T 40: Pixel Detectors 2

Time: Tuesday 16:15–18:30 Location: T-H25

T 40.1 Tue 16:15 T-H25

Tangerine: Monte Carlo simulations of MAPS in a 65 nm imaging process — •Manuel Alejandro Del Rio Viera, Håkan Wennlöf, and Adriana Simancas for the Tangerine-Collaboration — Deutsches Elektronen-Synchrotron (DESY)

The Tangerine project's goal is to develop the next generation of small collection electrode monolithic silicon pixel detectors using the 65 nm CMOS imaging process. This offers a higher logic density and overall lower power consumption compared to previously used processes. In monolithic sensors the sensitive volume and readout are in a single chip, which enables a lower material budget, and reduced cost and production effort compared to hybrid sensors.

In order to understand the processes and parameters that are involved in the developments in the new 65 nm technology, a combination of TCAD and Monte Carlo (MC) simulations are used. Allpix Squared utilizes the realistic electric fields and doping profiles provided by the TCAD simulations and by the use of MC methods, obtains results that can later be compared to experimental data from test beam experiments.

This presentation will cover the design and setup of the Monte Carlo simulations and present the results obtained so far.

T 40.2 Tue 16:30 T-H25

Tangerine project - Studies of MAPS prototypes in CMOS 65 nm technology — •Gianpiero Vignola for the Tangerine-Collaboration — Deutsches Elektronen-Synchrotron, Hamburg, Germany

CMOS Monolithic Active Pixel Sensors, widely used as imaging devices, represent an attractive alternative to hybrid pixel detectors in High Energy Physics. The Tangerine project at DESY aims to develop a fully integrated 65 *nm* CMOS pixel sensor for future application, from beam-test facilities to Higgs factories. The goal is to achieve time resolutions of the order of 1 ns and spatial resolution below 3 μm. First 65 *nm* CMOS test chips with 4 pixels of 16 μm pitch and analog readout have been investigated in beam-test studies and with an Iron-55 source. Results of detailed waveform analysis, characterizing the charge sensitive amplifier, will be reported. The outcome of these studies will be used to improve the sensor layout and its signal-processing circuitry in the next Tangerine prototype.

T 40.3 Tue 16:45 T-H25

Device simulations of a MAPS developed in 65nm CMOS Imaging Technology — •Adriana Simancas for the Tangerine-Collaboration — Deutsches Elektronen-Synchrotron, Hamburg, Deutschland

Monolithic CMOS sensors have found their way through imaging technologies into High Energy Physics thanks to multiple advantages in particle detection. Their main characteristic is the integration of an active sensor and readout in the same silicon wafer, which provides a reduction in production effort, costs and material. The Tangerine project aims to develop the next generation of silicon pixel sensors for lepton colliders using a 65 nm CMOS imaging technology with a small collection electrode. It offers a significant improvement in the logic density of the pixels, the power consumption, the material budget and the S/N in comparison to previously studied technologies. Since the electric fields in monolithic sensors are quite complex, device simulations are needed to develop an understanding of this technology and provide important insight into performance parameters of the sensor. TCAD is a very powerful tool that allows to simulate the electrical properties of semiconductors. Herewith, it is possible to optimize the sensor layout and other features to achieve excellent time and spatial resolution. This contribution will present the latest developments in device simulation of a 65 nm CMOS sensor with a small collection electrode using TCAD.

T 40.4 Tue 17:00 T-H25

Simulating Hexagonal Monolithic Pixel Sensors in CMOS Imaging Technology — •Larissa Mendes for the Tangerine-Collaboration — Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany

In this research, monolithic pixel sensors in CMOS imaging technologies with small collection electrodes are investigated for fast signal collection and precise timing to be used at future lepton colliders. Integrated monolithic CMOS offers a cost-effective monolithic integration of sensor and electronics. It allows significant reductions in the material budget compared to hybrid pixel detectors, providing an excellent signal-to-noise ratio and position resolution.

When compared to a square grid, the distance between the pixel border and the collection electrode can be reduced by placing the collection electrodes on a hexagonal grid for a given area defined by the circuit functionality. The hexagonal grid reduces charge sharing, increasing the signal in the seed pixel. The studies are being carried out with 3D Synopsys' Technology Computer-Aided Design (TCAD) to create a sensor structure that can optimize the depletion region size and increase the lateral electric field for fast charge collection by drift. The electrode size, electrode size, as well as other parameters of the sensor design, are optimized using 3D TCAD simulations.

T 40.5 Tue 17:15 T-H25

Guard-ring optimisation for sensors in LFoundry 150nm CMOS technology — •Sinuo Zhang, Tomasz Hemperek, and Jochen Dingfelder — Physikalishes Institut, Rheinishe Friedrich-Welhem Universität Bonn, Nussallee 12, 53115 Bonn, Germany

In high energy physics, the silicon pixel sensors manufactured in commercial CMOS chip fabrication lines have been proven to have a good radiation hardness and spatial resolution. Along with the mature manufacturing techniques and the potential of large throughput provided by the foundries, the so-called "passive CMOS" sensor has become an interesting alternative to standard planar sensors, in particular for large-area applications. High and predictable breakdown behaviour for pre- and post-irradiation is a major design goal for sensors and the guard-ring structure is one factor to optimise. This is especially important for applications that require higher voltages.

