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Measurements on HV-CMOS active sensors after irradiation to HL-LHC fluences

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Deep-submicron HV-CMOS processes feature moderate bulk resistivity and HV capability and are therefore good candidates for drift-based radiation-hard monolithic active pixel sensors (MAPS). It is possible to apply 60-100V of bias voltage leading to a depletion depth of ˜10-20 µm. Thanks to the high electric field, charge collection is fast and nearly insensitive to radiation-induced trapping. Alternatively, CMOS Imaging Processes often feature high-resistive substrates, thinning, stitching and backside processing, which makes them also interesting to study.

We explore the concept of using such processes to produce active pixel sensors (APS) that contain simple circuits to amplify and discriminate the signal. A readout chip (ROC) is still needed to receive and organize the data from the active sensor and handle high-level functionality such as trigger management. This chip can follow the pixel chip concept with the readout circuits distributed over the area of the chip, or the strip concept with one or few rows of pads along one (or more) sides of the chip. The connection between APS and ROC can be made in a “traditional”way (wire/bump-bonding) or by capacitive coupling (e.g. gluing) which could lower the production cost significantly.

The active sensor approach offers many advantages with respect to standard silicon sensors: fabrication in commercial CMOS processes costs less than traditional diode sensors, aggressive thinning is resulting in much lower mass, bias voltage and operation temperature requirements are favorable. From a practical perspective, maintaining the traditional separation between sensing and processing functions lowers development cost and makes use of existing infrastructure.

Test ASICs compatible with ATLAS readout chips were produced in a variety of processes. Pixel-like, strip-like and limited standalone readout could be selected on most devices. Measurements were done on chips either in standalone mode or capacitively coupled by gluing with less than about 10 µm of glue layer thickness. Results of their characterization will be shown, in particular also after irradiation to HL-LHC fluences (10^{15} n_{eq}/cm² to 10^{16} n_{eq}/cm² and up to 1GRad of dose). In addition, dedicated TCT and edge-TCT measurements have been conducted to study in detail the charge collection homogeneity and extension within the silicon bulk; first results will be shown.

Finally, plans for further submissions and improvements (e.g. production on high-resistivity (HR) substrates to increase the signal charge) and perspectives for the use of HV/HR-CMOS active sensors in the Inner Tracker upgrade of the ATLAS detector will be outlined.

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