Single photon emission from an InAs quantum dot in a GaAs nanowire grown on Si substrate

Jinkwan Kwoen [1], Katsuyuki Watanabe [2], Yasutomo Ota [2], Satoshi Iwamoto [1, 2] and Yasuhiko Arakawa [1, 2]

[1] *Institute of Industrial Science,* [2] *Institute for Nano Quantum Information Electronics, The University of Tokyo, 4-6-1 Komaba, Meguro-ku, Tokyo 153-8505, Japan*

Single quantum dots (QDs) in nanowire (NW) structures generate bright single photons in highly controlled manners. Especially, those which are fabricated solely from III-V semiconductors using top-down or bottom-up approaches have shown their distinguished properties as non-classical light sources [1, 2]. Further advantages of these emitters could be obtained by direct growth of them on Si substrate [3], which opens a promising avenue toward facile integration of such emitters into future 'on-silicon' quantum optical circuits. In this study, we report for the first time single photon generation from an InAs QD in a GaAs NW that was directly grown on a Si substrate.

Figure 1 shows a schematic of our QD-in-NW. The structure is based on a lateral core-shell heterostructure, composed of a GaAs NW core, an InAs QD layer, and a GaAs/AlGaAs/GaAs capping shell. The AlGaAs layer is expected to suppress non-radiative surface carrier recombination processes [3]. The QD-in-NWs were grown on 3-inch Si(111) wafer using a solid-source molecular beam epitaxy system under a self-catalyzed vapor-liquid-solid growth condition. Figure 2 shows an image of a typical NW containing QDs. The structures have a length of ~750 nm and a diameter of ~130 nm, on average. QDs are expected to be grown on the sidewall of the NWs [4].

We characterized optical properties of a grown QD-in-NW by micro photoluminescence (PL) measurements at 10K. An emission spectrum from the sample is shown in the inset of Fig. 3. We observed bright discrete emission lines from the QD. Intensity auto-correlation was measured for the emission line denoted as X using a conventional Hanbury-Brown-Twiss setup with a pair of silicon avalanche photodiodes, and is plotted in Fig. 3. The estimated time-origin value for the normalized second-order coherence function, $g^{(2)}(0)$, is 0.18 (< 0.5), which clearly demonstrates single photon generation from the QD-in-NW on Si.

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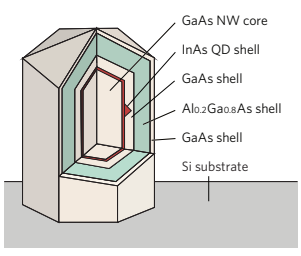

Figure 1: Schematic of the investigated QD-in-NW structure.

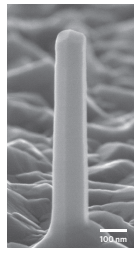

Figure 2: Scanning electron micro-graph of a typical GaAs NW containing an InAs QD.

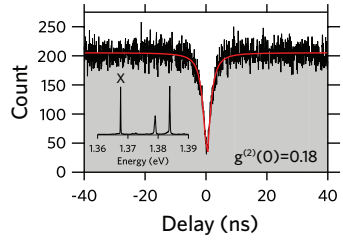

Figure 3: Measured auto-correlation histogram. Single photon generation ($g^{(2)}(0)<0.5$) from a single QD-in-NW grown on Si is clearly demonstrated. The inset shows a PL spectrum of the QD.