



Contribution ID: 212

Type: **Oral presentation**

## Study of X-ray Radiation Damage in Silicon Sensors

*Wednesday, 6 July 2011 12:35 (20 minutes)*

The European X-ray Free Electron Laser (XFEL) will deliver 30,000 fully coherent, high brilliance X-ray pulses per second with duration below 100 fs. This will allow to record diffraction patterns of single molecules and study ultra-fast processes. Silicon pixel sensors will be used to detect the diffraction images. In 3 years of operation the sensors will be exposed to doses of up to 1 GGy of 12 keV X-rays. At these X-ray energies no bulk damage in silicon is expected. However fixed oxide charges in the SiO<sub>2</sub>/Si<sub>3</sub>N<sub>4</sub> layer and interface traps at the Si-SiO<sub>2</sub> interface will build-up.

We have investigated as function of the 12 keV X-ray dose the microscopic defects in test structures and the macroscopic electric properties of segmented sensors. From the test structures we determine the oxide charge density and the density of interface traps as function of dose. We find that both saturate (and even decrease) for doses above a few MGy. For segmented sensors the defects introduced by the X-rays increase the full depletion voltage, the surface leakage current and the inter-pixel capacitance. In addition an electron accumulation layer forms at the Si-SiO<sub>2</sub> interface which increases with dose and decreases with applied voltage. Using TCAD simulations with dose dependent parameters obtained from the test structures, we are able to reproduce the observed results. This allows us to optimize the sensor design for the XFEL requirements.

In addition the Si-SiO<sub>2</sub> interface has been studied by time resolved signals induced by 660 nm laser light, which has a penetration of about 3 micrometer in silicon. Depending on the biasing history, humidity and irradiation dose, losses of either electrons or holes or no charges losses are observed. The relevance of these results for sensor stability and performance is under investigation.

Keywords: XFEL, silicon pixel sensor, radiation damage, TCAD simulation and charge losses.

**Primary authors:** Mr FRETWURST, Eckhart (Institute for Experimental Physics, Hamburg University); Mrs PINTILIE, Ioana (National Institute of Materials Physics, Romania); Mr ZHANG, Jiaguo (Institute for Experimental Physics, Hamburg University); Mr SCHWANDT, Joern (Institute for Experimental Physics, Hamburg University); Mr KLANNER, Robert (Institute for Experimental Physics, Hamburg University); Mr SCHUWALOW, Sergej (Institute for Experimental Physics, Hamburg University); Mr POEHLSEN, Thomas (Institute for Experimental Physics, Hamburg University)

**Presenter:** Mr ZHANG, Jiaguo (Institute for Experimental Physics, Hamburg University)

**Session Classification:** Free Electron Lasers

**Track Classification:** Free Electron Lasers