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Monolithic and hybrid pixel sensors in vertically integrated CMOS technology for vertexing applications

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Experiments at the future high luminosity colliders (like ILC, SuperB and SLHC) will set severe requirements on each of the parts making up the silicon vertex tracker (SVT), including the detector (i.e., the sensitive silicon volume) and the readout electronics. In order to separate the very dense particle jets emerging from the interaction region, the first detector layer will be placed very close to the pipeline axis and will have to provide remarkably high spatial resolution, with a pitch of a few tens of microns. Thin detectors, with overall thickness in the order of a few hundred microns or less, will be required for the purpose of minimizing the amount of material in the sensitive region of the tracker, therefore reducing multiple scattering and improving momentum measurement accuracy. While not being the only possible solution, vertical integration, or 3D, technologies may satisfy many (if not all) of the above requirements at the cost of some increase in process complexity. Use of a 3D technology, besides increasing the functional density in the front-end electronics, also is expected to improve the charge collection properties of the collecting electrode in the case of the so called deep N-well monolithic active pixel sensors (DNW MAPS). The first vertically integrated DNW monolithic sensors have been fabricated in the framework of the 3D-IC consortium, led by the ASIC design group at Fermilab and involving several European research teams. Single pixel elements, small matrices with simple analog output and large matrices (including up to 65 kpixels) with sparsified digital readout and time stamping have been integrated in a 130 nm, double tier 3D CMOS technology provided by Tezzaron Semiconductor and Globalfoundries. This work, besides describing the main design features of 3D front-end electronics for hybrid pixels and of 3D DNW MAPS, will present the first experimental results from the characterization of the 3D DNW MAPS prototypes.

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