a strong dependence on ambient environments.