On-chip time-bin entanglement using Bragg-reflection waveguides as photon-pair sources

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To prepare quantum communication for its large scale commercialization, sources for quantum states of light have to be made smaller and better integrable. A promising candidate are Bragg-reflection waveguides (BRWs) made from the AlGaAs platform[1]. Their strong $\chi^{(2)}$ nonlinearity enables photon pair production in the telecom wavelength range via parametric down-conversion. We improved the fabrication recipe for BRWs and achieved a reduction in sidewall roughness by a factor of three leading to a decrease in optical loss coefficient of 0.14/mm compared to previous samples.

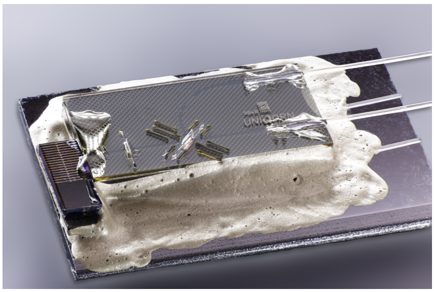

Fig. 1: A BRW sample (left) coupled to a polymer chip with passive optical elements and fiber coupling.

The BRW is end-face coupled to a polymer chip which hosts passive optical components for pump suppression and separation of the photons in a pair[2]. The photons are then relayed to time-bin analysis stations which correspond to Alice and Bob in a quantum key distribution scenario. There, the photons are sent through on-chip asymmetric Mach-Zehnder interferometers and detected by superconducting nanowire detectors. The impossibility to distinguish between photons created in the two time bins is evidenced by interference in the coincidence counts between the two photons detected at Alice's and Bob's site. The visibility of this interference fringe is measured by varying the phase in one of the interferometers.

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References

[1] H. Chen, S. Auchter, M. Prilmüller, A. Schlager, T. Kauten, K. Laiho, B. Pressl , H. Suchomel, M. Kamp, S. Höfling, C. Schneider, and G. Weihs, APL Photonics **3** 080804 (2018)

[2] M. Kleinert, D. de Felipe, C. Zawadzki, W. Brinker, J. H. Choi, P. Reinke, M. Happach, S. Nellen, M. Möhrle, H.-G. Bach, N. Keil, M. Schell, Physics and Simulation of Optoelectronic Devices 10098 (2017)