Advances of hyperspectral imaging for placement of nanophotonic structures

Quirin Buchinger[1], Constantin Krause[1], Aileen Zhang[1], Giora Peniakov[1], Andreas Pfenning[1], Sven Höfling[1], and Tobias Huber-Loyola[1]

[1] *Julius-Maximilians-Universität Würzburg, Physikalisches Institut, Lehrstuhl für Technische Physik, Am Hubland, D-97074 Würzburg, Germany.*

Semiconductor quantum dots (QDs) hold significant promise as a source of single or entangled photons for applications in quantum cryptography and optical quantum computing. Embedding QDs into nanophotonic structures, such as circular Bragg grating (CBG) resonators, offers a means to enhance the collection efficiency and leverage the Purcell effect [1,2]. Precise positioning of QDs relative to the cavity center is essential for achieving optimal QD-cavity coupling, particularly in CBG resonators, where alignment within approximately 20 nm is crucial to maximize overlap with the cavity mode profile [3]. Inadequate alignment can result in reduced Purcell enhancement and polarized light emission [3]. QDs exhibiting best optical performance are typically grown via Stranski-Krastanov growth or local droplet etching, which inherently yield a random spatial distribution of QDs [4,5,6]. Consequently, determining the exact location of QDs is required for reliably placing cavities around them.

Hyperspectral imaging is a method capable of simultaneously providing high-resolution spectral and spatial information [7]. However, previous reports of very accurate placement [7-9] were likely only precise and not as accurate as thought, as newest findings suggest [3, 10], probably due to unaccounted errors in the optical system [11].
In this talk, I will present our hyper-spectral imaging method, which we optimized for near infrared QDs (in the 900 nm – 960 nm range). I will discuss our advances in placement accuracy by various systematic improvements, our capabilities for imaging in the telecom wavelength range and how findings in the 900 nm range can be transferred to improve placement accuracy of telecom QDs.

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