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高 Q 値(>6900)AlN 一次元フォトニック結晶ナノ共振器

High-Q (> 6900) AlN 1D ladder-structure photonic crystal nanocavity

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The fabrication of 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 cavities with the development of new fabrication techniques [1]. Further improvement can be achieved by carefully designing the cavities. In this work, we use a 1D ladder-structure photonic crystal nanobeam cavity (NC) design [2] to maximize the normalized frequency a/λ_0 of the resonant mode, with a the crystal period and λ_0 the resonant wavelength. The design is implemented in a GaN/AlN quantum dot layer and we report on the highest Q obtained to date in optically active III-nitride nanocavities.

The design investigated here is a 1D photonic crystal NC constituted of a tapered array of rectangular holes. In AlN NCs presenting circular [1] or hexagonal [3] holes, increasing the hole radius r increases a/λ_0 and thus facilitates the cavity fabrication. In practice, r is however limited by proximity effects taking place during e-beam lithography. Rectangular holes give an additional degree of liberty in the NC design that circumvents such a limitation: both increasing the width and the length of the holes leads to higher a/λ_0. Such NCs are realized in a GaN/AlN QD epilayer by layer transfer [1] (Fig. 1(a)). Fitting photoluminescence spectra of fabricated structures with Lorentzian profiles reveals Q as high as 6900 at λ_0 = 403 nm (Fig. 1 (b)) for a = 140 nm. It corresponds to a/λ_0 = 0.347 as compared to a/λ_0 = 0.326 for the highest-Q resonance found in NC presenting circular holes [1]. Using a Voigt profile to take into account the Gaussian broadening of the setup resolution (50 pm) even suggests Q as high as 12700. This is the highest Q achieved to date in optically active III-nitride photonic crystal nanocavities and it builds the path toward the observation of CQED effects in III-nitrides.

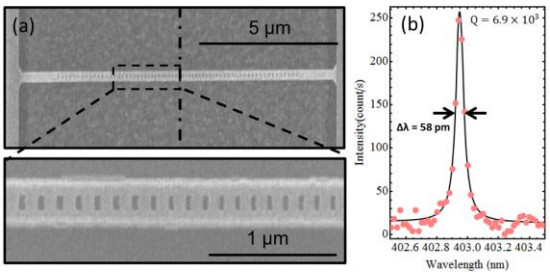

Fig. 1 (a) SEM views of an AlN ladder-structure cavity with a = 140 nm. (b) Microphotoluminescence spectrum of the cavity fundamental mode. The dots are actual data and the black line is a Lorentzian fitting curve.

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

[2] M. Notomi, E. Kuramochi, and H. Taniyama, Opt. Express **16**, 11096 (2008).

[3] S. Sergent, M. Arita S. Kako, S. Iwamoto, and Y. Arakawa, Appl. Phys. Lett. **100**, 121103 (2012).