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Broadband Biphoton Generation and Polarization Splitting in a Monolithic AlGaAs Chip

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Abstract. Integrated quantum photonics is a key tool towards large scale quantum technologies. In this work we present an AlGaAs-based photonic circuit for the on-chip generation of broadband orthogonally polarized photons and the deterministic separation of the photons into separate spatial modes, facilitating their further use in protocols. We demonstrate that 85% of the pairs are deterministically separated by the chip over a full 60 nm bandwidth and we assess the chip operation in the quantum regime via a Hong-Ou-Mandel experiment displaying a raw visibility of 75.5% over the same full bandwidth.

1 Introduction

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]. We demonstrate that 85% of the pairs are deterministically spatially separated via their polarization over a bandwidth of 60 nm through a birefringent directional coupler. The performances of the device as a quantum photonic chip are assessed by implementing a Hong-Ou-Mandel interferometer at the chip output.

2 Sample layout

The device combines a Type-II parametric source of orthogonally polarized photons pairs followed by a broadband polarizing mode splitter. In this design, the splitting is achieved through a birefringent directional coupler which 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 (fig.1).

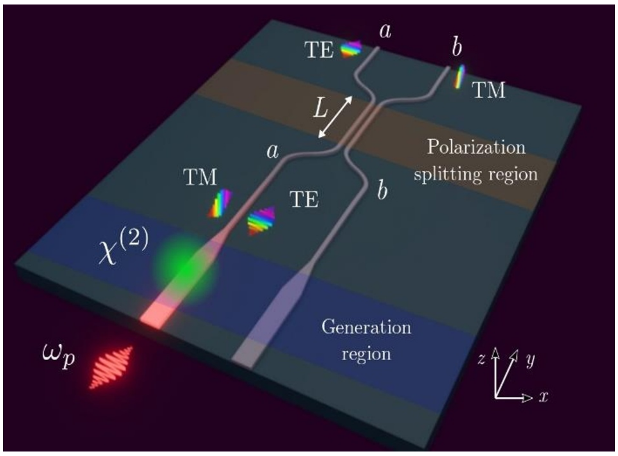

Figure 1: Chip layout showing the photon-pair generation region and the polarization splitting region.

3 Results

We demonstrate a high efficiency of the polarization splitting region design with 85% of the pairs deterministically separated by the chip over a 60 nm bandwidth (fig.2). 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

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the most fundamental nonclassical experiments in quantum optics lying at the heart of many quantum logic operations; the obtained raw visibility is 75.5% for a 60 nm-broad biphoton state (fig.3). 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.

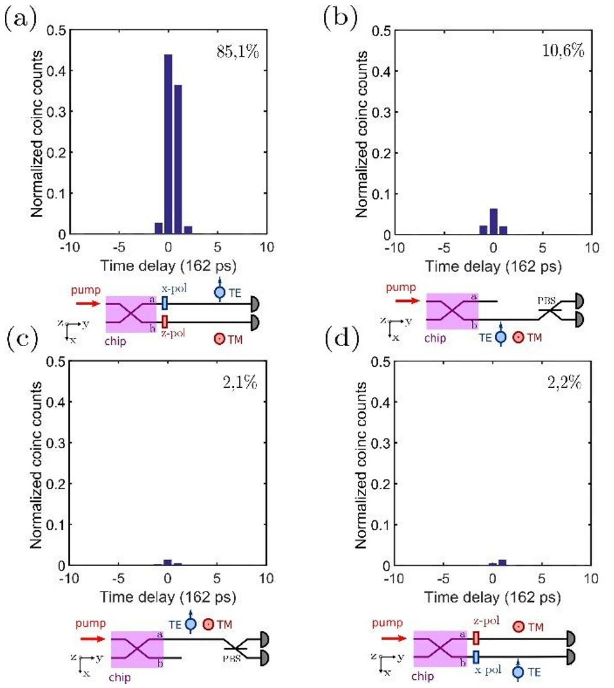

Figure 2: Measured coincidences normalized to the total number of coincidences measured in the following four configurations, showing the efficient on-chip generation and polarization splitting of the biphoton state: (a) Polarizer with transmission axis aligned along x in arm a and with transmission axis aligned along z in arm b; (b) Arm a blocked and arm b with a PBS; (c) Arm b blocked and arm a with a PBS; (d) Reversed configuration with respect to (a).

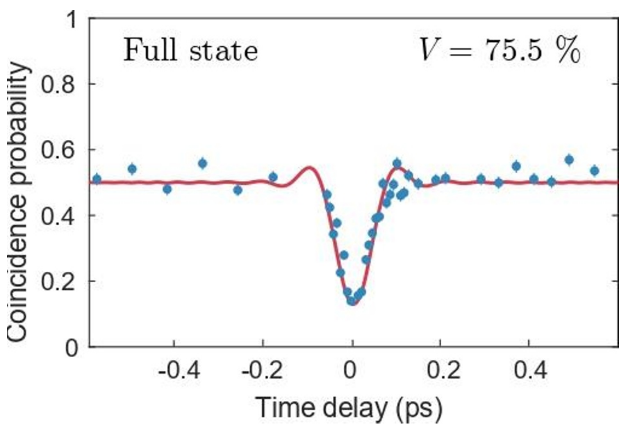

Figure 3: Hong-Ou-Mandel interferogram measured at the chip output.

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