On-chip single-photon emission from deterministically positioned and embedded InP-based colloidal quantum dots

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Solid-state emitters are attractive as non-classical light sources because of the scalability of their host system[1]. In particular, zero-dimensional quantum dots are prime candidates due to their atom-like properties and the possibility of on-demand single photon emission. Colloidal quantum dots (cQDs) are often overlooked for this application due to their alleged blinking behaviour or poor stability. However, blinking of cQDs can now be almost completely suppressed through development of appropriate shelling procedures resulting in bright and photo-stable emitters. Usually, this shelling gives rise to multi-exciton emission at high pump rates, a limiting factor for applications requiring pure single photons with unity quantum yield. Recent room temperature characterization of single InP/ZnSe cQDs showed a nearly blinking free emission and a high pure single photon emission ($g^2(0)<0.03$), even well beyond the saturation intensity[2]. Cryogenic single cQD spectroscopy revealed line-shapes consisting of fine-structure split zero-phonon lines down to 36 µeV width, phonon-assisted transitions resulting in a broad band, as well as spectral jitter. Though clearly promising, isolated cQDs as single photon sources are only usable when they can be deterministically positioned, both for practical purpose and to couple the cQDs to nanophotonic cavities. The latter will be required to further boost the brightness and directionality of single photon emission. Here, we show the deterministic positioning of single InP/ZnSe cQDs using electron-beam lithography followed by embedding into a silicon nitride host matrix. After the processing, the dots retain their excellent single photon emission at room temperature. Our results pave the way for reliable embedding of cQDs into nanophotonic cavities which will enable bright InP-cQD based single photon emitters.

References:

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[2] Chandrasekaran, V.; Tessier, M. D.; Dupont, D.; Geiregat, P.; Hens, Z.; Brainis, E. Nano Letters 2017, 17 (10), 6104–6109.