Simulation and first characterization of MAPS test structures with gain for timing applications

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In the last two decades several projects have been tackling the development of new Monolithic Active Pixel Sensors (MAPS) technologies to provide a cost-effective solution for high-energy physics experiments as well as for space and medical applications [1, 2]. In the ARCADIA project, a main demonstrator chip with an active pixel matrix composed of 512 x 512 pixels with 25 μm pitch was developed in a modified 110 nm CMOS production process together with several different test devices in two engineering runs in 2020 and 2021. Passive pixel structures were extensively tested in the past years to qualify the sensor concept and the results of the electrical and dynamic characterization were compared with TCAD simulations reaching an excellent agreement [3]. In view of applications requiring sub-ns timing resolution, although the process offers fast charge collection by drift, the timing resolution is limited by electronics noise. An effective way to enhance the Signal to Noise Ratio (SNR) is the incorporation of a gain layer into monolithic detectors: this solution has been recently shown to improve the timing resolution in monolithic detectors [4].

The third engineering run of the project contains wafers with different substrate thicknesses ranging from 50 to 200 μm and was delivered at the beginning of April 2023. The wafers include test structures with an integrated gain layer, that were designed to improve the timing performance achievable with the proposed sensor technology. The preliminary results of the electrical characterization of the passive structures with gain showed the possibility of applying the bias voltages needed both to deplete the sensor substrate and activate charge multiplication. The first results of the dynamic characterization of the passive test structures with implanted gain layer, performed employing an optical setup with a focused IR laser with 100 ps pulse width and 1060 nm wavelength, proved the existence of a multiplication of the collected charge.

By the time of the conference the authors will be able to show a comparison between the results of the TCAD simulations, that are currently being tuned by considering the experimental results, and the experimental data of the electrical and optical characterization of the passive test structures with integrated gain.

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