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Increasing the brightness of site controlled QDs with chip scale processing

Quantum dots (QDs) are a valuable technology to produce single photon as well as entangled photon pairs with immediate application in quantum technology. Site-controlled quantum dots grown in pyramidal patterned substrates give access to hundreds of thousand of single photon emitters, with highly uniform emission wavelength on a single sample. Here, we demonstrate a process to increases the extraction efficiency from these sources and improve their emission profile. The method does not require any direct writing step and is broadband so it can be efficiently applied to all the QDs on the sample.

Firstly, we produce a regular array of sub-micron triangular pillars with a self-aligned process that ensures a single QD inside each pillar, positioned along its axis. Subsequently, multiple cycles of chemical vapor deposition are used to create quasi-conformal dielectric shells that encapsulate the pillar. While the emitted light is guided by the GaAs pillar, the dielectric layers reduce the internal reflection at the pillar end, and create a convex surface that partially focus the output beam, acting as a lens. We succeed in increasing the extraction efficiency as measured through a NA=0.42 objective by obtaining a raw single photon count rate ≥1MHz, under continuous wave excitation. The dielectric coating also induces a shift of the emitted wavelength possibly due to materials strain that will be further investigated.

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