Integrated source of entangled photon pairs in a hybrid laser-written circuit

Simone Atzeni[1,2], *Adil S. Rab*[3], *Giacomo Corrielli*[1,2], *Emanuele Polino*[3], *Mauro Valeri*[3], *Paolo Mataloni*[3], *Nicolò Spagnolo*[3], *Andrea Crespi*[1,2], *Fabio Sciarrino*[3] *and Roberto Osellame*[1,2]

[1]*Istituto di Fotonica e Nanotecnologie - Consiglio Nazionale delle Ricerche (IFN-CNR), piazza Leonardo Da Vinci 32, 20133 Milano, Italy.*

[2]*Dipartimento di Fisica - Politecnico di Milano, piazza Leonardo da Vinci 32, 20133 Milano, Italy.*

[3]*Dipartimento di Fisica - Sapienza Università di Roma, piazzale Aldo Moro 5, 00185 Roma, Italy.*

The efficient generation of high quality quantum states of light is one of the main challenges in the field of experimental quantum optics, and plays a central role in the development of photonic quantum technologies. Adopting an integrated optics approach represents a promising strategy for the achievement of this goal, thanks to the unique features of compactness and stability offered by waveguide-based devices. [1]. In this framework, we report the development and the characterization of an integrated source of single photon pairs at telecom wavelength, based on spontaneous parametric down conversion (SPDC) in non-linear waveguide, capable of producing photon pairs both in separable or entangled states [2]. The scheme of our device is represented in Fig.1.

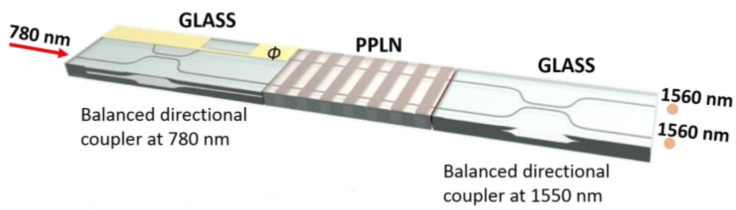

Figure 1: Schematic of the integrated photonics source of quantum light.

It consists in a reconfigurable Mach-Zehnder interferometer realized according to a modular approach, where a periodically poled lithium niobate (PPLN) chip, containing a pair of identical non-linear waveguides, is embedded between two glass chips containing two balanced directional couplers. All the components have been realized by femtosecond laser writing, confirming that this fabrication technique is extremely flexible, and it allows to process glass as well as crystalline materials [3]. The first chip works at 780 nm and its functionality is that of distributing equally the pump power in the PPLN waveguides. A thermo-optical phase adjuster fabricated on the top of one of the output arm permits to control the relative phase between the two optical modes. The waveguides in MgO:PPLN have been inscribed by adopting a multi-scan approach and they show single-mode behavior at both pump and down-converted wavelength (1560 nm). Interestingly, the non-linear features of this material are well preserved during the waveguide fabrication [4], and second harmonic generation experiments revealed that a very high degree of spectral indistinguishability is reached between the photons generated in the two waveguides. The third chip closes the interferometric loop and, depending from the value of the phase ϕ, permits to produce either a pair of indistinguishable photons, NOON states or polarization-entangled photons at the device output. The latter result is achieved by using for the last stage a specially designed glass chip, containing integrated optical waveplates and a symmetric polarization insensitive directional coupler [5]. In all cases, the fidelity of the generated states is higher than 93%, proving that the modular and hybrid approach followed is a very encouraging route towards the realization of complex integrated photonic platforms, with multiple applications in quantum technologies.

References

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