GaN 界面揺らぎ量子ドットにおけるスペクトル拡散時間スケールの測定

Measurement of the Temporal Scale of the Spectral Diffusion of a GaN Interface Fluctuation Quantum Dot

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Spectral diffusion is a linewidth limiting phenomenon of random jumps in the emission wavelength of an emitter due to interactions with its environment. The effect is prominent in III-nitride QDs and has been a topic of particular interest as it leads to linewidths which can reach up to several meV even at cryogenic temperatures. [1,2] Recently, GaN interface fluctuation QDs have been developed, and have been shown to exhibit several advantageous properties such as comparatively narrow emission linewidths and high single photon purities (with measured $g^{(2)}(0)$ as low as 0.085). [3]

However, while the emission is stable, even these dots undergo rapid spectral diffusions (shown by a significant Gaussian component of the emission line shape) that is much faster than what can be measured using typical spectroscopy. Here we reveal the time-scale of the spectral diffusion of such a GaN interface fluctuation QD via careful measurements of its intensity autocorrelation.[4] An isolated single GaN interface fluctuation QD was cooled to 10K and was excited by a 266nm wavelength CW laser with an excitation power of 200μW. A standard HBT setup with two PMT detectors was used to perform the autocorrelation measurement after spectral selection using the exit slit of the monochromator.

Half of the peak of a single emission line (as the brown box in Figure 1) from the QD was selected for autocorrelation measurement (see figure 2). As well as the single photon antibunching, we can observe an additional long scale bunching effect with a characteristic time of 22ns due to the spectral diffusion of the peak into and out of the selected spectral window.

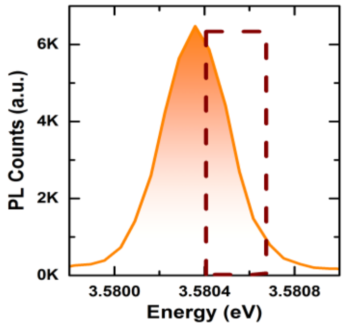

Figure 1: Spectrum of the GaN interface fluctuation QD under an excitation power of 200 μW at 10K.

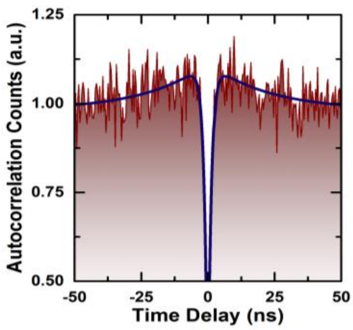

Figure 2: Autocorrelation measurement of the half emission profile selected as shown in the brown dashed box in Figure 1.

This measurement provides us with direct information on the temporal scale of the spectral diffusion process in such dots, which will have important implications for the generation of indistinguishable photons. Such QDs will be an important spectrally clean technical solution for the study of the properties of III-nitride semiconductors nanostructures.

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References: [1] M. Holmes et al., Phys. Rev. B 92, 115447 (2015). [2] C. Kindel et al., Phys. Status Solidi RRL 8, 408 (2014). [3] M. Arita et al., Nano Lett., 17, 2902 (2017). [4] G. Sallen et al., Nat. Photon. 4, 696 (2010).