1.55 µm photon emission from droplet epitaxy InAs quantum dots on InP(111)A

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Introduction Recently, we have successfully created symmetric InAs QDs on InAlAs/InP(111)A substrate using droplet epitaxy[1, 2]. However, the previous samples were not sufficiently optimized: the dot size distribution is relatively large so that careful dot selection is required to find a dot that emits at 1.55 µm. In this study, we extend the droplet epitaxy scheme to achieve a purely 1.55 µm photon emission. The use of a state-of-the-art superconducting photon detector allows us to investigate single photon emission dynamics in the standard telecom C-band.

Experimental The sample was grown on InP(111)A using a solid source molecular beam epitaxy. A lattice-matched InAlGaAs was used as barrier. We introduce the high temperature crystallization protocol, which has recently been applied to the GaAs material system, to the InAs/InP material system in order to improve the dot morphology property. We measured the stationary- and time-resolved responses of photoluminescence from single InAs dots. For stationary study we used a semiconductor laser diode at a wavelength of 980 nm as a cw excitation source. For the time-resolved study we used a ps mode-locked titanium sapphire laser whose wavelength is tuned to 900 nm as a pulsed source. The luminescence signal is spectrally analyzed using cooled InGaAs photodiode array and temporally resolved using a superconducting single photon detector with a fast response time-to-digital converter.

Results Figure 1(a) shows the photoluminescence spectra of the InAs QD ensemble. For low excitation, the spectrum has a Gaussian-like single peak centered at a wavelength of 1,550 nm. The majority of dots in the present sample can emit in the telecom C-band. Figure 1(b) shows the intensity autocorrelation function $g^{(2)}(t)$ of the exciton luminescence of a single InAs dot at a wavelength of 1,572 nm for different excitation power. With low excitation at 7 nW, the signal shows a clear antibunching dip, which yield nearly no probability of emitting two photons at the same time. With increasing excitation power, the dip width is observed to decease, and the signal quickly recovers to equilibrium level. This is due to the acceleration of exciton population recovery for strong excitations.

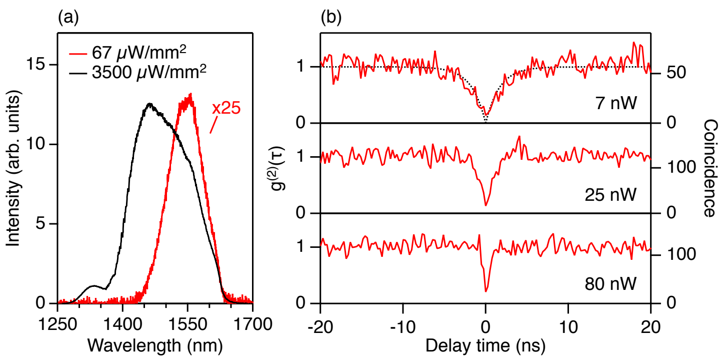

Fig. 1(a) The luminescence spectra of InAs QD ensemble at 12 K at different excitation powers. (b) The intensity autocorrelation function of exciton luminescence from a single dot for different excitation power. The correlation number was investigated with a time bin of 256 ns for 6 hours (7 nW), 80 min (25 nW), and 20 min (80 nW). The simulation results are also plotted by the gray broken line.

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[1] N. Ha, et al., *Appl. Phys. Lett.* **104**, 143106 (2014). [2] N. Ha, et al., *Appl. Phys. Express* **9**, 101201 (2016).