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Semiconductor nano-cones and Cooper-pair LEDs for single and entangled photons at 1.55 µm

Practical sources of single photons and entangled photon pairs in the telecommunication band are attracting plenteous attention for application in fiber-based quantum communication. We use InGaAlAs quantum dot (QD) and light emitting diode (LED) structures grown on InP substrates as emitters in the spectral range between 1.3 and 1.6 µm.

We present one approach to realize a source for single photons and polarization entangled photon pairs by etching tapered mesas (nano-cones) of 100 nm to 1 µm diameter from high density QD samples in order to address a small number of single emitters. To increase the light extraction the nano-cones are embedded in metal and the InP substrate is removed [1].

Another approach for the realization of entangled photon pairs is the concept of Cooper-pair (or Josephson) LEDs, where the photon pair originating from the recombination of an electron Cooper-pair is expected to be entangled [2]. We report on the fabrication of InGaAs LEDs with superconducting Niobium electrodes for the injection of electron Cooper-pairs. The precise Niobium etching, and the Josephson junction based on an approximately 100 nm wide slit in the n-side Niobium electrode was investigated to characterize the interface quality and the temperature as well as the diode bias dependence [3]. Optical characterization of the electro- and photoluminescence from such LEDs was performed to understand the contribution of electron Cooper-pairs to the luminescence and the photon statistics [4].

With the presented devices we want to give an overview of the application of emiconductor heterostructures as photon sources fulfilling major requirements for fiber-based quantum communication.

References:

[1] J.-H. Huh, et al., to be published in Jap. J. Appl. Phys. (2010)

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[3] J.-H. Huh, et al., Nanotechnology 22, 045302 (2011)

[4] H. Sasakura, et al., submitted to Phys. Rev. Lett.

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