T 53: Halbleiterdetektoren III (Strahlenhärte)

Zeit: Dienstag 16:45–19:00 Raum: VMP8 HS

T 53.1 Di 16:45 VMP8 HS

3-Dimensional Charge Collection Efficiency measurements using volumetric tomographic reconstruction — •Daniel Dobos — CERN, Geneva, Switzerland

For a better understanding of the electrical field distribution of 3D semiconductor detectors and to allow efficiency based design improvements, a method to measure the 3D spatial charge collection efficiency of planar, 3D silicon and diamond sensors using 3D volumetric reconstruction techniques is possible. Simulation results and first measurements demonstrated the feasibility of this method and show that with soon available 10 times faster beam telescopes even small structures and efficiency differences will become measurable in few hours.

T 53.2 Di 17:00 VMP8 HS

Strahlenhärte von n-in-p Siliziumstreifensensoren für das CMS-Phase-II-Upgrade — Felix Bögelspacher, Alexander Dierlamm, •Marius Metzler, Thomas Müller, Martin Printz, Daniel Schell und Pia Steck — IEKP

Im Jahre 2024 soll das Phase-II-Upgrade des Large Hadron Collider (LHC) zum HL-LHC und damit auch des Compact Muon Solenoid Detektors (CMS) umgesetzt werden, welches mit einer Steigerung der Luminosität von $1{\cdot}10^{34}$ auf $5{\cdot}10^{34}$ $cm^{-2}s^{-1}$ einhergehen wird. Dies entspricht bei einer Laufzeit von 10 Jahren bei geschätzten 3000 fb^{-1} einer Fluenz von $1{\cdot}10^{15}$ $n_{eq}cm^{-2}$, die man etwa 20 cm Entfernung vom Zentrum erwartet. Dementsprechend muss die Widerstandsfähigkeit des Spurdetektors gegenüber Strahlung angepasst werden.

Dieser Vortrag wird ausschließlich Messungen von n-in-p-Streifensensoren beinhalten. Im Detail heißt das, dass verschiedene Testsensoren unterschiedlichen Designs auf ihre elektrischen Eigenschaften vor und nach Bestrahlung bis $1{\cdot}10^{15}$ $n_{eq}cm^{-2}$ sowie ihre Ladungssammlungseffizienz untersucht werden.

T 53.3 Di 17:15 VMP8 HS

Characterization of irradiated thin silicon sensors for the CMS phase II pixel upgrade — •Matteo Centis Vignali[1], Doris Eckstein[2], Thomas Eichhorn[2], Erika Garutti[1], Alexandra Junkes[1], and Georg Steinbrück[1] — [1]Institut für Experimentalphysik, Universität Hamburg — [2]Deutsches Elektronen Synchrotron, DESY

The high-luminosity upgrade of the Large Hadron Collider, foreseen for 2025, necessitates the replacement of the tracker of the CMS experiment. The innermost layer of the new pixel detector will be exposed to severe radiation corresponding to a 1 MeV neutron equivalent fluence up to $\Phi_{eq} = 2 \cdot 10^{16}$ cm^{-2} and an ionizing dose of $\approx$ 10 MGy after an integrated luminosity of 3000 fb^{-1}. Silicon crystals grown with different methods and sensor designs are under investigation in order to optimize the sensors for such high fluences. Thin planar silicon sensors are good candidates to achieve this goal, since the degradation of the signal produced by traversing particles is less severe than for thicker devices.

Epitaxial pad diodes and strip sensors irradiated up to fluences of $\Phi_{eq} = 1.3 \cdot 10^{16}$ cm^{-2} have been characterized in laboratory measurements and beam tests at the DESY II facility. The active thickness of the strip sensors and pad diodes is 100 μm. In addition, strip sensors produced using other growth techniques with a thickness of 200 μm have been studied.

In this talk, the results obtained for p-bulk sensors are shown.

