GaN 量子ドット・ブルズアイ構造における単一光子放出の増強効果

Enhanced single photon emission from a GaN quantum dot in a Bullseye structure

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Single photon emitters made from III-nitride quantum dots (QDs) are of interest for use of quantum information processing technologies, and offer some benefits such as high temperature operation and wide range of emission wavelengths [1]. However, as part of ongoing research, it is now important to try and improve the optical properties of the devices, for example, by increasing the photon extraction efficiency and suppressing the effects of spectral diffusion. Recently, in order to increase the extraction efficiency from GaN QDs, we have been developing a bullseye structure (see fig 1a) to direct the emission into a narrow solid angle for efficient collection using an objective lens, leading to a theoretical extraction efficiency of ~13% into an objective lens of NA 0.4 (compared to an equivalent extraction efficiency of ~1.3% for an unprocessed QD) [2, 3]. In this presentation we describe the successful realization of single photon emission with an enhanced extraction rate from such a structure.

Bullseye structures were fabricated using electron beam lithography and reactive ion etching into a sample of self-assembled GaN/AlGaN QDs, and optical characterization was performed using μ-PL at 5K under pulsed excitation (λ = 266 nm, repetition rate: 80 MHz). The emission was collected using a 50× objective lens (NA=0.4). Single photon emission was confirmed from an isolated QD in a bullseye structure emitting at 296nm with a $g^{(2)}(0)$ value of 0.34. Moreover, the photon emission rate into the numerical aperture of the objective lens was measured to be 4.8MHz (corresponding to a experimental extraction efficiency of ~6%), far exceeding the limit of an unprocessed sample and thus verifying the extraction enhancement of the bullseye structure.

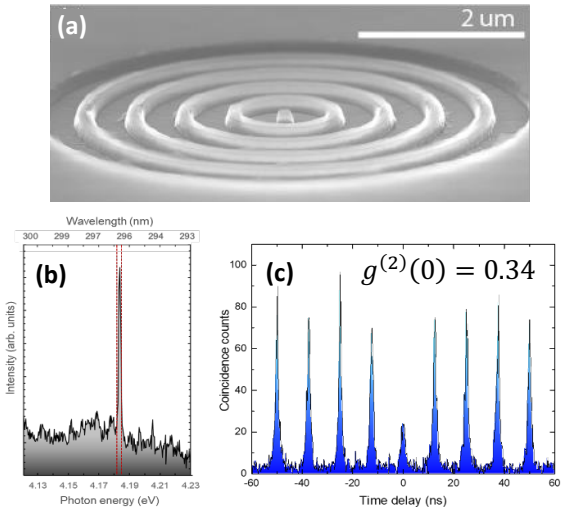

Figure 1. (a) SEM image of a fabricated bullseye structure (b) QD Emission spectrum (c) Auto-correlation function measurement at 5K, $g^{(2)}(0) = 0.34$

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References: [1] M. J. Holmes *et al.*, *Semicon. Sci. Technol.* **34**, 033001 (2019). [2] K. Gao *et al.*, *JSAP 77th Autumn Meeting.* 16p-A21-9 (2016) [3] T. Aoki *et al.*, *JSAP 80th Autumn Meeting*. 20p-E310-12 (2019).