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Broadband Biphoton Generation and Polarization Splitting in a Monolithic AlGaAs Chip

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Summary

Integrated quantum photonics is a key tool towards large scale quantum technologies. In this work we present an AlGaAs-based photonic circuit for on-chip generation and manipulation of broadband orthogonally polarized photon pairs [1]. Among different platforms used for the development of quantum photonic chips AlGaAs is extremely interesting for integrability [2]. This material has a direct bandgap, enabling monolithic integration of active components [3] and presents a large electro-optic effect that can be exploited for the manipulation of photonic states [4]. In this work, broadband orthogonally polarized photon pairs are generated by Type-II spontaneous parametric down conversion in AlGaAs Bragg reflection waveguides at telecom wavelengths and room temperature [5]. Orthogonally polarized photons are deterministically separated over a broadband frequency range through a birefringent directional coupler. This device is based on evanescently coupled waveguides; by a careful design of an induced birefringence, photons of the pair are separated, following their different polarizations, in two different spatial modes. We demonstrate that 85% of the pairs are deterministically separated over a 60 nm bandwidth. The performances of the device as a quantum photonic circuit are assessed by implementing at the chip output a Hong-Ou-Mandel interferometer, one of the most fundamental nonclassical experiments in quantum optics lying at the heart of many quantum logic operations; the obtained visibility is 75.5% for a 60 nm-broad biphoton state. These results, obtained at room temperature and telecom wavelength represent a significant step towards real-world quantum photonic integrated circuits working in the broadband regime.

Reference

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2) F. Appas et al., "Nonlinear Quantum Photonics With AlGaAs Bragg-Reflection Waveguides," in Journal of Lightwave Technology, vol. 40, no. 23, pp. 7658-7667, (2022)

3) F. Boitier et al. "Electrically injected photon-pair source at room temperature", Phys. Rev. Lett. 112, 183901 (2014)

4) J. Wang et al. "Gallium arsenide (GaAs) quantum photonic waveguide circuits"Optics Communications 327, 49 (2014)

5) F. Appas et al. "'Flexible entanglement-distribution network with an AlGaAs chip for secure communications'npj Quantum Information 7, 118 (2021)

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