Structural and Optical Characterizations of GaInN Multiple Quantum Wells Grown by Raised-Pressure Metalorganic Chemical Vapor Deposition

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We have found that photoluminescence spectra depend on microscopic structure in two types of GaInN multiple quantum wells (MQWs). The MQWs were grown using metalorganic chemical vapor deposition. In one type of MQW (1.0 atm sample), the MQW layers were grown under a pressure of 1.0 atm. In the other type (1.6 atm sample), the MQW layers were grown under a pressure of 1.6 atm. The designed values of the structure is same in both types of MQWs. The well number is three. The thickness and In content of the well are 3 nm and 8 %, respectively. Those of the barrier are 6 nm and 2 %, respectively. The structure was observed by transmission electron microscopy (TEM). Figure 1 shows cross-sectional TEM images taken with the reflection vector parallel to the heterointerfaces. In the MQW layers of the 1.0 atm sample, the strain is not uniform and is modulated at irregular intervals from 50 nm to 100 nm. On the other hand, in the 1.6 atm sample, the strain is uniform. Figure 2 shows cross-sectional TEM images taken with the reflection vector perpendicular to the heterointerfaces. In the MQW layers of the 1.0 atm sample, the thickness is increased locally as shown with white arrows, while in the 1.6 atm sample the thickness is uniform. Photoluminescence (PL) spectra of the samples were measured over a temperature (T) range from 6 K to 300 K. As shown in Fig. 3, the spectra of the 1.6 atm sample have one component, while those of the 1.0 atm sample have two components, high-energy and low-energy ones. The arrow in spectra of the 1.0 atm sample indicates the position of low-energy component. The peak energy of high-energy component decreases with increase of temperature, and is almost equal to the peak energy in spectra of the 1.6 atm sample. These results suggest that disorder in the structure induces additional radiative recombination center. The PL intensity of the low-energy component increase with increase of temperature for $T < 130$ K, indicating that the carriers transfer into the additional center in the 1.0 atm sample. Though the two component luminescence and the carrier transfer have been also reported by Kudo *et al.* [1] in the $Ga_{0.92}In_{0.08}N$ single layer, the 1.0 atm sample didn't show the S-shaped energy shift (redshift-blueshift-redshift) [2] as they have reported.

Further, in the workshop, we will discuss the non-radiative recombination processe in these two samples.

[1]H. Kudo, H. Ishibashi, R. Zheng, Y. Yamada, and T. Taguchi, phys. stat. sol. (b) **216**,163 (1999).
[2]Y. H. Cho, G. H. Gainer, A. J. Fischer, J. J. Song, S. Keller, U. K. Mishra, and S. P. DenBaars, Appl. Phys. Lett. **73**, 1370 (1998).

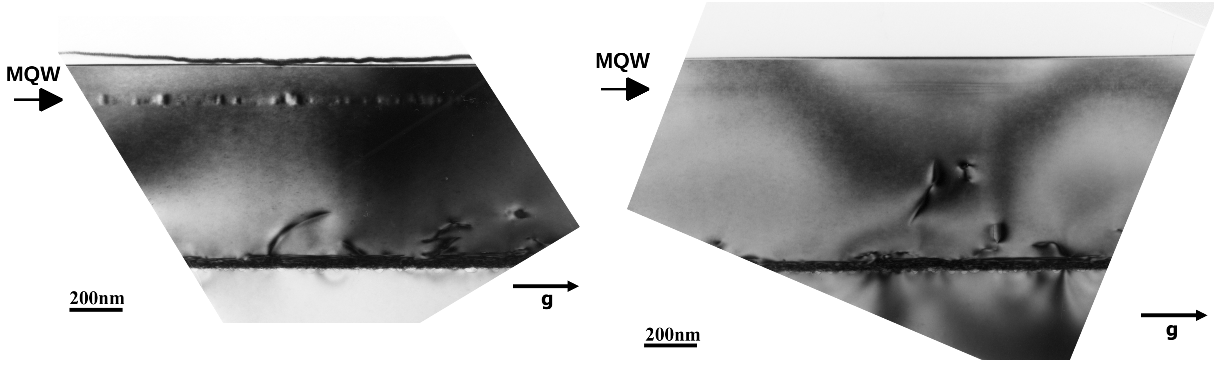

Fig. 1 Cross-sectional TEM images of two samples grown under pressures of 1.0 atm (left) and 1.6 atm (right). The reflection vector is set parallel to the heterointerfaces.

