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Silicon Detectors Beyond LHC –RD50 Status Report

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Within the RD50 Collaboration, a large and dedicated R&D program has been underway for more than two decades across experimental boundaries to develop silicon sensors with high radiation tolerance for Phase-II LHC trackers. Based on the success of this R&D, these trackers are now entering their construction phase. RD50 is continuing its mission to study silicon sensors for particle tracking, shifting the focus to applications beyond the LHC. The next generation of collision experiments, such as the FCC, requires unprecedented radiation hardness in the range of a few $10^{17} N_{eq}$ as well as time resolutions of the order of 10ps. Another key challenge is to move the sensor technology away from traditional planar passive float-zone sensors, which form large parts of the current trackers to sensor technologies such as CMOS where front-end electronics can be integrated, and where a wide availability in industry promises cost advantages.

Key areas of recent RD50 research include technologies such as Low Gain Avalanche Diodes (LGADs), where a dedicated multiplication layer to create a high field region is built into the sensor, resulting in time resolutions of a few tens of ps. LGADs will be employed by both ATLAS and CMS for their Phase-II LHC Upgrade. The radiation hardness of LGADs can be increased by using Carbon-implanted sensors which can be processed on 8-inch wafers. We also study 3D sensors as extremely radiation-hard sensors for the innermost layers of Phase-II LHC trackers. Fig. 1 shows SEM images from a pre-production 3D sensor made for the ATLAS pixel upgrade at CNM Barcelona. In addition, we investigate dedicated 3D sensors as a radiation-tolerant alternative to LGADs for fast timing applications. In another R&D-line we seek for a deeper understanding of the connection between macroscopic sensor properties such as radiation-induced increase of leakage current, doping concentration and trapping, and the microscopic properties at the defect level. A new measurement tool available within RD50 are the Two-Photon-Absorption (TPA) TCT systems, which allow position-resolved measurements down to a few um.

We will summarise the current state-of-art in silicon detector development in terms of radiation hardness and fast timing, and give an outlook on silicon sensors options for e.g. the FCC.

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