界面ゆらぎ GaN 量子ドットを有する高 Q 値 AlGaN フォトニック結晶ナノ共振器

High-Q AlGaN photonic crystal nanocavities for coupling with fluctuation GaN QDs

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The coupling of single GaN quantum dots (QDs) to group-III nitride cavities exhibiting high quality factors (Q) and small mode volumes is of major interest for the observation of cavity quantum electrodynamics (CQED) effects at high temperature. Significant progresses have been recently made in the fabrication of III-nitride photonic crystal (PC) cavities with the development of new fabrication techniques [1,2] but the active layer has been so far limited to quantum wells or high-density QD ensembles that are incompatible with the observation of individual QDs. In this work, we aim at coupling recently-developed low-density fluctuation GaN/AlGaN QDs [3] to high-Q AlGaN nanocavities in order to demonstrate CQED effects at high temperature. To that end, we use a PC fabrication technique that is based on the thermal evaporation of GaN and is compatible with the growth of fluctuation GaN QDs. We optimize the technique to adapt the resonant wavelength to the fluctuation QD emission range and boost the Q. We finally report on a Q as high as 5800 at 365 nm, the highest reported to date in an active III-nitride 2D PC nanocavity.

The design investigated here is a modified W1 waveguide PC nanocavity [4] presenting an intrinsic Q as high as 7.7 10^4 and a mode volume as low as 0.85 λ/n^3. The 2D PC nanocavities are implemented in an 85-nm-thick $Al_{0.21}Ga_{0.79}N$ epilayer embedding a GaN QW and grown by MOCVD on a GaN template. The PC slabs are realized in the AlGaN epilayer by electron beam lithography and subsequent Cl_2/Ar reactive ion etching and they are finally realeased by thermal evaporation of the underlying GaN (Fig. 1 (a)). Fitting room-temperature photoluminescence spectra of fabricated structures with Lorentzian profiles reveals Q as high as 5800 at λ_0 = 365 nm for a period a = 130 nm. This constitutes a significant improvement over previous nanocavities fabricated by this technique (Q = 5100 at λ_0 = 463 nm) [2] and it builds the path toward the observation of CQED effects in single GaN QD - nanocavity systems.

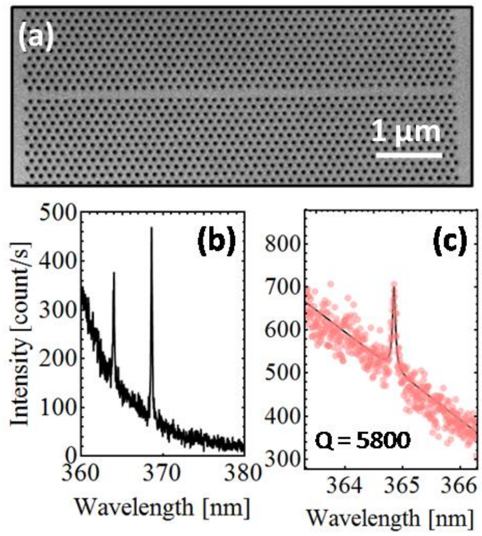

Fig. 1 (a) SEM views of an AlGaN PC nanocavity with a period a = 130 nm. (b) Spectrum of the cavity. (c) Fundamental mode. The dots are actual data and the black line is a fitting curve.

This work was supported by the Project for Developing Innovation Systems of MEXT.

[1] S. Sergent, M. Arita S. Kako, K. Tanabe, S. Iwamoto, and Y. Arakawa, Appl. Phys. Lett. **101**, 101106 (2012).

[2] M. Arita S. Kako, S. Iwamoto, and Y. Arakawa, Appl. Phys. Express **5**, 126502 (2012).

[3] M. Arita, T. Iki, S. Kako, and Y. Arakawa, 61st JSAP meeting, 17p-E13-16 (2014) .

[4] E. Kuramochi, M. Notomi, S. Mitsugi, A. Shinya, T. Tanabe, T. Watanabe, Appl. Phys. Lett. 88, 041112 (2006).