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Designing Single-Photon Sources: Towards Unity

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A key building block within optical quantum information technology is the single-photon source. The key figures of merit are the efficiency, defined as the number of photons detected by the collection optics per trigger, as well as the indistinguishability describing the coherence properties of the emitted photons. Spontaneous parametric down-conversion (SPDC) has been the main workhorse for generating single photons within quantum optics for many years; however SPDC is inherently probabilistic limiting the number of photons involved in an experiment to a handful.

Recently, the semiconductor quantum dot (QD) has emerged as an alternative to SPDC. By integrating the QD into a microstructure, the light emission can be controlled and extraction efficiency of around 0.7 [1,2] have been achieved. Furthermore, using resonant excitation and careful control of the neighbouring charge environment, indistinguishability up to 0.99 [2,3] has been demonstrated. However, future progress within QD-based single-photon sources will require the combination of high efficiency with high indistinguishability.

In this presentation, I will discuss the physical limitations of present-day design schemes, which must be overcome to combine near-unity efficiency and indistinguishability. I will discuss new promising QD-based design schemes and I will discuss the challenges ahead.

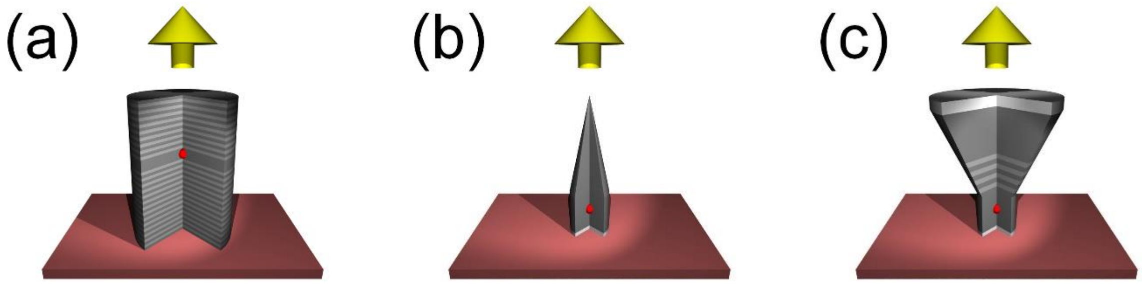

Figure 1: Major single-photon source design strategies: (a) The micropillar cavity, (b) the photonic nanowire and (c) the photonic "trumpet" geometry.

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[2] X. Ding et al., Phys. Rev. Lett. **116**, 020401 (2016).

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