Pulse position readout of a SNSPD array integrated in photonic circuit

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Single photons can be used as quantum bits for the optical implementation of quantum information processing (QIP) protocols. Many efforts have been devoted to scale such implementations up to few tens of photons, which can only be achieved by integrating all the key quantum optical functionalities on the same chip. Semiconductor photonic integrated circuits (PICs) operating at the single-photon level offer this perspective, but single-photon detection in waveguides is still challenging. SNSPDs [1] are unique detectors that showed a process compatibility with standard semiconductor PICs [2], nevertheless a full integration of all key components (sources, reconfigurable PICs and detectors) is still lacking and far from being achieved. Furthermore, the increasing complexity of integrated quantum optics experiments requires the manipulation of many modes and the simultaneous readout of an increasing number (N) of integrated detectors [3]. In this presentation, we discuss a new approach for the readout of several optical outputs using an integrated array of SNSPDs with pulse position resolution. A two elements array is fabricated on top of a silicon nitride PIC with a thermal silicon dioxide layer as bottom cladding. The configuration of the PIC is designed to measure the second order correlation function ($g2(\tau)$) of photons propagating in the circuits (see fig1 a). The light is coupled to the PIC using an input grating coupler (I), the photons travelling in the waveguide reach the two elements array detector (D1 and D2 see fig. 1b) passing through two 50:50 beam splitters (BS). During the experiment, the coupled power is controlled at the output port (O). Each active element of the array has in parallel a different normal resistance R_p (nominally R_2=2R_1). Fig1b) shows the array output taken with a 4 GHz bandwidth oscilloscope, being the array illuminated with a pulsed laser at 1550 nm at 1 MHz 10 ps pulse width and with an average number of photon per pulse ~1. Four pulse amplitudes corresponding to the firing of 0, 1 (D1 or D2) and 2 (D1 and D2 in coincidence) elements of the array are visible. The exploitation of this system allows the simultaneous readout of up to the SNSPDs using a single coaxial cable and consequently a reduction the thermal budget of the cryostat, permitting to operate a large number of integrated detectors.

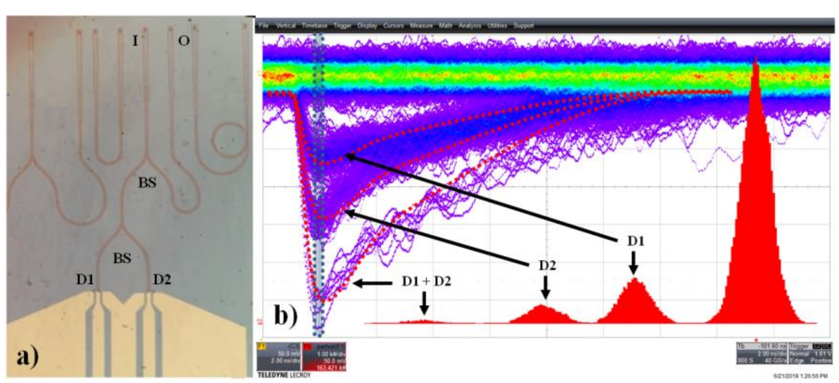

Figure 1: a) optical microscope image of PIC with integrated detectors. The PIC consists of a input grating coupler (I), two 50:50 beam splitters (BS) and the detectors (D1 and D2). The optical power is monitored through the output control port O. b) persistence trace of the array output. The source was a pulsed laser at 1550nm (1 MHz repetition rate, 10 ps pulse width). Four pulse amplitudes corresponding to the firing of 0, 1 (D1 or D2) and 2 (D1 and D2 in coincidence) elements of the array are visible. The histogram (in red) shows the population of each level in a 40ps time window.

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