Hybrid integrated quantum photonic circuits for highly efficient coupling to optically active spin systems

The Integrated Quantum Photonics Group at the Department of Physics is looking for a motivated physics student to join the group for doing a master thesis.

The project's goal is to build and characterize photonic circuits, which are based on the hybrid integration of diamond cavities into aluminum nitride waveguides [1]. The cavities are deterministically fabricated around single color centers in diamond whose spin can be interfaced with photons. Using the waveguides, the photons are adiabatically coupled into and out of the cavities.

The project should continue a previous master thesis in which a pick-and-place technique was established [2]. In this, the diamond cavities are picked up with a tungsten tip attached to a micromanipulator and placed on top of the aluminum nitride waveguides. Figure 2 shows how this was done with a diamond waveguide.

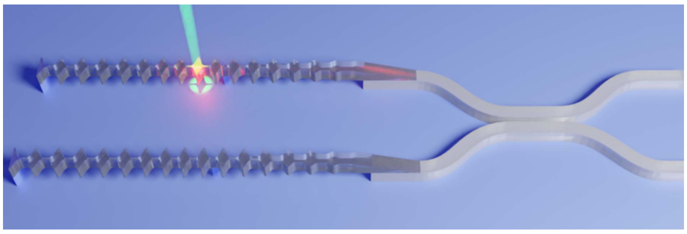

Figure 1: Schematic illustration of two photonic crystal cavities coupled to a waveguide directional coupler.

The master student will now build full hybrid integrated circuits with the established pick-and-place setup. In the next step, the circuits are characterized and the coupling efficiency is measured. The system is then put into the cryostat and investigated with a home-build confocal microscope. At temperatures of about 4 K, the cavities can be tuned into the color center resonance via gas deposition. This leads to a stronlgy increased spin-photon interaction and is the basis for an efficient quantum control of qubits inside a photonic circuit.

Another goal of the master's project is to add further integrated optical elements to the system. For this, photonic aluminum nitride nanostructures should be designed and simulated.

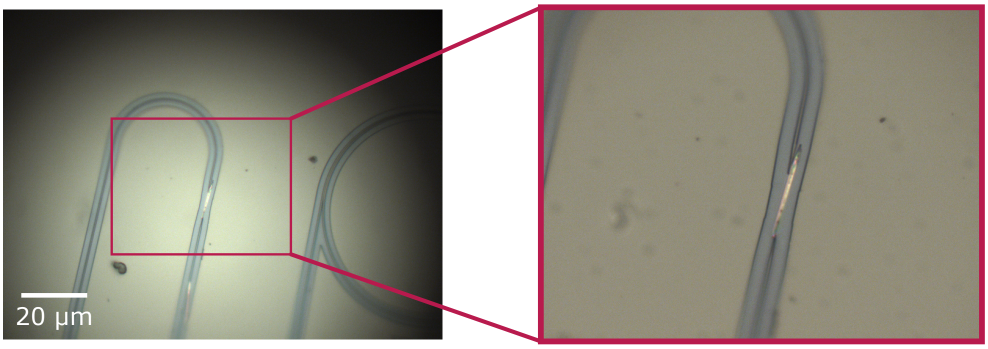

Figure 2: First attempts to place a diamond waveguide on an aluminum nitride waveguide with our recently developed pick-and-place technique.

If you are interested, please contact Maarten van der Hoeven (maarten.van.der.hoeven@physik.hu-berlin.de) and Julian Bopp (julian.bopp@physik.hu-berlin.de) or Prof. Tim Schröder (tim.schroeder @physik.hu-berlin.de).

[1] A. W. Elshaari, W. Pernice, K. Srinivasan, O. Benson, and V. Zwiller. "Hybrid integrated quantum photonic circuits". In: *Nature Photonics* 14 (2020), pp. 285–298.

[2] Sara L. Mouradian et al. "Scalable Integration of Long-Lived Quantum Memories into a Photonic Circuit". In: *Physical Review X* 5.3 (2015), p. 031009.