AlGaN/空気 DBR 微小共振器の運動量空間分光

Momentum Space Spectroscopy of AlGaN/Air DBR Microcavities

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III-nitride/air distributed Bragg reflector (DBR) microcavities (MCs), due to the large refractive index contrast, have revealed a relatively high quality factor [1], and thus could be a promising system to study cavity-exciton interaction in nitrides. On the other hand, momentum space measurement is one main tool to characterize the cavity-exciton interactions in DBR MC system. In this work, we fabricated air/nitride DBR MCs and then performed photolumenescence (PL) measurement in momentum space to study the cavity-exciton coupling phenomena.

The samples were initially grown on m-plane free-standing GaN substrates ($-1°$off toward [0001]) by metalorganic chemical vapor deposition (MOCVD), which incorporate a 2λ-cavity sandwiched between three and four periods of AlGaN/GaN ($\frac{3\lambda}{4n_{AlGaN}}/\frac{3\lambda}{4n_{Air}}$) layers. After dry etching and thermal decomposition processes [1], we obtained the air/nitride DBR MCs, as schematically shown in Figure 1(a). In the cavity region, three GaN layers were designed to be at the antinodes (Figure 1(b)).

Momentum space PL measurement was performed at room temperature with a 266 nm CW laser. Figure 1(c) shows PL intensity mapping in $E - k_{\|}$ space. At large angles (or $k_{\|}$), when approaching the exciton line (E_A), the dispersion is obviously suppressed or bending. The same behaviour can also be seen from Figure 1(d), where the spectra picked out from Figure 1(c) with a step size of 2° are vertically offset. The dispersion bending when approaching the exciton line is a characteristic of strong coupling between cavity photon and exciton. The coupling could be modelled by two-coupled-harmonic-oscillator model, which gives two new modes: lower polariton (LP) and upper polariton (UP) [2], with $E_{LP,UP}(k_{\|}) = \frac{1}{2}[E_x + E_c \mp \sqrt{4g_0^2 + (E_x - E_c)^2}]$, where Ex is exciton energy, $E_c(k_{\|}) = \frac{\hbar c}{n_c}\sqrt{k_{\perp}^2 + k_{\|}^2}$ cavity dispersion, and g_0 coupling strength. Using this model, the observed dispersion is fitted in Figure 1(c), with brown curve being the polaritons (LP and UP), white curves the pure cavity and exciton. A Rabi splitting of $\Omega_{Rabi} = 2g_0 = 70$ meV is obtained ($n_c = 2.59$, $E_c(0) = 3.406$ meV), about 1.5 times larger than the reported values in nitrides. Considering the large refractive index contrast in DBRs and large exciton-photon overlap and three active layers in cavity, this large Rabi splitting is reasonable.

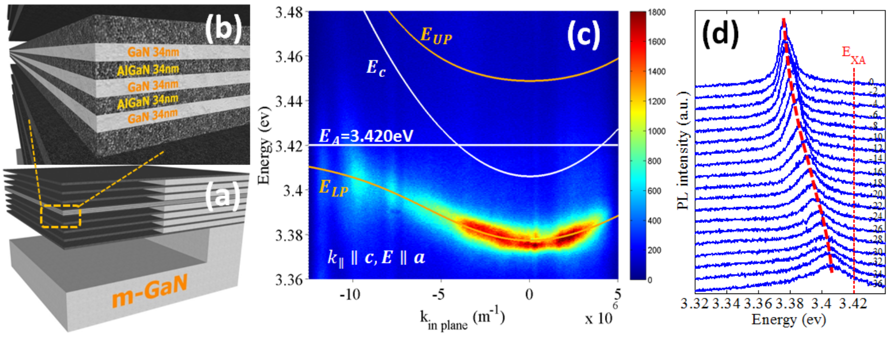

Figure 1: Schematic view of (a) the whole structure and (b) cavity region; (c) PL intensity mapping in momentum space with fitting dispersions for each modes; (d) Spectrum stack with 2° step interval.

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References

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