NEWS AND VIEWS

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An efficient entangled-photon source from semiconductor quantum dots

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Photon entanglement, also known as "Spooky Action at a Distance", is a promising solution to quantum cryptography and quantum computing. The former will construct a cryptosystem that is impossible to break, and the latter will be capable of solving specific problems much more quickly than any classical computer. An ideal entangled-photon source meeting the following criteria is needed for eventually the practical implementation of quantum information processing: on-demand generation[1], high-fidelity[1], ultrabright[2], high extraction efficiency[3], and high-temperature operation[4]. For practical applications, it is preferred to have a simple approach that is compatible with current solid-state technologies. Self-organized semiconductor quantum dots (QDs) represent a promising option as an on-demand source of a triggered single-photon and entangled-photon pairs, through the radiative recombination of excitons and biexcitons[5, 6].

However, the photon extraction efficiency is extremely low because of the refractive indices mismatch between the bulk matrixes and vacuum. Moreover, to realize entangled-photon emission, it is necessary to grow highly symmetric QDs with sufficiently small intrinsic fine-structure splitting (FSS), which will lead to excellent entangled-photon emission via the biexciton-exciton radiative cascade[7]. Different schemes have been proposed to overcome the photonextraction issue. A double-micropillar structure and QDs-in-nanowires have been used for an entangled or single-photon source; however, the complexity makes them difficult for wide applications[2, 8].

Recently, Ding *et al.* reported a high-efficiency, high-brightness entangled-photon source from semiconductor QDs by using a broadband optical antenna to beam photons[9]. QDs with very small FSS were grown by filling in-situ droplet etched nanoholes, which resulted in ultrahigh in-plane symmetry. By bringing the high refractive index GaP lens with anti-reflection coating close to the interface and accurately engineering the gap between them by using polymethyl methacrylate (PMMA) as the intermediate layer, the photons traveling in directions above the critical angle are beamed efficiently into the lens, as shown in Fig. 1. The enhancement of a factor of more than 100x is observed in the typical photoluminescence (PL) spectrum.

Their design can be used to improve the extraction efficiency of QDs for practical applications in any telecommunication network. The broadband antenna is also applicable to different optical-active materials. The efficient generation of entangled photon pairs in this report paves the way for the development of various quantum technologies.

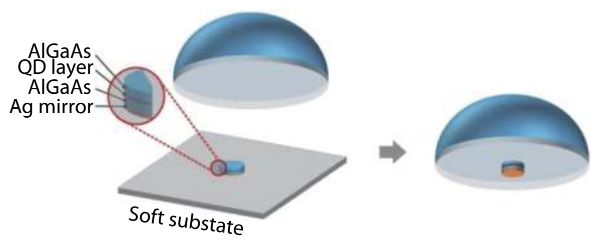

Fig. 1. (Color online) The dielectric antenna consisting of a QD-containing membrane, PMMA spacer, and the GaP solid immersion lens. Reproduced with permission from Ref. [9]. Copyright 2018, Springer Nature.

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