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SPAD Array Chips with Integrated Readout with High Fill Factor and Low Dark Count Rate at Low Temperatures

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The observation of few optical photons is a very common requirement in instrumentation, for instance for the detection of scintillation photons from liquid noble gases in dark matter search experiments. The photon sensors must in particular offer low dark count rate (DCR), high fill factor and good quantum efficiency. Commonly used SiPMs require a single photon sensitive readout for each of many channels. We propose using Single Photon Avalanche Diodes (SPADs) fabricated in a CMOS technology so that the readout circuitry can be integrated and noisy pixels can be disabled. Chips fabricated in an optimized manufacturing process reach a DCR of 0.04 Hz per mm^2 of active SPAD area at 160 K for typical pixels. In the latest design, the geometric fill factor is above 80% and should still be around 70% after disabling noisy SPADs. The implemented low power readout is fully data driven and provides time-stamped hits with a spatial granularity of $\approx 250 \times 200 \mu\text{m}^2$. The proposed approach could provide a performant, compact, low power single photon readout for large area detectors.

Collaboration

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