T 53.4 Di 17:30 VMP8 HS

X-ray irradiation effects of interface traps and trapped-oxide charge at the Si-SiO$_2$ interface of segmented silicon sensors — •Ioannis Kopsalis, Eckhart Fretwurst, Erika Garutti, Robert Klanner, and Joern Schwandt — Institute for Experimental Physics, Hamburg University, Luruper Chaussee 149, D-22761 Hamburg, Germany

The surface radiation damage of SiO_2 grown on high-ohmic Si, as used for the fabrication of segmented silicon sensors, has been investigated. Circular p- and n-MOSFETs, biased in accumulation and inversion at a field in the SiO_2 of about 500 kV/cm, have been irradiated by X-rays up to a dose of about 17 kGy(SiO_2) in different irradiation steps. Before and after each irradiation, the gate voltage has been cycled from inversion to accumulation conditions and back, and from the dependence of the drain-source current, on gate voltage, the threshold voltage of the MOSFET and the hole and electron mobility at the Si-SiO_2 interface determined.

From the threshold voltage, the effective oxide-charge density is calculated. Using the subthreshold-current technique the contribution of interface traps, in the lower and the upper part of the energy Si bandgap, and of fixed oxide-charge to the effective oxide-charge density has been estimated. Results on the dose dependence of the above quantities, the charging-up and discharging of border traps when changing the gate voltage, and the hole and electron mobilities at the Si-SiO_2 interface are presented.

T 53.5 Di 17:45 VMP8 HS

TSC measurements on proton-irradiated p-type Si-sensors — •Elena Donegani, Eckhart Fretwurst, Erika Garutti, and Alexandra Junkes — University of Hamburg

Thin n^+p Si sensors are potential candidates for coping with neutron equivalent fluences up to $2{\cdot}10^{16}$ n_{eq}/cm^2 and an ionizing dose in the order of a few MGy, which are expected e.g. for the HL-LHC upgrade. The aim of the present work is to provide experimental data on radiation-induced defects in order to: firstly, get a deeper understanding of the properties of hadron induced defects, and secondly develop a radiation damage model based on microscopic measurements.

Therefore, the outcomes of Thermally Stimulated Current measurements on 200 μm thick Float-Zone (FZ) and Magnetic Czochralski (MCz) diodes will be shown, as a results of irradiation with 23 MeV protons and isothermal annealing. The samples were irradiated in the fluence range (0.3-1)$\cdot 10^{14}$ n_{eq}/cm^2, so that the maximal temperature at which the TSC signal is still sharply distinguishable from the dark current is 200 K.

In particular, special focus will be given to the defect introduction rate and to the issue of boron removal in p-type silicon. Annealing studies allow to distinguish which defects mainly contribute to the leakage current and which to the space charge, and thus correlate microscopic defects properties with macroscopic sensor properties.

T 53.6 Di 18:00 VMP8 HS

Messungen des Leckstroms zur Bestimmung der effektiven Bandlücke und Schädigungskonstante stark bestrahlter Siliziumsensoren — •Moritz Wiehe[1], Tony Affolder[2], Gianluigi Casse[2], Paul Dervan[2], Susanne Kühn[1], Riccardo Mori[1], Ulrich Parzefall[1] und Sven Wonsak[2] — [1]Albert-Ludwigs-Universität Freiburg — [2]University of Liverpool

Der Leckstrom bestrahlter Siliziumsensoren führt zur Selbsterwärmung und verschlechtert das Signal-zu-Rausch-Verhältnis eines Detektors. Daher ist eine genaue Vorhersage der im Experiment zu erwartenden Höhe des Leckstroms für die Planung und den Betrieb eines Detektors erforderlich. Die Abhängigkeit des Leckstroms von der Sensortemperatur und der Bestrahlungsdosis wird parametrisiert durch die effektive Bandlücke $E_{g,eff}$ und die Schädigungskonstante, die sogenannte *current related damage rate* α. Im Vortrag werden Messungen zur Bestimmung dieser Parameter in Abhängigkeit der Bestrahlungsdosis vorgestellt. Es wurden Messungen des Leckstroms unter Variation der Biasspannung bei Sensortemperaturen von $-32°$C, $-27°$C und $-23°$C durchgeführt. Die oben genannten Parameter wurden so für 18 verschiedene n-in-p Siliziumstreifensensoren der Firmen Hamamatsu Photonics und Micron Semiconductor Ltd, welche mit einer Dosis von $2 \cdot 10^{14}$ bis $2 \cdot 10^{16}$ n_{eq}/cm^2 bestrahlt wurden, bestimmt.

