トップダウン法で作製された位置制御 GaN 量子ディスクの光学特性

Optical properties of top-down fabricated site-controlled GaN quantum disks

○夏 思佳 [1]，有田 宗貴 [2]，荒川 泰彦 [2]，M. J. Holmes[1, 2]

（1：東大生研，2：東大ナノ量子機構）

○ S-J. Xia[1], M. Arita[2], Y. Arakawa[2], and M. J. Holmes[1,2]

(1: IIS, Univ. of Tokyo, 2: NanoQuine Univ. of Tokyo)

E-mail: xia@iis.u-tokyo.ac.jp

GaN/AlGaN nanostructures are of considerable interest for application in optical devices such as LEDs, laser diodes, and even single photon emitters. In particular, quantum structures in nanopillars are considered promising as way to improved device performance (in terms of reduced strain, increased material quality, and increased photon output coupling). We have fabricated UV-emitting site-controlled GaN/AlGaN quantum disks (QDisks) in nanopillars using a top-down lithography/etching process, and here we discuss the device characteristics, including analyzing the carrier dynamics of the structures using both time-integrated photoluminescence (TIPL) and time-resolved photoluminescence (TRPL) spectroscopy.

Our fabrication strategy involves the site-controlled etching of a single GaN/AlGaN QW into nano-scale pillars using e-beam lithography, metal evaporation/lift-off, ICP etching, and finally a wet-etch process to reduce the pillar diameter. The resulting GaN/AlGaN QDisks have diameters ranging from ~100nm to ~40nm (see figure 1a). Optical characterization was performed at 5K under excitation at 266nm. The emission energy of the QDisks is increased relative to the original quantum well (see figure 1b), possibly due to a combination of strain relaxation and increased lateral confinement. Dynamic internal field screening in the QDisks is also observed via spectrally resolved TRPL measurements (see figure 1c). The emission starts at high energy with a relatively fast lifetime of ~1.3ns and dynamically shifts to lower energy as the carrier density decreases (and the corresponding internal-field shielding decreases). Finally we note that some emission peaks are as narrow as 8 meV, indicating that quantum dots may also be fabricated using this method in the future.

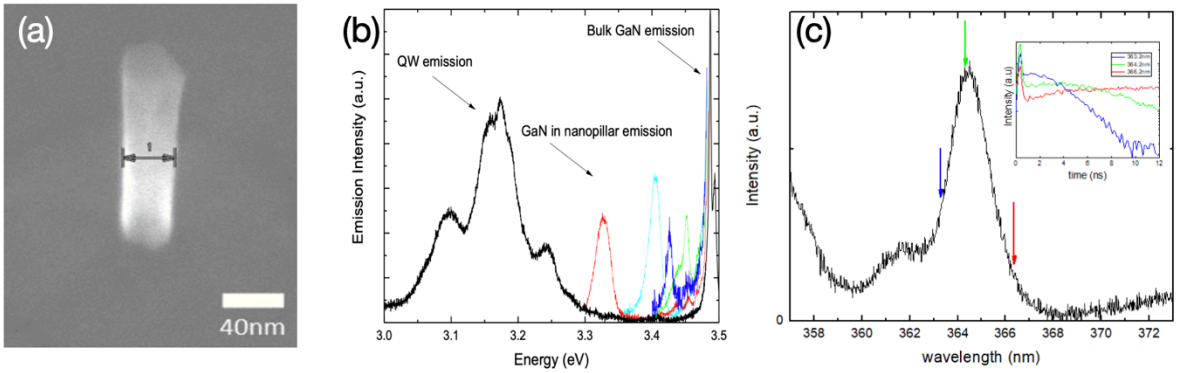

Figure 1. (a) SEM image of a fabricated nanopillar. (b) PL spectra of the GaN QW and GaN QDisks. (c) Emission spectrum and spectrally resolved TRPL measurements from a single QDisk. showing the dynamic shift of the emission during the carrier decay.

Acknowledgements: This work is supported by the JSPS Kakenhi project (19K15039) and the Takuetsu program of MEXT.