

TEMPLATE

TITLE Quantum photonic circuits for chemical simulations

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ABSTRACT: Single photon sources are the main building blocks of quantum applications. Single photons can be generated by deterministic or probabilistic sources. One method to make a single photon probabilistic source is to use time correlated photon pairs generated by nonlinear optical processes: one uses one photon in the pair as the herald of the second photon. These sources are therefore named heralded single photon sources. They are easy to integrate at the chip level and with low cost. Within this framework, one platform is silicon photonics. Silicon has a high third order optical nonlinearity which enables efficient spontaneous four wave mixing (FWM) for correlated photon generation. Typically, such photons have to be strongly filtered to yield high purity single photons at the expenses of the source brightness. Moreover, they are generated close to the pump wavelength, suffering of high noise from pump and Raman photons. Such limitations can be mitigated by means of intermodal FWM, where phase matching is achieved by using different modes of multimode waveguides. Intermodal FWM exhibits discrete band phase matching which yields narrow band generation of high purity single photons. Moreover, the intermodal phase matching can be easily tuned with the waveguide geometry which allows wide wavelength separation between the generated photons. Therefore, the herald and heralded photons can be generated far from the Raman and pump wavelengths, with easy noise filtering. In addition, wide detuning allows making a chip scale MIR heralded single photon sources. This is of particular interest for quantum gas sensing and free space quantum communications. In the presentation, we will describe a silicon photonic integrated chip for intermodal FWM for single photon generation. We demonstrate the heralding of a single photon beyond 2 μm with the herald photon at 1260 nm. We measure a coincidence to accidental ratio larger than 50 and a single photon purity of 0.75 (see Figure 1).

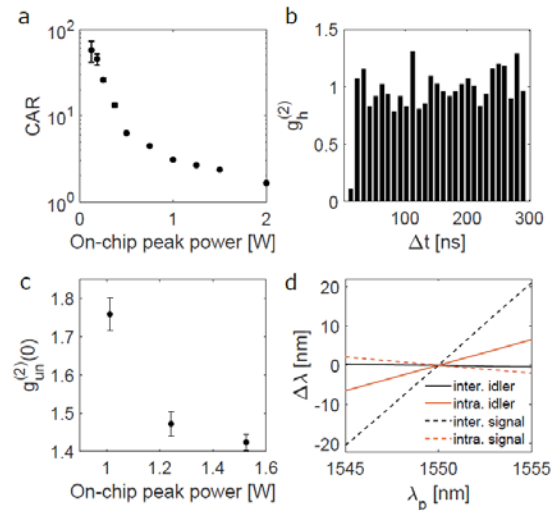


Figure 1 a) Measured CAR as a function of the pump power. b) Heralded $g(2)$ as a function of the delay between subsequent heralded detection. c) Unheralded $g(2)$ for the signal beam as a function of the pump power. d) Simulated wavelength variation of the generated pairs as a function of the pump wavelength.

References

- On-chip heralded single photon sources, S Signorini, L Pavesi AVS Quantum Science 2 (4), 041701 (2020)
Single-Particle Entanglement, S Azzini, S Mazzucchi, V Moretti, D Pastorello, L Pavesi Advanced Quantum Technologies 3 (10), 2000014 (2020)
Near-ideal spontaneous photon sources in silicon quantum photonics, S Paesani, M Borghi, S Signorini, A Mainos, L Pavesi, A Laing Nature communications 11 (1), 1-6 (2020)
Structures and methods for fully-integrated quantum random number generators, F Acerbi, N Massari, L Gasparini, A Tomasi, N Zorzi, G Fontana, L Pavesi, ... IEEE Journal of Selected Topics in Quantum Electronics (2020)