Coupling single quantum dot emission into single mode fibers using 3D printed microoptics for quantum technology

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We couple the emission of single semiconductor quantum dots into single mode fibers. We utilize different dots at emission wavelengths of 700 – 1550 nm. The dots are buried in the semiconductor and are being located with photoluminescence mapping with respect to reference alignment marks with an accuracy below 100 nm. The emission pattern of the single photon modes depends on the local environment, ranging for dipolar emission to more Gauss-mode type emission for micropillars and bull's eye type confinement.

We use femtosecond 3D printing to directly print aspherical, NA matched optics onto single mode fibers. Additionally, different collection and recollimation optics are being printed onto the quantum dots. This can include diffractive as well as refractive and reflective (TIR) structures in order to collect high numerical aperture angles. Through our combination of optics, a numerical aperture adjustment and necessary mode conversion between the QD emission and the acceptance solid angle of the single mode fiber is achieved.

Additionally, a chuck is 3D printed around the quantum dots with high alignment accuracy in order to insert the single mode fibers with optics and to maintain perfect focusing distance. When inserting the fibers into the chuck and performing lateral alignment accuracy measurements, we find that our positioning is better than 100 nm laterally. When comparing with theory, we find that correct alignment angles better than 3 degrees also matter significantly [2].

We obtain single photon emission with count rates in the 100 kHz to MHz range after the fiber, confirmed by Hanbury-Brown-Twiss measurements [3].

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