Use of SPAD arrays for quantum technology

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Thanks to their capability to detect single photons with good timing resolution, Single Photon Avalanche Diode (SPAD) can be considered as a good candidate for quantum experiments. In this work we present recent advances on the design of SPAD-based devices for quantum technology in two different projects.

The SuperTwin project [1] aimed to develop an all-solid-state super resolution microscope based on entangled photons. A quantum image sensor having a large degree of flexibility has been developed [2]. In the 60k-pixels array, each element pairs a SPAD with a reconfigurable logic block that can operate in one of the following modes: (i) photon timestamping with a fine (180 ps) or (ii) coarse (≥ 10 ns) resolution, (iii) photon counting, or (iv) high-speed binary imaging. The imager shows a high sensitivity (PDP up to 60%) and low noise (DCR of 100 Hz). Figure 1 shows the chip functionalities and the first and second-order correlation function of an SPDC source in the far field.

One of the goals of the Qrange project [3] is to develop tiny and low-cost quantum random number generator (QRNG) for IoT application. Differently from other approaches, mainly using an external source of light, we investigated on monolithic solutions [4]. The final design consists of a SPAD-based array of independent cells each integrating one central emitter and multiple detectors for random number extraction (see Figure 2). Different sources of light (Si-LED) have been also implemented. The typical bit rate generated by each cell is to few kbps. The device is now under test for validation.

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References

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[3] https://qrange.eu/
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Figures

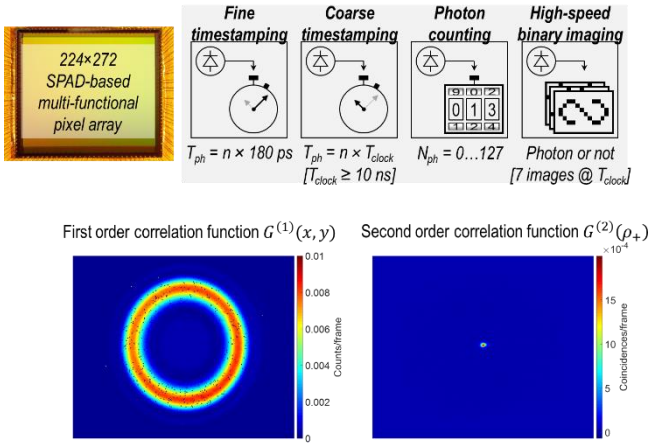

Figure 1: Micrograph and concept of the Quantum imager (top). Acquisition of SPDC photons (bottom)

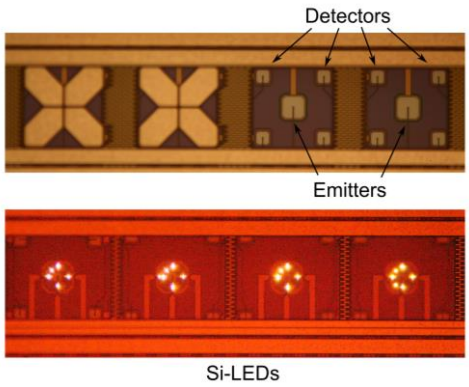

Figure 2: Implemented cell for random number generation and Si-LED.