Luminescence Spectroscopy of Moduration-doped AlGaAs/GaAs Quantum Structures with a Low-temperature Scanning Near-field Optical Microscope

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In the moduration-doped AlGaAs/GaAs single heterostsructures, it has been known that electrons are confined one-dimensionally at the heterointerface. The magneto photo-luminescence spectra show characteristic features of two-dimensional electron gas (2DEG) systems [1]. However, small fluctuations of the interface and the carrier density affect the local potential for the 2DEG, and these may be influence the spatial distribution of the luminescence intensity and the spectra.

In this paper, we have investigated the influence of the local fluctuation to the luminescence using the scanning near-field optical microscope (SNOM). The samples consist of 1-μm undoped GaAs, 20-nm undoped AlGaAs and 80-nm Si-doped AlGaAs layers. The layers are etched with 1-μm line and space pattern. The density of the 2DEG is estimated to be $2x10^{11}$ cm^{-2}. A sample was set on the low-temperature SNOM [2], which was cooled down to 17 K. The sample was irradiated with the 633-nm HeNe-laser light through the probe-tip aperture with the diameter of 200 nm, which dominates the spatial resolution of the SNOM. The luminescence of the sample was corrected by the same probe-tip aperture, and was sent to the spectrometer.

Figure 1 shows (a) the topographic image and (b) the luminescence image measured at 817 nm, which is the center wavelength of the luminescence of the heterostructure. The measured area with the size of 600 nm x 600 nm is around the center of a line stripe pattern. The surface is almost flat with the height difference of several angstroms, while the dot like structures caused by frozen air were observed unfortunately. In the luminescence image, the intensity is fluctuated by >10 % in the measured area. The positions with strong luminescence do not completely correspond to those with thicker semiconductor layer. It is suggested that the lower potential ponds for the 2DEG are affected to not only the semiconductor layer thickness but also the other fluctuations. The origins will be elucidated by the detailed spectroscopy.

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References

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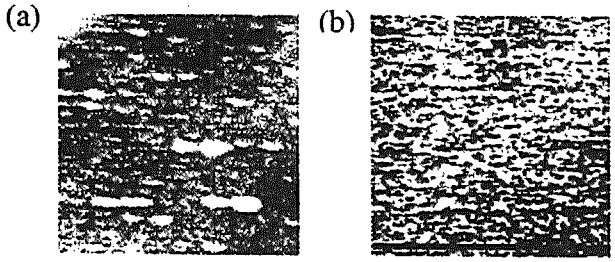

Fig.1
(a) Topographic image and (b) luminescence image measured at 817 nm.