Long Range Screening Effect on Photoluminescence Spectrum in Quantum Hall regime

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It is well known that the photoluminescence(PL) spectra in quantum Hall regime show strong dependence on the sample structures[1-2]. In the previous works, we have performed measurements of several samples with different quantum well width and found that magnetic field dependence of PL spectra are drastically changed with a slight change of well width around 1000Å [3-4]. Especially, signal ratio between ground state PL and excited state PL was found to be affected not only by the well width but also by strength of screening effect induced with change of filling factor. Estimating simplified rate equation, we have clarify long range screening effect plays an important role for the PL recombination process in quantum Hall regime. On the other hand, in asymmetric wide well samples, distance between electron and hole wave function are affected by the carrier density. So, for the estimation of the screening property, continuous carrier density dependence should be studied. In this paper, we will show the results of the systematic study of magneto-PL characteristics with different quantum well width samples and also gate voltage dependence with use of transparent gate fabricated samples.

Samples are GaAs/AlGaAs asymmetric quantum wells grown by MBE. Magneto-PL spectra were measured for two different carrier density series of samples of quantum well width ranging from 100Å to 10000Å. Magnetic fields were applied by superconducting magnet up to 15T and water-cooling magnet up to 25T. For the polarization measurements, we used film polarizer and reversing magnetic field direction. Some samples are fabricated into Hall-bar geometries for the current dependence measurements.

Narrower well width samples than 500Å show clear oscillation of PL peak energy from the lower magnetic fields. This oscillation is accompanied by a large jump of PL peak energy at filling factors ν=1 and 2[4]. On the other hand, samples with the wider well than 1000Å show absence of PL peak at lower magnetic fields than that at ν=2 and, instead, the PL signal from the first excited subband can be seen clearly which oscillates its PL intensity with Shubnikov de Hass oscillation. At ν=1 and 2, the PL peak energy shows no discontinuity, however, PL peak intensity is drastically changed especially around ν=1. From the ratio between ground state PL intensity and excited state PL intensity, we found that the hole state is strongly screened by the two dimensional electrons for higher magnetic fields than ν=2. Magnetic field dependence of the ratio shows minima at integer fillings of ν=1 and 2 and also a fractional fillings of ν=2/5 and 1/3, suggesting that screening affects PL process even for samples with longer electron-hole separation than 1000Å. Furthermore, for getting much precise relation between electron-hole separation and screening effect, we performed PL spectra measurements of carrier density dependence with use of transparent gate samples. We will report analysis of the data with self-consistent band bending calculation.

References

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