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Multipixel Geiger-mode photon detectors for ultra-weak light sources.

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We developed and tested prototype arrays of Single Photon Avalanche Detectors (SPAD), fabricated in silicon planar technology and working at low voltage ($\gg 30$ V) in Geiger mode operation, to achieve a photon-resolving operational mode; the size of the elementary cells is from $20\text{ }\mu\text{m}$ up to $100\text{ }\mu\text{m}$. Coupling such a multipixel sensor to light sources as scintillators and laser, we have characterized the timing, amplitude, cross-talk, afterpulsing and the dependence from the temperature. For $50\text{ }\mu\text{m}$ diameter SPADs the measured gain is of the order of $106 \div 107$, with dark counting rates at room temperature below 1 kHz. The detection efficiency is typically around 50% at 550 nm, 10% at 850 nm and 3% at 1000 nm. We proved that in the single photon regime, obtained with a very low laser intensity, this photodetector can reconstruct the charge spectrum and the time profile of a sub-nanosecond optical pulse, while its intrinsic time resolution is below 100 ps. Between adjacent pixels we observed a cross-talk probability of the order of 10^{-4} , while we did not observe any indication of a dependence on the distance between the triggering pixel and its neighbour. We also tested a sensor where each pixel was optically isolated from the neighbours by means of an optical trench suitably placed around it. No difference was observed with respect to the standard sensor, and this excludes the optical cross-talk.

In the meanwhile, with the Deep Lithography with Ions (DLI) technology we are working to develop micro-mechanical and micro-optical components, finalized to optimize the coupling between light sources (fibers, bulk scintillators, etc) and the multipixel sensor. The goal is to fabricate compact high-sensitivity and high-resolution solid state photon detectors, for applications in several scientific areas, in particular regarding medical diagnostics, bioluminescence, TCSPS microscopy, chemical analysis, etc.

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