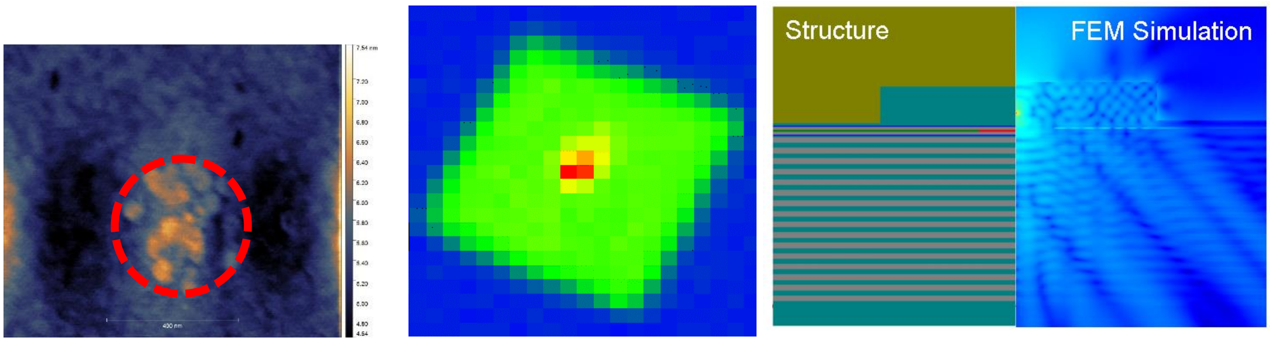
Development of nanophotonic quantum light sources for the investigation on collective effects

Background: Semiconductor nanostructures embedded in optical microcavities have attracted great scientific interest in the recent years as these structures are capable of demonstrating cavity quantum electrodynamics (cQED) effects in practical devices, which allows one to study the quantum nature of light-matter interaction. Semiconductor nanostructures also lead to a wide range of applications in photonic quantum technology, for instance, single-photon emitters, high-β thresholdless lasers, sources of entangled photon pairs, and superradiant light sources. Sub- and superradiance, first proposed by Dicke in 1954, are intriguing collective radiative emission processes which occur when coherence is built up among the emitters spontaneously via exchange of photons. This project aims to optimize and realize nanophotonic light sources consisting of site-controlled quantum dots for the comprehensive insight into the full photon statistics of collective effects.



Left: AFM pictures of the site-controlled QDs located on top of the aperture, middle: μ-PL heat map of the site-controlled QDs located in the center of a macro-mesa structure, right: FEM simulation of a simple mesa structure which enhances the extraction and quantum efficency

The project:

For a systematically experimental study of sub- and superradiance, it is of crucial importance to establish a precise control over the coupled emitters in terms of number, position, emission energy, and their common electromagnetic field. In this project a so called buried-stressor approach will be applied to control the position and the number of the InGaAs quantum dots (QDs) via tailoring the strain induced by the oxidation aperture. Furthermore, electron beam lithography (EBL) will be implemented to fabricate micropillar laser or mesa structures to enhance the extraction and quantum efficiency of the nanophotonic devices. In the final stage, optical and quantum optical studies will be carried out to study the full photon statistics of the collective effects in the nanophotonic devices.

Your tasks:

- You will support the development and optimization of the nanophotonic quantum light sources in MOCVD epitaxial growth of site-controlled quantum dots and cleanroom device processing.
- You will perform device characterizations including AFM, XRD, PL, μ-PL, etc..
- You will support quantum optical study including autocorrelation measurement, full photon statistics measurement with photon-number resolving (TES) detectors, time resolved μ-PL, etc..

What you can expect:

- You will study a cutting-edge and exciting topic in nanophotonics.
- You will learn the basics and deepen your knowledge of semiconductor materials, semiconductor quantum dots, optoelectronic components and modern simulation, nanotechnology and characterization methods of optoelectronic components.

- You will get a deep insight into semiconductor nanotechnology by supporting epitaxial growth and the fabrication of nanophotonic quantum light sources.
- You will work in a friendly environment and discuss with other motivated and talented scientists on a daily basis.
- We greatly value the importance of close training and support to students in all aspects.

Prerequisite:

- A strong ambition and passion to carry out a project.
- An open mind to learn new knowledges and tackle down the encountered problems.
- The ability to co-work with others as one team.
- Having some basic knowledge in semiconductor quantum dots, optoelectronic components, and quantum optics is advantageous, but is however never as important as above!

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Please don't hesitate to contact us at any time. We are always glad and open to provide more information!