Dissertation Topic:

"Electrical controlled photon condensates in III/V semiconductor heterostructures"

One of the important open questions to current research on modern quantum technologies is their application in quantum simulations, which cannot be realised with classical computers. Bose-Einstein condensates, such as thermalised photons in dye solutions, are suitable as a hardware platform for such simulations. An important prerequisite for using such condensates for simulations is the ability to dynamically control and couple several of them and to integrate them scalably into a chip architecture.

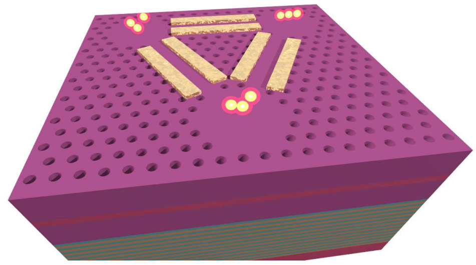
Fig.1: Schematics of our targeted semiconductor photonic chip architecture.

The project focuses on spatially structured semiconductor chips as a platform for the condensates. For this purpose, we use semiconductor quantum well structures as an active medium on a highly reflective Bragg mirror. In addition, the coupling between neighbouring condensates is controlled piezoelectrically. We want to use this to simulate dynamic calibration fields for photons, for example. Together with the thermodynamic equilibrium characteristics of photon condensates, our unique solid-state chip platform offers a scalable architecture for quantum simulations.

Goals, focus and work tasks in the project:

- Molecular beam epitaxy (MBE) of highly reflective AlAs/AlGaAs and AlOx/AlGaAs Bragg mirrors and planar microresonators
- Structural investigation of the structures using AFM, SEM, XRD and optical character-risation with time-resolved photoluminescence spectroscopy and reflectivity
- Optimisation of the optical properties with regard to a minimum spectral linewidth of the microresonators
- Proof of Bose-Einstein condensation of photons in these microresonators in a large temperature range
- Development of the epitaxy of piezo-electric AlN layers and integration of these into the microresonators for electrical tuning of the wavelength of the resonators.
- Design, nanostructuring and integration of several microresonators in a planar geometry (see Fig.1) to couple several Bose-Einstein condensates in an integrated-photonic chip structure

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