T 48: Silicon Detectors V (R&D, Simulation)

Time: Wednesday 16:15–18:45 Location: VG 0.111

T 48.1 Wed 16:15 VG 0.111

Design and Production of Pixel Strip Modules for the P2 Tracking Detector — •Lucas Sebastian Binn for the P2-Collaboration — Institute of Nuclear Physics, Johannes Gutenberg-University Mainz

The P2 Experiment at the new Mainz Energy-Recovering Superconducting Accelerator (MESA), which is currently under construction in Mainz, will measure the weak mixing angle in electron-proton scattering at low momentum transfer with unprecedented precision.

A key parameter for the analysis, the momentum transfer Q^2, is measured by a tracking detector consisting of 4 identical modules arranged in two layers. Each module consists of two sensor planes, with pixel sensors glued and wire-bonded on rigid-flex strips.

The mechanical, electrical, and cooling design have been developed and are currently undergoing testing. For this purpose, a scaled-down protoype has been constructed.

With a total production of 260 strips, processes are semi-automated, with dedicated glue and bonding machines.

This talk gives an overview of the P2 experiment with focus on the tracking detector, as well as the current state of the development of the strip modules and readout.

T 48.2 Wed 16:30 VG 0.111

Validation of TCAD simulations of the edge of planar silicon sensors to understand breakdown — •Christian Scharf[1], Peilin Li[1], Heiko Lacker[1], Ingo Bloch[2], Ilona Stefana Ninca[2], and Ben Brüers[2] — [1]Humboldt-Universität zu Berlin — [2]Deutsches Elektronen-Synchrotron (DESY)

Silicon sensors are widely used in high-energy physics due to their low material budget and radiation hardness. However, they are susceptible to surface breakdown, particularly under humid conditions. This study aims to improve the understanding of the underlying mechanisms by identifying the relevant defects contributing to electrical breakdown, and developing new methods to probe the electric field at the sensor's edge. Avalanche breakdown primarily occurs near the Si-SiO_2-interface, where localized electric field peaks can form between the guard ring and the edge. The local electric field is influenced by defects near the oxide surface and interface as well as the geometry of the sensor. Therefore, accurate simulations are challenging and it is essential to validate simulation parameters by comparing the simulation results to measurements.

The edge region of planar silicon diodes was simulated using Synopsis TCAD. Current, capacitance, and Transient Current Technique (TCT) simulations were performed and compared to measurements. Additionally, Allpix Squared simulations were used to determine whether the surface electric field near the edge can be extracted from top TCT measurements with 660 nm laser pulses using the prompt current method, similar to edge TCT.

T 48.3 Wed 16:45 VG 0.111

Open-Source Simulation of Semiconductor Detectors using SolidStateDetectors.jl — •Felix Hagemann, Julian Henzler, Benedikt Nagler, Ariana Pearson, and Oliver Schulz — Max Planck Institut für Physik, Garching, Deutschland

`SolidStateDetectors.jl` is a novel open-source software solution used to simulate the behavior of solid state detectors, e.g. germanium and silicon detectors. The package calculates the electric fields and weighting potentials, as well as the charge drift in the detectors and detector output signals.

Users can define arbitrary detector geometries via simple configuration files using constructive solid geometry. Detectors may also be segmented/pixelized and have more than two electrical contacts. The environment of the detector can be included in the geometry and the field calculation to simulate the effect of nearby objects on the field in detectors with large passivated surfaces.

`SolidStateDetectors.jl` features fully multi-threaded high-performance 3D field calculation in both cylindrical and Cartesian coordinates. Recent feature additions include simulation of the charge-cloud self-interactions, automatic detector capacitance calculation, GPU-support for accelerated field calculations, a simple charge trapping model and an extension to the Julia wrapper `Geant4.jl`, which allows for the simulation of realistic event distributions.

T 48.4 Wed 17:00 VG 0.111

Resistive Silicon Detector R&D for Future Detectors — •Ling Leander Grimm, Alexander Dierlamm, Umut Elicabuk, Ulrich Husemann, Markus Klute, and Brendan Regnery — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

The HL-LHC and future colliders present new challenges for the next generation of detectors, including improving pileup mitigation in high luminosity environments and particle identification. Resistive Silicon Detectors (RSDs/AC-LGADs) provide a promising solution by allowing "4D" tracking while minimizing power consumption, number of readout channels, and material budget.

