The Carrier Concentration Dependence of Magneto-Photoluminescence in n-type Modulation Doped $Cd_{1-x}Mn_xTe$ / $Cd_{1-y}Mg_yTe$ Single Quantum Wells

A. Yuzawa [1], T. Iwazaki [1], N. Ozaki [1], S. Kuroda [1], K. Takita [1]
[1] *Institute of Materials Science, University of Tsukuba, Tsukuba, Ibaraki, 305-8573, Japan*
K. Sato [2], Y. Imanaka [2], T. Takamasu [2], G. Kido [2]
[2] *National Institute for Materials Science, Tsukuba, Ibaraki, 305-0003, Japan*

Recently, there have been reported on *magnetic* two dimensional electron gas (2DEG), which is realized in modulation doped II-VI diluted magnetic semiconductor (DMS), such as $Cd_{1-x}Mn_xTe$, quantum wells where localized spins (Mn^{2+}, S=5/2) are interacting with the 2DEG via a strong *s-d* exchange interaction. This interaction leads to an enhanced spin splitting which is proportional to Mn^{2+} magnetization expressed by the Brillouin function. In this system, the enhanced spin splitting can exceed the Landau-splitting and Fermi energy, and this means that the spin state of electrons can be highly polarized even at low magnetic field. The aim of this work is to investigate the spin-dependent properties using highly spin-polarized *magnetic* 2DEG which contain a wide range of carrier concentration, i.e, from undoped to 3.0×10^{11} cm^{-2}.

Magneto-photoluminescence (PL) measurements are performed under magnetic fields up to 7T in samples A and B, 15T in samples C−E, at 2K. Fig1 shows the image plots of magneto-PL spectra for the σ^+ polarization for a series of samples. Electron densities of samples are determined by transport measurements. Shubnikov-de Hass (SdH) oscillations and integer quantum Hall effect are observed in doped samples D and E. The PL spectra show large redshift in magnetic fields due to the enhanced Zeeman shift of Landau levels. Furthermore, several interesting behaviors are observed in the magnetic field dependence. At first, in all samples, the intensity of the lower energy peaks or the peaks started from zero field becomes weaker with increasing magnetic field and, in contrast, another peaks begins to appear at the higher energy side which becomes stronger with increasing magnetic field. Secondly, with increasing electron density of samples, disappearance-field of the lower energy peaks (indicated by the dotted line) shifted to the higher magnetic field. The former implies that the origin of the lower and the higher energy peaks are related to each other. The latter suggests that the origin of lower energy peaks is affected by spin-polarization degree of electrons. Further it is found that new peaks with a moderate intensity seems to appear in the magnetic field region between $\nu=2$ and $\nu=1$ in the doped samples D and E. From comparison with Landau fan chart of each sample, the observed results seem to be consistent with an interpretation that the lower energy peaks, the peaks in the intermediate field and the higher energy peaks are originated from singlet chaged exciton, triplet charged exciton and neutral exciton, respectively.

Sample	x(%)	$n_{2D}(cm^{-2})$	$\mu\,(cm^2 / V.s)$
A	3.5	undoped	—
B	3.5	$\sim 10^{10}$	—
C	5.0	1.3×10^{11}	1300
D	5.0	2.2×10^{11}	3100
E	3.0	3.0×10^{11}	7000

Table1: Summary of sample characteristics.
x , n_{2D} and μ are Mn composition, 2D electron density and mobility, respectively.

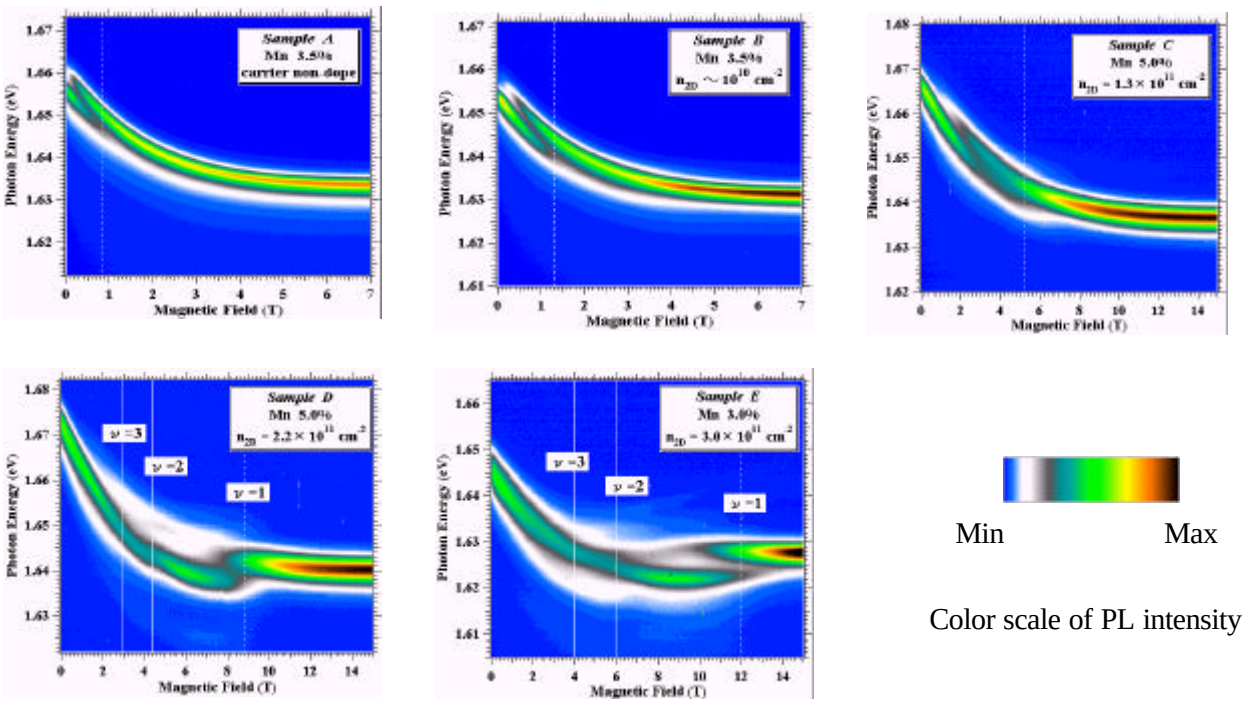

Figure1: image plots of Magneto-PL spectra for σ^+ polarization
from *magnetic* 2DEGs with varied electron density.