# T 13: Semiconductor Detectors:Radiation Hardness, new Materials and Concepts

Time: Monday 16:15–18:15 Location: T-H26

T 13.1 Mon 16:15 T-H26

**Voltage scans on germanium detectors** — •Felix Hagemann for the GeDet-Collaboration — Max-Planck-Institut für Physik, München

Germanium detectors are used in fundamental research to search for neutrinoless double-beta decay or dark matter. In many of these experiments, a perfect understanding of the working principle and characteristics of these detectors is essential.

The electric field inside a germanium detector consists of two main components: one resulting from the potentials applied to the contacts to bias the detector, and one from the ionized impurities in the germanium crystal. While the overall number of ionized impurities can be estimated from Hall measurements on the surface of the detector, the spatial distribution of the impurities inside the germanium crystal is not well known. This results in large uncertainties on the resulting electric field.

One way to probe the impurity density profile is through voltage scans. In voltage scans, the pulses resulting from the same volumes of the detectors are recorded with different bias voltages applied to the detector. This way, the contribution from the bias voltage is varied and the constant contribution from the impurities can be separated and determined. This also requires reliable pulse shape simulation.

In my talk, I will present first data from voltage scans on a p-type segmented point-contact germanium detector and compare them to simulation results obtained from the open-source Julia software package *SolidStateDetectors.jl* to give an estimate of the impurity density profile.

T 13.2 Mon 16:30 T-H26

**Eine neue Software zur 3D Simulation von Halbleiterdetektoren - SolidStateDetectors.jl** — •Martin Schuster für die GeDet-Kollaboration — Max-Planck Insitut für Physik, München, Deutschland

Halbleiterdetektoren, insbesondere aus Silizium und Germanium, haben schon lange einen festen Platz in zahlreichen Experimenten und Industriefeldern. In der GeDet (Germanium Detektor Entwicklung) Gruppe am Max-Planck Institut für Physik werden Germaniumdetektoren genau untersucht. Eine entscheidende Rolle spielt dabei der Vergleich von in Testständen aufgenommenen und simulierten Daten. In der Gruppe wurde eine neue "Open Source" Software in der jungen Programmiersprache Julia geschrieben, mit der das Verhalten aller auf Dioden basierenden Halbleiterdetektoren simuliert werden kann. Das Paket ermöglicht die schnelle Berechnung der elektrischen Potentiale und Felder und bietet die Möglichkeit der Pulsformsimulation basierend auf der Drift der Ladungsträger. Das Einlesen von GEANT4-generierten Ereignissen ist möglich. In diesem Vortrag werden die Funktionsweise und Möglichkeiten der Software erläutert. Als Beispiel dient ein vierfach segmentierter n-Typ Punktkontakt - Germaniumdetektor.

T 13.3 Mon 16:45 T-H26

**Influence of radiation damage on the absorption of near-infrared light in silicon** — •Annika Vauth, Robert Klanner, and Jörn Schwandt — Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland

Radiation damage of silicon sensors is an important area of investitation in high energy physics today. Frequently, red and near-infrared light is used to generate electron-hole pairs to study the charge collection efficiency of radiation-damaged silicon sensors. In order to determine the absolute number of produced charge carriers, the light absorption coefficient, $\alpha$, has to be known.

To study the change of $\alpha$ due to radiation-induced defects, we have measured the transmission of light with wavelengths between 1-2 $\mu$m through silicon samples irradiated to 1 MeV-neutron-equivalent fluences between 0 and $1 \times 10^{17}$ cm$^{-2}$.

In this contribution, the results of these measurements will be presented: the contribution of the irradiation to $\alpha$ was found to scale with fluence for the entire fluence range investigated. In the wavelength region around 1.8 $\mu$m, evidence for the production of the radiation-induced divacancy defect $V_{2i}^0$ with a density approximately proportional to the fluence was found. A decrease of the effective band gap of silicon with irradiation fluence will be shown, up to a reduction of about 60 meV for a fluence of $1 \times 10^{17}$ cm$^{-2}$.

T 13.4 Mon 17:00 T-H26

**Studies of irradiated ATLASpix3.1 sensors for the LHCb MightyTracker** — •Jan Hammerich for the LHCb MightyTracker group-Collaboration — University of Liverpool, Liverpool, United Kingdom

The Mighty Tracker is a proposed upgrade to the downstream tracking system of LHCb for operations at luminosities of up to $1.5 \times 10^{34}$ cm$^{-2}$ s$^{-1}$ starting with the LHC Run 5 data taking period. It foresees the replacement of the most central area of the current scintillating fibre tracker with High Voltage CMOS (HV-CMOS) pixel sensors. HV-CMOS sensors have demonstrated a significant radiation tolerance and good performance making them an ideal choice of technology for the LHCb experiment.

Monolithic Active Pixel Sensors (MAPS) fabricated in HV-CMOS processes provide fast charge collection via drift and allow the implementation of the readout on the same die as the sensitive volume. Due to the use of commercial processes, these sensors can be fabricated at low cost as no hybridisation with bump bonds is required. Since they are not fully depleted, the inactive volume can be thinned away.

