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Carrier lifetime variations in MCZ Si during irradiation by 3 - 8 MeV protons at temperatures in the range of 40 -300 K

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Variations of carrier recombination lifetime, linearly dependent on radiation induced defects density, have been in situ examined during irradiations by stopped and penetrative protons in MCZ Si wafers of 350 μm thickness. Irradiations and in situ lifetime measurements were performed at different stabilized temperatures in the range of 40 -300 K. Registration of the averaged carrier decay transients were carried out every second during exposure of a proton beam in remote mode over 15 m distant from vacuumated irradiation chamber by examination of microwave probed photoconductivity transients. Adjustments of the intersection at a boundary of wafer for the laser excitation beam transferred to a fiber spot and of the needle-tip microwave antenna have been performed by 3D stepper connected to irradiation chamber by flexible bellow system with lateral movement precision of ˜ 2 μm. Precision of adjustments were controlled remotely by using LAN interface and PC in safe area for measurements. Visual control of a location of probes within wafer thickness was also arranged by using optical fiberscope combined with VC. Probes were located at half-thickness of wafer under irradiation by penetrative protons, while these were positioned within stopping range for 3 MeV protons. Irradiation was kept for ˜52000 counts or 15 –20 min at 2 - 9 nA beam current. Carrier lifetime varied from 500 μs to 0.5 ns over a complete exposure for initially non-irradiated material, while it changed from 1 μs to 0.2 ns for 1012 p/cm2 pre-irradiated samples. Cross-sectional scans of carrier lifetime were performed just after irradiation. A lifetime reduction has been revealed within stopping range of 3 MeV protons. Carrier lifetime temperature variations in the range of 30 –300 K had been examined before and after irradiations. Carrier decay transients appeared to contain several components caused by growth and radiation induced defects, which can be separated to recombination and carrier trapping centres. Spectrum of temperature variations of different carrier decay components enabled us to identify different defects. Rate of introduction of the radiation defects under proton beam exposure has been unveiled to be dependent on initial state and sample temperature during irradiation. More detailed analysis of evolution of radiation defects during irradiation by penetrative and stopped protons will be discussed.

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