Characterisation and simulation of stitched CMOS strip sensors

NAOMI DAVIS

Deutsches Elektronen-Synchrotron

Particle tracking detectors in high-energy physics primarily rely on silicon sensors as tracking devices. With the active area of tracking detectors constantly increasing, the high-energy physics community faces a challenge in scaling production volumes and managing costs to cover large-area detectors with high-resolution, radiation-hard silicon sensors. Based on this challenge, sensors for particle tracking are only produced by a few foundries, creating the risk of a single-vendor scenario.

This study addresses that challenge by exploring strip sensors based on CMOS imaging technology. CMOS imaging technology is widely used for industrial and commercial silicon sensor production, offering access to fast, large-scale production by various vendors. In addition, one can profit from the larger wafer size available in commercial processes.

The CMOS Strips project is investigating stitched, passive CMOS strip sensors fabricated by LFoundry in a 150 nm technology. The sensors are produced on p-type, 8-inch, Float-Zone wafers with a resistivity between $3\,\mathrm{k\Omega}$ and $5\,\mathrm{k\Omega}$. The wafers undergo an additional production step at IZM Berlin, where they are thinned down to a thickness of $150(10)\,\mu\mathrm{m}$ from the backside and a laser-annealed p^+ layer with a closing metallisation layer is implemented as backside implant. The stitching technique enables the realisation of a long (4.1 cm) and a short (2.1 cm) strip sensor format. Furthermore, the strip implant design varies in doping concentration and width to study various electric field configurations.

The sensor performance of an unirradiated sample is characterised based on measurements at the DESY II Test Beam Facility. The sample is measured with a 4.2 GeV electron beam and the ADENIUM beam telescope as a reference for reconstructing particle trajectories through the Device Under Test (DUT).

Additionally, an initial study of the charge carrier propagation for the various strip sensor layouts is conducted with the Allpix^2 framework. In order to evaluate the impact of the intrinsic sensor characteristics on charge carriers generated within the sensor, the electric field and doping concentration of the sensor from a finalised TCAD simulation are used as input to the Allpix^2 framework.

This contribution demonstrates that the stitching technique does not compromise the hit detection efficiency or resolution of the strip sensors. Furthermore, a first look at the electric field within the sensor and its impact on generated charge carriers is presented.

Finally, an outlook on the next sensor development phase is given, including integrating a front-end stage to advance towards a fully monolithic strip sensor.