T 53.7 Di 18:15 VMP8 HS

An edge-TCT setup for the investigation of radiation damaged silicon sensors — •Finn Feindt, Christian Scharf, Erika Garutti, and Robert Klanner — Institute for Experimental Physics, Hamburg University, Luruper Chaussee 149, D-22761 Hamburg, Germany

The aim of this work is to measure the electric field, drift velocity and charge collection of electrons and holes in radiation-damaged silicon strip sensors.

For this purpose the edge Transient Current Technique (TCT) is employed. In contrast to conventional TCT, this method requires light from a sub-ns pulsed, infrared laser to be focused to a μm-size spot and scanned across the polished edge of a strip sensor. Thus electron-hole pairs are generated at a known depth in the sensor. Electrons and holes drift in the electric field and induce transient currents on the sensor electrodes. The current wave forms are analyzed as a function of the applied voltage and the position of the laser focus in order to determine the electric field, the drift velocities and the charge collection.

In this talk the setup and the procedure for polishing the sensor edge are described, and first results, regarding the measurement of the laser light focus are presented.

T 53.8 Di 18:30 VMP8 HS

Module mit dünnen planaren Silizium-Sensoren für den ATLAS Pixel-Detektor am HL-LHC — •Natascha Savic, Anna Macchiolo, Richard Nisius und Stefano Terzo — Max-Planck-Institut für Physik, München

Um der höheren Detektor-Okkupanz und Strahlendosis in der nächsten Phase der Steigerung der Luminosität des LHC (HL-LHC) Rechnung zu tragen, wird das derzeitige ATLAS-Pixel-System bis zum Jahr 2025 vollständig ersetzt werden. Dazu sind neue weitaus strahlenresistentere Pixelsensoren nötig. Die zur Zeit verwendeten 200-250μm dicken Silizium-Sensoren können aufgrund steigender Dunkelströme, niedriger Sammeleffizienzen und hoher Depletionsspannungen dann nicht mehr effizient betrieben werden. Das am Max-Planck-Institut für Physik dazu entwickelte, neuartige Modulkonzept nutzt dünne planare n-in-p Siliziumsensoren in Verbindung mit dem ATLAS FE-I4 Auslesechip. Im Vergleich zu den zur Zeit benutzten Sensoren wird die Funktion der dünnen Siliziumsensoren mit Dicken von 50 bis 150μm nach intensiver Bestrahlung weniger beeinträchtigt. Die Leistungsfähigkeit der Pixeldetektoren in Bezug auf Ladungssammlung und Pixeleffizienz wird mithilfe von radioaktiven Quellen und Test-Strahlen untersucht und verglichen. Es werden Resultate von Pixelmodulen vor und nach Bestrahlung vorgestellt. Der Einfluss der Sensordicke, sowie neuartiger Punch-Through Designs (Strukturen welche die Funktionsprüfung der Sensoren vor Verbindung mit dem Auslesechip ermöglichen) und aktiver Kanten, auf die Eigenschaften der Sensoren wird untersucht.

T 53.9 Di 18:45 VMP8 HS

Absorption of light, drift velocity, and trapping times in highly irradiated silicon pad sensors — •Christian Scharf, Robert Klanner, and Erika Garutti — Institute for Experimental Physics, Hamburg University, Luruper Chaussee 149, D-22761 Hamburg, Germany

The aim of this work is to obtain information on the drift velocities and trapping rates in radiation damaged silicon sensors as a function of electric field and dose. For highly irradiated silicon sensors the electric field under reverse bias takes the shape of a double junction with high field near the implants and a region of lower field in between. For this condition it is difficult to determine separately the electric field, the trapping and multiplication of charge carriers, and the drift velocity; all of which are functions of the irradiation and the position in the sensor. However, for forward bias the electric field and the trapping rates are expected to be independent of position. We analyze transient current measurements of forward biased silicon pad sensors irradiated with proton doses above 10^{15} n_{eq}/cm^2 . The transients are induced by charges produced by sub-ns laser light of wavelengths of 670 and 1060 nm. In the analysis we considered that radiation-induced defects in the silicon can result in a decrease of the light absorption length, resulting in an increase of the number of electron-hole pairs generated by infrared light. This effect influences the determination of the charge collection efficiency of highly irradiated silicon sensors using infrared laser pulses, which is a method frequently used. The analysis method and first results will be presented.