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Toward a Time Resolved Single Photon Image Sensor based on SPAD array

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Time resolved imaging up to the single photon sensitivity is one of the most ambitious and important goals of photonics. Currently there are no commercial devices able to provide both the information on position (imaging) and arrival time of photons emitted by weak and ultra-weak source. Only very expensive sensors (ICCD) are able to reach the single photon threshold with the possibility to get information in small time window (few ns) but unfortunately such devices are not able to provide any information on arrival time of photons.

There are applications where time correlation analysis is fundamental and actually this analysis is performed only by using the information of few points in the image. Many scientific areas like astronomy, biophysics, biomedicine, nuclear and plasma physics etc. can benefit from a time resolved imaging device; it can provide physical information otherwise inaccessible.

Recently, thanks to technological developments on Single Photon Avalanche Diodes (SPAD) [1 and internal ref.], the implementation of a time resolved imaging device, based on SPADs, has been proposed [2].

The key point is the read-out strategy; it should be easy, in order to read a great number of elements, and able to address the information of each individual sensor, in order to get its time response. The simplest strategy is to address each diode, with a consequent requirement of a great number of channels, n2 for a square matrix of n x n diodes. We proposed an alternative solution, a [1], initially based on the signals collection from both anode and cathode of the same diode. Signal extracted from anode is used to determine the row position while the cathode signal for the column position. The rows x columns strategy require a number of reading channels of 2n instead of n2. recent results will be discussed. We will present also the R&D work in collaboration with FBK (Fondazione Bruno Kessler) –Trento on the new bi-dimensional arrays, where we improved the pixel red-out by using two quenching resistor and the large-scale integration. General performance of the first prototypes will be presented.

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