Exciton-phonon interaction in AlGaN ternary alloys  
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In III-nitrides, Coulomb interaction between electrons and electric field associated with the longitudinal-optical (LO) phonons (Fröhlich interaction) is strong because of their ionic nature [1]. The electron-phonon interaction plays a significant role in optical and electrical properties of III-nitride devices. The electron-phonon interaction can be observed as phonon replicas of exciton emission, and the exciton-phonon interaction has been particularly studied in binary AlN and GaN as well as in InGaN/GaN, GaN/AlGaN and AlGaN/AlN quantum wells [2-5]. In this work, we study the exciton-phonon interaction in Al\textsubscript{x}Ga\textsubscript{1-x}N ternary alloys with various Al compositions \(x\).

C-plane Al\textsubscript{x}Ga\textsubscript{1-x}N layers were grown on sapphire or SiC (0001) substrates using AlN buffer layers by MOVPE. Photoluminescence of the Al\textsubscript{x}Ga\textsubscript{1-x}N layers was measured at 9 K. Figure 1 shows a PL spectrum of an Al\textsubscript{x}Ga\textsubscript{1-x}N layer with \(x = 0.85\). The main peak at 5.593 eV can be assigned to the exciton emission. At the low energy side, shoulder peaks due to the LO phonon replicas are observed. The emission peaks are deconvoluted using a multiple Gaussian fitting function as shown by dotted lines in Fig. 1. In a Franck-Condon approximation [6], the distribution of their intensities depends on the exciton-phonon coupling strength, which is described by Huang-Rhys (\(S\)) factor, and the emission intensities of the main emission peak (\(I_0\)) and the \(n\)th phonon replica (\(I_n\)) are related by \(I_n = I_0(S^n/n!)\). The \(S\) factor of the Al\textsubscript{x}Ga\textsubscript{1-x}N layer with \(x = 0.85\) was estimated to be 0.35.

Figure 2 shows the \(S\) factors of the Al\textsubscript{x}Ga\textsubscript{1-x}N layers as a function of Al composition \(x\). The \(S\) factors of the Al\textsubscript{x}Ga\textsubscript{1-x}N ternary alloys are larger than binary GaN (\(S = 0.017\)) and AlN (\(S = 0.056\)), indicating a stronger exciton-phonon interaction. A non-linear trend of \(S\) factor with composition is observed. This result implies that the exciton-phonon coupling strength in the Al\textsubscript{x}Ga\textsubscript{1-x}N ternary alloys is influenced by alloy broadening and/or compositional fluctuation.

This work was partly supported by KAKENHI (25246022).