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AlGaAs Bragg reflection waveguides for hybrid quantum photonic devices

Photonic quantum technologies represent a promising platform for several quantum information applications, ranging from long-distance communications to the simulation of complex phenomena. On the one hand, the advantages offered by single photons (robustness to decoherence, propagation over very large distances) make them the candidate of choice to carry quantum information in a wide variety of domains. On the other hand, the emergence of integrated quantum photonics has led to the demonstration of photon manipulation on complex circuits with near-perfect phase stability.
Among the various investigated platforms, AlGaAs semiconductor chips emerge for their strong nonlinearity and direct bandgap, for their capability of generating non-classical states of light at room temperature and for their high integrability. Here we demonstrate a broadband photon pair source consisting of an AlGaAs waveguide based on Bragg reflectors, supporting three types of possible phase-matching (PM) schemes and thus providing a high versatility in the polarization of the emitted photons in view of a large variety of applications. The nonlinear response of the device is first characterized through second harmonic generation (SHG) measurements: the three types of available PM resonances were demonstrated on the same chip. In particular, type 0 and type 2 PM offer a considerably high efficiency (˜250% W-1cm-2).
Photon pairs are then generated via spontaneous parametric down-conversion, with a measured internal pair generation rate of 2.5×10ˆ6 s-1 over a bandwidth larger than 90 nm. The non-classicality of the emitted photons is characterized through an energy-time entanglement measurement, using a fibered Franson interferometer in the folded configuration. The broadband nature of the produced biphoton states combined with the PM versatility of the source offers a testbed to investigate the delicate interplay of chromatic and polarization dispersion in the energy-time entanglement visibility, paving the way to possible metrological applications. Visibilities up to 99% are observed for both type 0 and type 2 generation processes. Such a high visibility, together with its intrinsic robustness to environment perturbations, make energy-time entanglement a promising resource for quantum information applications, especially in quantum communication.
This AlGaAs source is envisioned for its integration with Silicon-on-Insulator (SOI) photonic circuits, in order to leverage the assets of both material platforms. The design and fabrication of a hybrid AlGaAs/SOI device has already been accomplished, as well as its optical characterization in the classical regime. Preliminary results in the quantum regime open interesting perspectives for the on-chip quantum state generation and manipulation with hybrid circuits.

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