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First prototypes of two-tier avalanche pixel sensors for particle detection

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In this paper, we present the proof-of-concept implementation and preliminary evaluation of a new type of silicon sensor based on Geiger-mode avalanche detectors. The proposed device, formed by two vertically-aligned pixelated detectors, exploits the coincidence between two simultaneous avalanche events to discriminate between particle-triggered detections and dark counts. This approach offers several advantages in applications requiring low material budget and fine detector segmentation as, for instance, for tracking and vertex reconstruction in particle physics experiments and charged particle imaging in medicine and biology. In addition, a timing resolution in the order of tens of picoseconds can potentially be achieved thanks to the fast onset of avalanche multiplication in Geiger-mode regime.
A two-tier sensor assembly was designed and fabricated in a commercial 0.15μm CMOS process. The sensor consists of a 48x16 pixel array, and includes avalanche diodes of different sizes to evaluate the detection efficiency for different fill factors. Each pixel, having a 50μm x 75μm area, includes detectors and electronics on both layers, with the top-layer signal transmitted to the bottom layer using a vertical interconnection per pixel. The two layers were tested separately and proved to be fully functional. Several sensor samples are currently being vertically-integrated through bump bonding. The first test results on the vertically-integrated sensors will be discussed.

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