GaN 界面揺らぎ量子ドットにおける 単一光子発生ダイナミクスの励起強度依存性

Power dependent single photon emission dynamics of a GaN fluctuation quantum dot

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Single Photon Sources (SPSs) have attracted extensive attention thanks to their possible applications in secure communication and quantum information processing (QIP). SPSs based on quantum dots (QDs) are becoming increasingly important due to their solid state nature, high emission purities, and a large possible emission wavelength range. In particular, it has been shown that III-nitride QDs can operate at high temperature and at wavelengths ranging from the UV all the way to the IR due to their large band offsets and wide range of bandgaps[1]. Recently, GaN interface fluctuation QDs have been developed which exhibit narrow emission linewidths (down to 87 μeV)[2]. It has been reported that SPSs based on the GaN interface fluctuation QDs can reach high purity with a $g^{(2)}(0)$ autocorrelation measurement result as low as 0.085[3].

In this study, we present measurements of high purity single photon emission from an interface fluctuation QD under different excitation laser powers, revealing the power dependent single photon emission dynamics. From analysis of our data we are able to estimate the emission lifetime of this QD. Micro photoluminescence experiments were conducted using a 266nm continuous wave (CW) laser. The sample was held under vacuum in a continuous flow liquid Helium cryostat and cooled to a temperature of 10K. Photon autocorrelation measurements were performed using a standard HBT setup with PMT detectors.

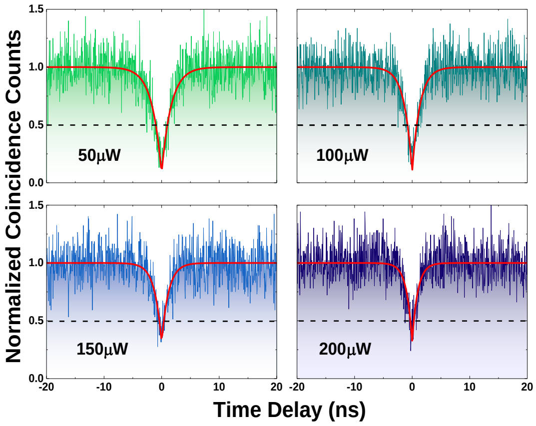

Figure 1. Power dependent autocorrelation measurements showing single photon emission.

Figure 1 shows the measured autocorrelation $g^{(2)}(\tau)$ from a GaN interface fluctuation QD under various excitation laser powers. In all cases the observed anti-bunching reveals clear single photon emission ($g^{(2)}(0)<0.5$). Figure 2 shows the excitation power dependence of the anti-bunching rate extracted from the data, and a linear fit according to[4]

$$\frac{1}{\tau_R} = \frac{1}{\tau_0} + \alpha P, \quad (1)$$

where $1/\tau_R$ represents the anti-bunching rate, P is the pump power intensity, αP is the effective pump rate into the upper state, and τ_0 is the exciton recombination time.

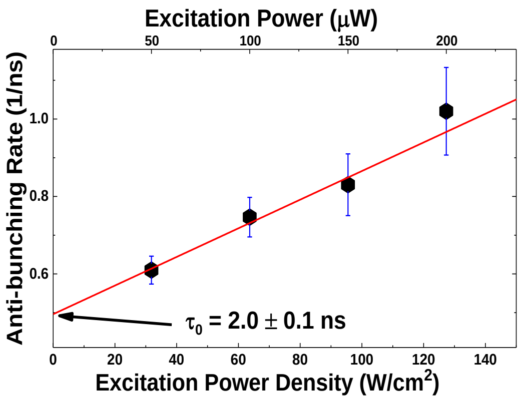

Figure 2. Power dependent decay rate of the confined exciton.

The data follow the expected linear trend, and we are able to evaluate the exciton recombination time (from the intercept) as 2.0 ± 0.1 ns. This value is comparable with typical III-nitride QDs. GaN fluctuation QDs may become an important technical solution for III-nitride based single photon sources, but also act as a clean platform for the study of fundamental III-nitride nanostructure properties.

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References: [1] M. J. Holmes *et al., ACS Photonics* 3, 543 (2016). [2] M. Arita *et al.*, *JSAP 76th Autumn Meeting*, 16a-1D-8 (2015). [3] F. Le Roux *et al., JSAP 77th Autumn Meeting*, 16p-A21-8 (2016). [4] P. Michler *et al., Nature* 406, 968 (2000).