RSDs combine Low Gain Avalanche Diode (LGAD) technology with a resistive cathode layer. Thanks to internal gain, the detector can be kept thin and therefore reduce material budget, while the resistive layer enables charge sharing among readout electrodes. As a result, the electrodes can be spaced further apart, which decreases the total number of required readout channels.

TCAD simulations aid in optimizing detector parameters and understanding internal functionality. Especially important is the determination of pad size and electrode shape.

This talk presents recent progress in Sentaurus TCAD simulations and experimental advances for RSD development at KIT and INFN/University of Torino.

T 48.5 Wed 17:15 VG 0.111

Measurements on the bPOL48V DC-DC Converter for a Future Particle Collider — Lutz Feld, Katja Klein, Martin Lipinski, Alexander Pauls, and •Joëlle Savelberg — 1. Physikalisches Institut B, RWTH Aachen

The bPOL48V is a DC-DC Point-Of-Load (POL) converter characterized in collaboration with CERN under the DRD7 program, a new Detector R&D initiative to develop future electronic systems and technologies for particle physics detectors. The bPOL48V enables power distribution by converting a 48V input to a 12V (adjustable) output voltage. This enables distribution at higher voltage and reduced current in supply cables, enhancing overall system efficiency by minimizing the power loss.

The bPOL48V consists of a rad-hard controller designed at CERN (GaN Controller), which is capable of continuous operation up to a high radiation limit of 50 Mrad and in magnetic fields exceeding 4 T. The GaN controller operates in conjunction with a power stage featuring a GaN chipset from EPC (EPC2152). This combination provides performance in harsh radiation and magnetic field environments, making it a potential solution for power distribution in high energy physics experiments.

This talk focuses on the tests conducted with the bPOL48V in various setups and the resulting performance. Key aspects include the converter's efficiency, temperature dependency, noise characteristics, and its ability to maintain a stable output voltage despite variations in input voltage and current.

T 48.6 Wed 17:30 VG 0.111

Characterisation and Simulation of stitched CMOS Strip Sensors — •Naomi Davis for the CMOS Strips Collaboration-Collaboration — Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany

In high-energy physics, there is a need to investigate silicon sensor concepts that offer large- area coverage and cost-efficiency for particle tracking detectors. Sensors based on CMOS imaging technology present a promising alternative silicon sensor concept. As this technology follows a standardised industry process, it can provide lower sensor production costs and enable fast and large-scale production from various vendors.

The CMOS Strips project is investigating passive CMOS strip sensors fabricated by LFoundry in a 150 nm technology. The stitching technique was employed to develop two different strip sensor formats. The strip implant layout varies in doping concentration and width, allowing to study various depletion concepts and electric field configurations.

The performance of unirradiated samples is evaluated based on several test beam campaigns conducted at the DESY II test beam facility. Additionally, the detector response is simulated using Monte Carlo methods combined with TCAD Device simulations.

This contribution presents studies on the test beam performance of the sensors concerning their hit detection efficiency and resolution. In particular, the simulated detector response is presented and compared to test beam data.

T 48.7 Wed 17:45 VG 0.111

A novel Low Gain Avalanche Diode design: MARTHA — •Constanze Wais[1], Alexander Bähr[2], J. Damore[2], Erika Garutti[1], Christian Koffmane[2], Jelena Ninkovic[2], Rainer Richter[2], Gerhard Schaller[2], Florian Schopper[2], Jörn Schwandt[1], Johannes Treis[2], and Annika Vauth[1] — [1]University of Hamburg — [2]Semiconductor Laboratory of the Max Planck Society

The MARTHA - 'Monolithic Array of Reach THrough Avalanche photo diodes' design aims to tackle the collapse of the electric field at the gaps of LGAD (low gain avalanche diode) pixel arrays while also preventing the pixel edges from becoming blind. By adding an additional n-doped field drop layer (FDL) between the multiplication layer and the n^+-pixel contacts, the electric field at the n^+-edges is reduced, thereby preventing them from breaking down. Since this FDL does not interrupt the multiplication layer, particle detection is also possible in the interpixel regions. A first prototype batch with test structures, such as diodes with and without a gain layer, and strip sensors based on the MARTHA principle has already been fabricated. The sensors are optimised for photon science and are expected to have a fill factor of 100%. In this talk the MARTHA concept as well as initial characterisation measurements, utilising I-V, C-V and TCT techniques, will be presented.

