Surface characterization of Si single crystals modified by laser irradiation

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Preamorphization implantation of Si wafer by Si^{+} ions is commonly used in ultrashallow junction formation in order to achieve high dopant activation level and to prevent dopant channeling. A drawback is that implantation leaves a damage band, rich in Si-interstitials. During the post-implantation activation annealing process, Si-interstitials agglomerate into extended defects and evolve via the Ostwald ripening mechanism. These defects are responsible for dopant diffusion and activation anomalies as well as junction leakage. High power laser annealing is a promising alternative for production of a highly activated, ultrashallow, and boxlike junction profile. High fluence excimer laser irradiation melts the surface of the substrate and the melted surface layer subsequently undergoes a liquid phase epitaxy re-growth. However recrystallization of the melted layer may leave undesired point defects beyond the liquid/solid interface. To check this possibility variable energy positron annihilation spectroscopy (VEPAS) was employed to characterize microstructure of sub-surface region of Si single crystals re-grown after surface melting by high power laser treatment. Virgin Si (001) crystal was compared with crystals subjected to laser irradiation with increasing number of laser pulses and with laser power varied in the range from 0.4 to 0.75 J/cm^2.

From VEPAS measurements one can conclude that Si crystals contain a sub-surface region consisting of a mixture of crystalline and amorphous SiO_2 and also crystalline Si. Laser-induced meting and re-growth cause an increase of crystallinity in the sub-surface region. Thickness of the modified layer corresponds well with the expected depth of the melted region (60 nm). No significant enhancement in the concentration of open volume defects was detected at the interface between the re-grown sub-surface region and Si bulk.

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