Single photon emission from novel site-controlled Ga(AsN) quantum dots

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Semiconductor quantum dots (QDs) have attracted increasing research interest over the last few years, mainly because of the possibility to emit non-classical light states relevant for quantum information protocols [1]. However, progresses in this field have been limited by a general lack of control over the QD size, shape, and position. To overcome this issue, we propose a novel QD fabrication technique, which exploits the hydrogen-assisted, spatially selective passivation of N atoms in dilute nitride semiconductors. Owing to the formation of stable N-2H-H complexes, hydrogen irradiation of these materials results in the neutralization of all the effects of N incorporation on the host matrix, including the large reduction of the band-gap energy [2]. Therefore, deposition of H-opaque Ti masks on the sample surface by electron beam lithography and subsequent hydrogenation allows for the realization of site-controlled nanostructures with arbitrary shape and size, wherein carriers are quantum-confined in all spatial directions [3].

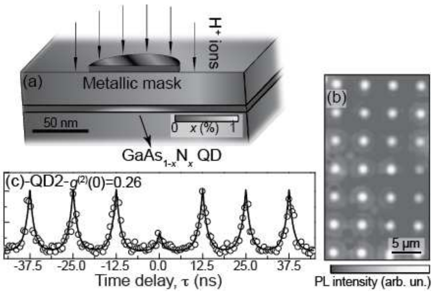

Fig.1 (a) Sketch of the process leading to the formation of a Ga(AsN) QD. (b) Micro-PL image of a highly uniform array of QDs. (c) Autocorrelation plot of the exciton emission of a single QD, showing a clear antibunching.

In the present work, we report on the fabrication of ordered arrays of Ga(AsN) quantum dots, whose optical properties have been extensively investigated by means of micro-photoluminescence (PL), micro-magneto-PL, time-resolved PL and photon correlation spectroscopy. Power-dependent micro-PL measurements of single dots allow us to identify emission lines originating from the recombination of excitons, biexcitons, and charged excitons. The genuine zero-dimensional nature of excitons confined in Ga(AsN) QDs is further confirmed by probing the exciton wavefunction extent via micro-PL measurements under high magnetic fields. Also, we demonstrate for the first time that these QDs emit single photons on demand, as revealed by the second-order correlation function of the single-exciton emission [4] (see Fig. 1). These results, along with the near-perfect control achieved over the QD positioning, confirm the high potential of this novel technique for the realization of site-controlled single-photon sources, uniquely suited for the integration in nanophotonic devices.

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