Magneto Optical Study of GaSb-InAs-AlSb Quantum Wells

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Introduction
Among the candidates possibly reaching exciton BEC in 2D systems, InAs/GaSb CQW has a unique type-II band alignment, in which the bottom of the conduction band in bulk InAs lies below the top of the valence band in bulk GaSb. The overlap of electron and hole band edges can spontaneously form excitons without photoexcitations if the single particle energy gap is smaller than the exciton binding energy. These spontaneously formed excitons have no recombination, and hence, possess long lifetimes. In this type of 2DEHS, several far-infrared active modes around CR have been observed. On one hand, the results suggest the formation of stable excitons by showing exciton’s 1s-2p internal transitions; [1] on the other, they were interpreted as the hybridization gap due to a mixing of the electron and hole wavefunctions. [2] The hybridization model in association with the $k\cdot p$ model can account for several features observed in this type of material. We have observed a pair of IR modes in the weakly hybridized CQWs, which have narrow well width and a barrier layer separating electrons and holes. This pair of modes occurs only at magnetic fields higher than 14T with a field-independent energy separation. They do not decay with increasing temperature up and is insensitive to increasing parallel magnetic fields. These features distinguish our results from the ones reported in the literature. We suggest a spontaneous phase separation is responsible for the CR splitting.

Experimental
The detail of the InAs-AlSb-GaSb CQW can be found in ref. [3]. The FIR transmission spectroscopy is carried out by a commercial FTIR interferometer using light-pipe optics. The magneto-FIR modes are extracted by the ratio of the spectra measured with and without a magnetic field.

Results and Discussion
The spectra were offset horizontally to align CRL and the energies of the modes as a function of magnetic field are plotted in the bottom. There exist three zones with three distinct separation energies. In general, the energies of CRL and CRH increase linearly with increasing magnetic field. Two abrupt drops in each trace divide the region into a succession of three zones, labeled: zones (1), (2) and (3), respectively. These values are of the same magnitude as compared to the exciton binding energies calculated by various works. In zones (1) and (2), the energy separations between CRL and CRH are generally larger than the separation in zone (3), which is inconsistent with the concept that the CR splitting are a result of a pair of LLs with different spin states. Moreover, within zones (1) and (2), the energy separation is again slightly larger at lower fields, inconsistent with the nature of the Zeeman splitting. In zone (3), the energy separation maintains a nearly perfect field-independent energy separation up to 30T. At high magnetic fields, the influence of the spin splitting should be discernibly visible. The lack of a magnetic-field dependent energy separation in this work suggests that the CR splitting is not a consequence of a set of spin-split LLs, and is thus unlikely to result from the hybridization.

Conclusions
The CR splitting exhibit several features, which are very different from those reported in the past. The energy separation is slightly larger at lower magnetic field, while it is magnetic-field independent at high magnetic field. A spontaneous phase separation seems to account for most of the features observed in this work.

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References