We present several concepts of the guard-ring design that can be realised in LFoundry 150nm CMOS technology. As was studied with TCAD simulations, such designs can lead to a higher breakdown voltage by modifying the potential and electric field distribution in the guard-ring area. A number of test structures have been designed for the RD50 MPW-3 and the CMS CROC submission for verifications and further studies.

T 40.6 Tue 17:30 T-H25

Monte Carlo simulations of a beam telescope setup based on the 65nm CMOS Imaging Technology — •Sara Ruiz Daza for the Tangerine-Collaboration — Deutsches Elektronen-Synchrotron, Hamburg, Germany

Monolithic CMOS sensors enable the development of detectors with a low material budget and a low fabrication cost. Moreover, using a small collection electrode results in a small sensor capacitance, a low analogue power consumption, and a large signal-to-noise ratio. These characteristics have become very attractive in the development of new silicon sensors for charged particle tracking at future experiments. A beam telescope setup consisting of detector prototypes designed in a novel 65 nm CMOS imaging process is being simulated. This contribution describes the first steps and verifications in the design of such a telescope using the Allpix Squared and Corryvreckan frameworks for simulation and analysis.

T 40.7 Tue 17:45 T-H25

The Allpix Squared pixel detector simulation framework — •Håkan Wennlöf, Simon Spannagel, and Paul Schütze — DESY, Notkestrasse 85, 22607 Hamburg, Germany

The Allpix Squared sensor simulation framework is a modular and flexible open-source tool for simulating pixel detectors. The framework has the capability of simulating the full detector chain, from energy deposited by incident particles to signal formation and digitisation. Both single detectors and more complex setups, such as testbeam telescope experiments, can be investigated in great detail. Through its interface to GEANT4, Allpix Squared has access to advanced physics models and particle sources. The framework can also import fields and doping maps from technology computer-aided design (TCAD) simulations, creating a detailed simulation of individual charge carrier behaviour in the investigated sensor models. This yields a powerful combination of TCAD and Monte Carlo simulations, which provides accurate highstatistics results while also accounting for stochastic fluctuations in the involved processes. This method has been used in comparing simulations with testbeam data, and finding a good match between results. Through the detailed electric field inclusion, time-dependent charge pulse formation can also be simulated in the framework.

Allpix Squared is currently used as part of developments of several state-of-the art sensors, for example in the Tangerine project at DESY. This contribution will present the current status of the Allpix Squared framework, and give examples of use cases.

T 40.8 Tue 18:00 T-H25

Development and characterization of a DMAPS chip in TowerJazz 180 nm technology for high radiation environments
— Ivan Berdalovic[2], •Christian Bespin[1], Jochen Dingfelder[1], Tomasz Hemperek[1], Toko Hirono[1,3], Fabian Hügging[1], Hans Krüger[1], Thanushan Kugathasan[2], Cesar Augusto Marin Tobon[2], Konstantinos Moustakas[1], Heinz Pernegger[2], Walter Snoeys[2], Tianyang Wang[1], and Norbert Wermes[1] — [1]Universität Bonn, Bonn, Deutschland — [2]CERN, Genf, Schweiz — [3]DESY, Hamburg, Deutschland

The increasing availability of commercial CMOS processes with high-resistivity wafers has fueled the R&D of depleted monolithic active pixel sensors (DMAPS) for usage in high energy physics experiments. One of these developments is a series of monolithic pixel detectors with column-drain readout architecture and small collection electrode facilitating low-power designs: the TJ-Monopix series.

TJ-Monopix is designed in a 180 nm TowerJazz CMOS process and features a pixel size of 33 um * 33 um. Due to improvements on the front-end electronics and sensor design of the current iteration TJ-Monopix2 the radiation hardness and efficiency could be increased while lowering the threshold and noise. Results from laboratory measurements and test beam campaigns will be presented to discuss the suitability of TJ-Monopix2 for use in high-radiation environments.

T 40.9 Tue 18:15 T-H25

Characterization of depleted monolithic active pixel sensors (DMAPS) designed in 150nm CMOS technology
— •Lars Schall[1], Jochen Dingfelder[1], Christian Bespin[1], Ivan Caicedo[1], Tomasz Hemperek[1], Toko Hirono[1,2], Fabian Hügging[1], Hans Krüger[1], Piotr Rymaszewski[1], Tianyang Wang[1,3], and Norbert Wermes[1] — [1]Physikalisches Insitut, University of Bonn — [2]DESY, Hamburg — [3]Zhangjiang Laboratory, China

Monolithic active pixel sensors with depleted substrates are a promising option for pixel tracker detectors in high radiation environments. The use of a highly resistive silicon substrate and short drift paths enhance the radiation tolerance, while a careful guard ring design facilitates high biasing voltages to deplete the sensor.

LF-Monopix2 is the latest prototype of a DMAPS development in 150 nm CMOS technology. It features a fully functional column-drain readout architecture in a 2x1 cm^2 matrix. A reduced pixel pitch of 50x150 μm^2 compared to its predecessor results in a smaller detector capacitance and an improved spatial resolution. Each pixel's digital electronics are integrated within the large collection electrode. Optimization of the pixel layout minimizes potential cross talk from the digital transients into the sensor node.

LF-Monopix2 chips have successfully been thinned to a thickness of 100 μm while their breakdown voltage remained above 350 V. In this talk, the ongoing characterization and preliminary results of the first test-beam campaign of these sensors are discussed.