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Slim edges in double-sided silicon 3D detectors

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Owing to several advantages provided by their peculiar structure, where the electrode distance is decoupled from the active thickness, silicon 3D detectors are emerging as one of the most promising technologies for future experiments at high luminosity particle colliders. An additional feature available with the original 3D technology is the active edge, enabling to reduce the insensitive edge region to less than 10 μm [1]. These interesting properties come at the expense of a rather complicated technology, involving several non standard steps such as wafer bonding and Deep Re-active Ion Etching.

Since 2004, we have developed modified 3D architectures aimed at a simplification of the manufacturing technology with respect to the original design. In particular, in the past few years, we have thoroughly investigated 3D-DTTC (Double-side, Double-Type-Column) detectors [2], which involve columnar electrodes of both doping types etched from both wafer sides (junction columns from the front side and ohmic columns from the back side), and stopping at a short distance from the opposite surface. A similar approach is pursued by CNM-IMB (Barcelona, Spain) [3]. In 3D-DDTC detectors, the charge collection efficiency and the radiation hardness critically depend on the columnar electrode overlap. In order to rule out the effects of the column depth non uniformities on the detector characteristics, we have developed a modified 3D-DDTC process allowing for passing-through columns [4]. This advanced 3D-DDTC process still does not require a support wafer, thus avoiding the related wafer bonding and final removal. One additional advantage is that the wafer back-side is fully accessible: the detector substrate bias can be provided from the back-side, and dual-readout detector systems can be easily achieved. Two batches of these new detectors have been fabricated and are currently being tested both in laboratory and in beam tests. A few more batches are being fabricated as a pre-production for the ATLAS Insertable B Layer.

In this paper, we focus on one additional design option offered by these detectors, the so called "slim edge". In fact, the considered technology is not suitable for active edges, due to the absence of the support wafers. However, the active area can be terminated by a multiple ohmic column fence aimed at preventing the depletion region spreading from the outermost junction columns to reach the device physical edge. By doing so, no leakage current contribution from the highly damaged cut-line can reach the active area. Slim edge terminations have been designed with the aid of TCAD simulations and experimentally validated, showing that the insensitive region at the sensor edge can be reduced to less than 100 μm .

At the conference, the main design and technological issues will be reviewed and selected results from electrical and position resolved laser tests will be presented.

References

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