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Experimental study of the Si-SO2 interface region in p+n-silicon strip sensors before and after X-ray irradiation

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The Si-SO2 interface region in a DC-coupled p+n-silicon strip sensors has been studied by TCT measurements for eh-pairs produced by focused, sub-nanosecond laser light with wavelengths of 660 nm and 830 nm. Charge losses of either electrons or holes have been observed. The charge losses depend on the biasing history; after changing the sensor voltage, they change, with time constants between tens of minutes and several days, depending on humidity. The observations are qualitatively explained by detailed TCAD simulations: the charge losses depend on the charge distribution on the surface of the sensor, which is in a non-equilibrium state after changing the sensor voltage. The big difference in time constants in reaching the equilibrium is due to the strong dependence of the surface resistivity on humidity. Results before and after irradiation to 1 MGy (˜10 keV X-rays) will be presented. The results are relevant for defining the surface boundary conditions when simulating segmented silicon sensors for different surface damages.

The measured dependence of the charge losses on wavelength is compatible with simulations of the electric field close to the Si-SiO2 interface: a region of zero electric field (saddle point of the potential) in the center between p+ strips, about 5 mum from the Si-SiO2 interface.

Using simulated weighting potentials for the strips and the backplane, the extension and properties of the electron accumulation layer at the Si-SiO2 interface for the different experimental conditions is extracted before and after X-ray irradiation. The extension of the accumulation layer strongly influences the breakdown conditions at the edges of the p+implants, and thus the breakdown voltage of the sensor.

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