Ultrafast Absorption and Emission from 2d High-Density Magneto-Plasma: Absence of Excitonic Mott Transition

G. T. Noe (Rice, ECE), J. Lee (UF, Physics), D. H. Reitze (UF, Physics), A. A. Belyanin (Texas A&M, Physics), and G. Solomon (NIST), S. McGill (NHMFL), J. Kono (Rice, ECE)

Introduction
The photo-induced magneto-excitonic state of multiple quantum wells in high magnetic fields results in stimulated emission or coherent bursts of radiation (superfluorescence) at sufficiently high densities [1-3]. Here we investigate emission and absorption properties of In$_{0.2}$Ga$_{0.8}$As/GaAs multiple quantum wells at low temperature and with increasing magnetic field up to 17.5 Tesla for both the high and low density regimes. Landau fan diagram analysis reveals that the 2D electron-hole pair transforms from the metallic plasma state to a clear excitonic state (Mott transition) when the magnetic field is applied, even in the high density regime.

Experimental
A multiple quantum well sample, 15 layers of In$_{0.2}$Ga$_{0.8}$As/GaAs, cooled to 5K was placed a 17.5 Tesla superconducting magnet in the Faraday geometry. A quartz-tungsten lamp was used for white light transmission measurement. A He-Ne laser and chirped pulse amplifier (CPA) were used for low and high excitation photoluminescence (PL), respectively. A right angle micro prism mounted at the side of the sample redirected the in-plane emission from the edge of the sample to a 0.6mm core diameter multimode fiber [1].

Results and Discussion
Fig.1 shows the magnetic field (H) dependent white light absorption and PL in the regime of low and high excitation. As we can see, the energy dependence of the first Landau level (00LL) is quadratic in H (the diamagnetic shift) and linear in H at high field. Physically, the separation between the bandgap energy and the extrapolation of the 00 Landau level peak position is the excitonic binding energy and Fig 1(Left) shows an 11 meV binding energy in the case of white light absorption. In contrast to low density excitation, the excitonic binding energy becomes zero at high densities (Fig. 1 - Right), corresponding to the electron-hole plasma state. All of the fits in Fig. 1(Right) converge to one value indicating zero excitonic binding energy at 0 Tesla. However, the experimental 00LL PL data follows the quadratic form of diamagnetic shift which shows excitonic character for increasing magnetic fields.

Conclusions
The findings above are indicative of a metal-insulator transition, whereby the Coulomb correlation is changed by the density of carriers (Mott transition) and magnetic field. Under ordinary conditions (in the absence of a magnetic field), The insulating phase of a low density exciton gas becomes unstable at high densities and transforms into a conducting phase of an unbounded electron-hole plasma because of screening of the Coulomb interaction. However, even in sufficiently high densities, as soon as magnetic field is switched on, the plasma state present at 0 Tesla undergoes transition to excitonic state.

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References