A dedicated sensor called the MightyPix is developed for this programme. It is based on the HV-MAPS families MuPix and ATLASpix and tailored to the requirements of LHCb. To demonstrate the feasibility of this technology for the LHCb environment, ATLASpix3.1 sensors have been irradiated. These sensors are studied in terms of time resolution and power dissipation in a temperature controlled environment.

T 13.5 Mon 17:15 T-H26

**Full-size passive CMOS sensors for radiation tolerant hybrid pixel detectors** — •Yannick Dieter[1], Michael Daas[1], Tomasz Hemperek[1], Fabian Hügging[1], Hans Krüger[1], David-Leon Pohl[1], Tianyang Wang[2], Norbert Wermes[1], Pascal Wolf[1], and Jochen Dingfelder[1] — [1]Physikalisches Institut der Universität Bonn — [2]Zhangjiang Laboratory, China

CMOS process lines are an attractive option for the fabrication of hybrid pixel sensors for large-scale detectors like ATLAS and CMS. Besides the cost-effectiveness and high throughput of commercial CMOS lines, multiple features like poly-silicon layers, metal-insulator-metal capacitors and several metal layers are available to enhance the sensor design.

After an extensive R&D programme with several prototype sensors in 150 nm LFoundry technology, passive CMOS pixel sensors have been manufactured for the first time as full-size sensors compatible with the RD53 readout chips designed for the ATLAS and CMS tracker upgrades.

This presentation will focus on IV-curve and hit-detection efficiency measurements and the characterization of the full-size sensors, before and after irradiation to fluences of $2 \times 10^{15}\,\mathrm{n_{eq}/cm^2}$ and $5 \times 10^{15}\,\mathrm{n_{eq}/cm^2}$, using a minimum ionising electron beam.

T 13.6 Mon 17:30 T-H26

**Electrical characterisation of passive CMOS strip sensors** — •Hannah Jansen[1], Jan-Hendrik Arling[3], Marta Baselga[1], Leena Diehl[2], Ingrid Maria Gregor[3,4], Tomasz Hemperek[4], Kevin Kröninger[1], Sven Mägdefessel[2], Ulrich Parzefall[2], Arturo Rodriguez[2], Surabhi Sharma[3], Dennis Sperlich[2], and Jens Weingarten[1] — [1]TU Dortmund University — [2]University of Freiburg — [3]DESY Hamburg — [4]University of Bonn

One of the major limitations of experiments in high energy physics are the production costs of the sensors used. Silicon sensors made with CMOS technology can solve this problem because they are very cost efficient and allow big production possibilities. Therefore, passive CMOS strip sensors with different implant layout types are investigated in this project to determine their suitability for high energy physics experiments as well as in medical applications. In particular, large passive strip sensors produced with CMOS technology are considered. In this talk, the current results of the electrical characterisation of the passive CMOS strip sensors will be presented.

T 13.7 Mon 17:45 T-H26

**Total Ionizing Dose effects on CMOS Image Sensor of the ULTRASAT space mission** — •Vlad Dumitru Berlea for the

ULTRASAT-Collaboration — DESY Zeuthen Platanenallee 6, 15738

ULTRASAT (ULtraviolet TRansient Astronomy SATellite) is a wide-angle space telescope that will perform deep time-resolved surveys in the near ultraviolet spectrum. ULTRASAT is led by the Weizmann Institute of Science (WIS) in Israel and the Israel Space Agency (ISA) and is planned for launch in 2024. The telescope implements a backside-illuminated, stitched pixel detector. The pixel has 4T architecture with a pitch of 9.5 $\mu$m and is produced in 180 nm process by Tower Semiconductor.

As part of the space qualification for the sensors, radiation tests are to be performed on both test sensors provided by Tower and the final flight design of the sensor. One of the main contributions to sensor degradation due to radiation for the ULTRASAT mission is Total Ionizing Dose (TID). TID measurements on the test sensors have been performed with Co-60 gamma source at Helmholz Zentrum Berlin (HZB) and CC-60 facilities at CERN, and preliminary results are presented in this talk.

T 13.8 Mon 18:00 T-H26

**CVD diamonds for the use in radiation hard particle detectors** — Holger Stevens, •Patrick Hölken, and Robert Konradi — Experimentelle Physik 5, TU Dortmund

Chemical-vapor deposition (CVD) diamond sensors have gained more influence in the area of particle detection in recent years. For example, they are used in the beam conditions monitor (BCM) of the LHCb experiment at CERN. The BCM monitors the quality of the particle beam and can abort the beam in flawed conditions, such as insufficient beam focus, to protect the experiment setup from possible radiation damage. The big advantages of CVD diamonds include their radiation hardness and fast response time. Furthermore, the CVD diamonds have a high tissue equivalence, which is why they are theoretically well suited for clinical dosimetry in hospitals.
In order to further investigate the radiation characteristics of the diamonds, measurements of the time behavior are carried out. In addition, a possible spatial resolution of the diamond sensors is of interest. This talk will give an overview about the results of these studies.