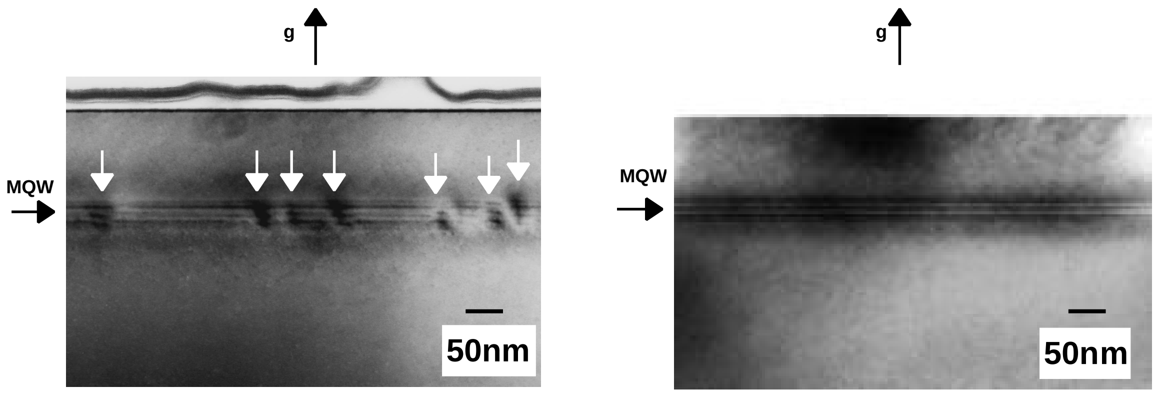

Fig. 2 Cross-sectional TEM images of two samples grown under pressures of 1.0 atm (left) and 1.6 atm (right). The reflection vector is set perpendicular to the heterointerfaces.

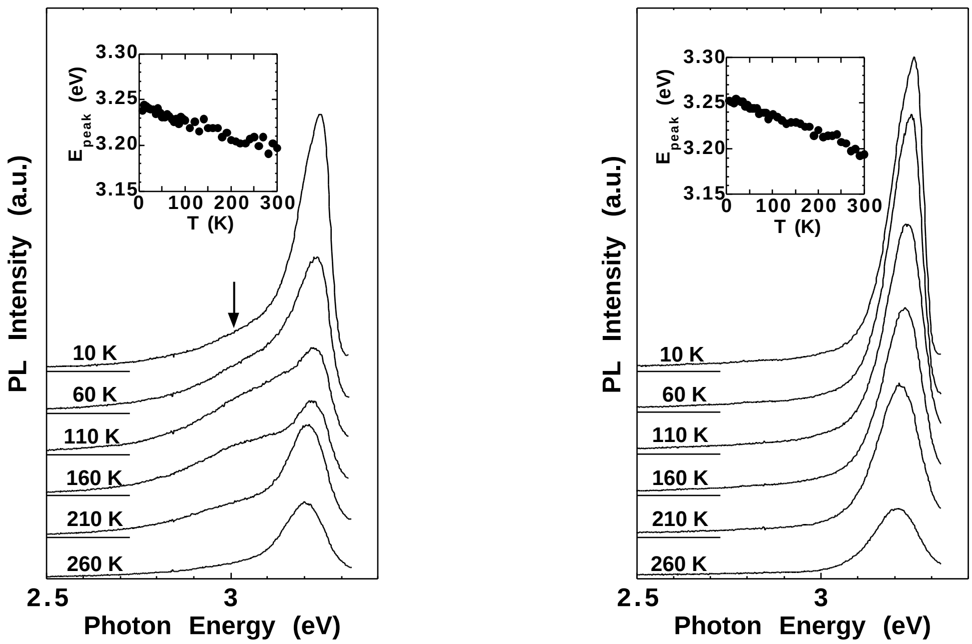

Fig. 3 Photoluminescence spectra of two samples grown under pressures of 1.0 atm (left) and 1.6 atm (right). The insets show temperature dependence of the peak energy.