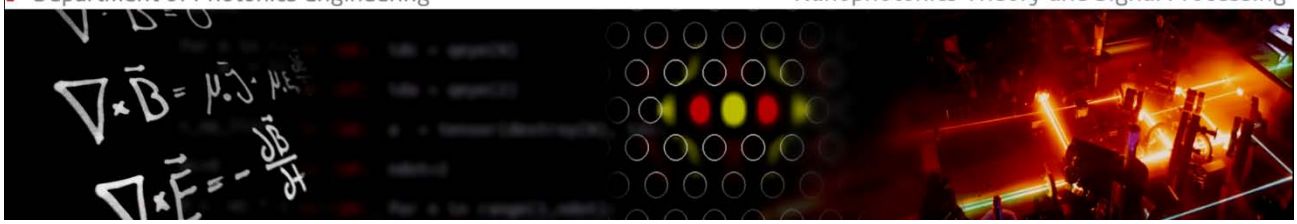

B.Sc. Project

Nanowire single-photon sources

A nanowire is a semiconductor pillar (Fig. 1) with diameter in the nanometer range. By implementing a quantum dot (QD) in its center, single photons can be generated inside the nanowire. Furthermore, the light emission profile from the nanowire can be controlled using a conical tapering, allowing for efficient coupling to e.g. a single-mode fiber. The nanowire is thus a candidate for a highly efficient solid-state single-photon source (SPS), which is of great interest in quantum information applications.

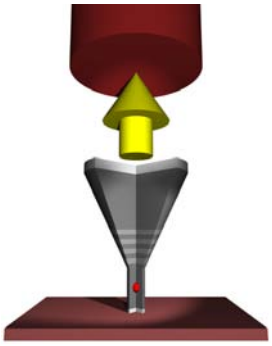

Fig. 1: Sketch of nanowire SPS with inverted tapering

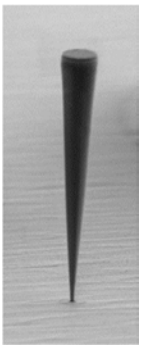

Fig. 2: SEM image of the inverted nanowire (CEA Grenoble)

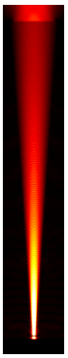

Fig. 3: Optical field profile.

DTU Fotonik is collaborating with the Commissariat à l'Energie Atomique (CEA) in Grenoble, France who fabricates (Fig. 2) and characterizes the nanowire SPS based on designs provided by Fotonik. This collaboration has already lead to the demonstration of a nanowire SPS with a record-high efficiency [1]. However, for quantum information not only high efficiency but also the emission of indistinguishable photons is required. Currently, the details of obtaining efficient light emission (Fig. 3) in combination with indistinguishability are not well understood.

The overall aim of this project is to establish a theoretical understanding of the physical mechanisms governing light emission in the nanowire SPS. Important parameters include the β factor describing the QD-mode coupling, the Purcell factor *F* giving the enhanced spontaneous emission rate due to cavity effects and the collection efficiency γ of the optical detection system. An investigation of these parameters is challenging, since the lengths scales are similar to or smaller than the wavelength of light and a full 3D vectorical simulation of the optical field is required.

While the exact nature of the project will depend upon the student's interests, possible activities are to

- develop an optical modeling tool to simulate Maxwell's equations
- analyze nanowire SPS designs featuring both regular and inverted conical tapers
- optimize the distributed Bragg reflector in both taper geometries
- propose an SPS design with Purcell enhanced emission of single photons for emission of indistinguishable photons

Knowledge of electromagnetics (Maxwell's equations), waveguide theory and Matlab programming is recommended.

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References:

[1]: J. Claudon et al, Nat. Photonics **4**, 172 (2010).