Adiabatic fiber tapers as highly efficient interfaces between optical fibers and quantum photonic nanostructures

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's Thesis.

The project's goal is to develop a procedure to make adiabatic fiber tapers, which can be used to optically interact with color centers (e.g. nitrogen-vacancy centers) in diamond waveguides or cavities. In a quantum photonic device, especially when information is encoded in single photons, any photon loss is detrimental. A promising solution is adiabatic fiber coupling. Here, the waveguide is gradually tapered down and is brought in contact with an optical fiber that is also tapered (see Figure 1). For this, efficiencies $> 99\%$ are predicted theoretically and $> 90\%$ have been achieved experimentally [1].

The project should continue a previous master thesis in which an etching technique was established [1]. In this, the fiber is submerged in hydrofluoric acid and then lifted out slowly with a motorized stage. The parts of the fiber that remain in the acid longer are etched more and this way a taper shape can be created. In a fiber-to-fiber transmission experiment the coupling efficiency between two etched tapers was measured to be around 50 %.

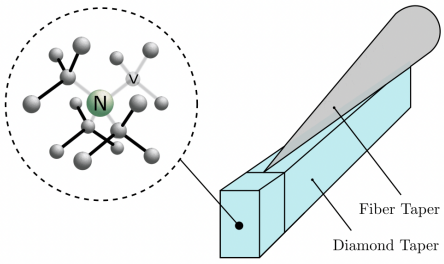

Figure 1: Schematic illustration of a tapered fiber coupled to a tapered diamond waveguide with a nitrogen-vacancy color center inside.

Now the established process has to be optimized. Most likely, the coupling efficiency is limited due to damage induced to the fiber tips during the cleaning step. Therefore, a softer cleaning method has to be developed. The next step is to measure the fiber-to-waveguide transmission with aluminum nitride on sapphire tapers and freestanding diamond tapers. When this is demonstrated, the coupling to color centers in novel photonic crystal cavities, which are currently designed in our group should be investigated. Such quantum photonic nanostructures are an important building block for realizing a quantum repeater.

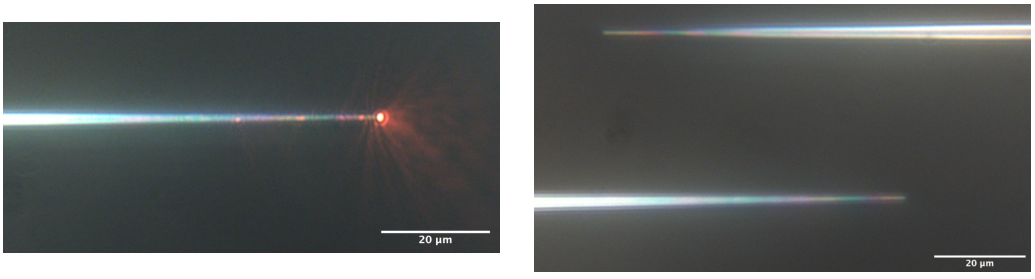

Figure 2: Experimentally produced fiber tips. Left image: Red laser light is guided through the fiber and exits at the fiber tip. Right image: Coupling between two fibers. During coupling the fibers a brought into direct contact.

If you are interested, please contact Maarten van der Hoeven (maarten.van.der.hoeven@physik.hu-berlin.de) or Dr. Tim Schröder (tim.schroeder@physik.hu-berlin.de).

[1] Michael J. Burek et al. "Fiber-Coupled Diamond Quantum Nanophotonic Interface". In: *Physical Review Applied* 8.2 (2017), p. 024026.