Abstract

The energy and flux measurements of laser-generated Si and Ge plasma ions investigated by using Faraday cup (FC) technique in Time-of-Flight (TOF) mode under ultra-high vacuum condition. Nd: YAG laser (532 nm, 6 ns) at different irradiances ranging from 4 $GWcm^{-2}$ to 7.1 $GWcm^{-2}$ has been employed as an irradiation source for Si and Ge ablation and plasma formation. Ion flux and energy measurements of laser induced Si and Ge plasmas are performed by varying the distance between FC ion collector and target surface (from 4 cm, 6 cm, 8 cm upto 10 cm), angle of ion collector with respect to the target surface normal from 0°, 15°, 30°, 45° to 60° as well as for various negative biasing voltages. From the observed TOF ion profiles, slow ion peaks were used to evaluate the laser induced Si and Ge plasma parameters. It is revealed that both flux and energy of Si and Ge plasma ions increase with increasing irradiance. At the target to collector distance of 4 cm, the flux of Si ions increases from $4.9\times 10^{20}\ cm^{-3}$ to $5.5\times 10^{20}\ cm^{-3}$ and for Ge ions, it increases from $11\times 10^{20}\ cm^{-3}$ to $12\times 10^{20}\ cm^{-3}$ with increasing irradiance from 4 $GWcm^{-2}$ to 7.1 $GWcm^{-2}$. Similarly, the energy of Si ions varies from 156 eV to 166 eV and for Ge, this range is from 108 eV to 124 eV with increasing irradiance from 4 $GWcm^{-2}$ to 7.1 $GWcm^{-2}$. With increasing the angles of ion collector with respect to target surface normal from 0° to 60°, a decreasing trend in flux and energy of semiconducting material is observed due to forward peaking of plasma expansion. The ion flux decreases from $3.47\times 10^{20}\ cm^{-3}$ to $0.17\times 10^{20}\ cm^{-3}$ and from $6.5\times 10^{20}\ cm^{-3}$ to $1.54\times 10^{20}\ cm^{-3}$ for Si and Ge respectively. Whereas, ion energy decreases from 351 eV to 177 eV for Si and from 503 eV to 285 eV for Ge at an irradiance of 7.1 $GWcm^{-2}$ when the ion collector is placed at a distance of 6 cm. With increasing biasing voltage from 10 to 70 V, flux of Si ions increases from $1.44\times 10^{20}\ cm^{-3}$ to $5.1\times 10^{20}\ cm^{-3}$ and for Ge, it increases from $3.2\times 10^{20}\ cm^{-3}$ to $11.2\times 10^{20}\ cm^{-3}$ at the fixed value of irradiance of 7.1 $GWcm^{-2}$ and at ion collector distance of 4 cm from the target surface. Similarly, with increasing biasing voltage, the energy of Si ions varies from 252 eV to 351 eV and Ge ions energy varies from 307 eV to 504 eV. In order to correlate the evaluated plasma parameters with the surface modification, Scanning Electron Microscopy analysis (SEM) of laser-ablated Si and Ge targets has been performed. For both Si and Ge, small sized cones, cracks, nano-ripples and ridges are the dominant structures at the lower irradiances, whereas higher values of irradiances along with enhanced flux and energy of plasma ions result into formation of more diffusive structures such as large sized cones, sharp spikes along with well-defined ripples due to more energy deposition.