T 48.8 Wed 18:00 VG 0.111

Exploring the potential of 4H-SiC diodes: Electrical properties and electron-hole pair creation energy — •Silas Müller[1], Pascal Wolf[1], Patrick Ahlburg[1], Grégory Grosset[2], Tomasz Hemperek[1], and Jochen Dingfelder[1] — [1]University of Bonn, Physikalisches Institut, Nußallee 12, 53115 Bonn, Germany — [2]Ion Beam Services IBS, Rue Gaston Imbert prolongée, ZI Peynier Rousset, 13790 Peynier, France

Silicon detectors are often used as tracking detectors in high-energy physics experiments as they can be designed for high radiation tolerance, high granularity and fast readout needed in such experiments. Furthermore, silicon is well understood and widely available. Silicon carbide (SiC) exhibits promising characteristics for the use in high-energy physics as well. Its wide band gap of 3.23 eV results in low leakage current, allowing for operation at high temperatures. The high displacement energy of 30-40 eV compared to 13-15 eV in silicon results in potentially better radiation hardness.

This talk presents an investigation of the properties of a p-in-n 4H-SiC diode. Details regarding the electrical characteristics of the diode as well as measurements determining the energy needed to create electron-hole pairs in 4H-SiC are discussed.

T 48.9 Wed 18:15 VG 0.111

Wafer-to-wafer bonded hybrid pixel detectors for high energy physics and medical applications — Fabian Hügging[1], Kevin Kröninger[2], Maximilian Mucha[1], •Janna Vischer[2], and Jens Weingarten[2] — [1]Universität Bonn, Bonn, Germany — [2]Technische Universität Dortmund, Dortmund, Germany

Semiconductor pixel detectors allow for precisely tracking ionizing particles in high-energy physics experiments and medical applications. Previously, during the manufacturing of hybrid pixel detectors, a common practice to combine the separately manufactured sensor and its readout chip is to bump-bond two single dies together. Wafer-to-wafer bonding is a method in development for manufacturing hybrid pixel detectors, where whole detector wafers and chip wafers are bonded before being diced to their definite size. This promises detectors to have larger sensitive areas and a reduced thickness through thinning of the wafers after bonding. Currently, silicon sensor wafers have been developed for a combination with Timepix3 read-out chip wafers.

This talk will give an introduction to the first wafer-to-wafer semiconductor pixel detectors with a focus on the investigations of the still unbounded sensor wafer and a prospect of upcoming bonded wafer measurements.

T 48.10 Wed 18:30 VG 0.111

Test beam analysis of irradiated, passive CMOS strip sensors — •Fabian Lex for the CMOS Strips Collaboration-Collaboration — Albert-Ludwigs-Universität Freiburg, Freiburg, Germany

Nearly all envisioned future high-energy particle detectors will employ silicon sensors as their main tracking devices. Due to the increased demand in performance, large areas of the detectors will have to be covered with radiation hard silicon, facilitating the need for silicon sensors produced in large quantities, reliably and cost-efficiently. A possible solution to these challenges has been found in the utilization of the CMOS process, which is an industrial standard, offering the advantage of a large choice of vendors and reduced production costs. To create the larger sensor structures typical for silicon strip trackers, the stitching process has to be used. Three variations of passive CMOS strip sensors have been designed by the University of Bonn and produced by LFoundry in a 150 nm process. Sensor samples have been irradiated up to a fluence of $1 \cdot 10^{16} \mathrm{n_{eq}/cm^2}$ with reactor neutrons and up to $1 \cdot 10^{15} \mathrm{n_{eq}/cm^2}$ with 23 GeV protons. In order to investigate the general performance of the designs, they were simulated with Sentaurus TCAD software and investigated in several test beam campaigns at the DESY-II facility. This talk will summarise the most important results of the simulation as well as the measurements of the irradiated samples.