Cyclotron Resonance in Corrugated Lateral Superlattices

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Recently, the two-dimensional electron system (2DES) subjected to periodically modulated structure, i.e. lateral superlattice (LSL), was formed on (775)B-oriented GaAs substrate by molecular beam epitaxy (MBE) [1]. This LSL structure is well-ordered unidirectional and has ultrashort period, 12nm, much shorter than those available by the standard lithographic methods. The schematic view of this structure is shown in Fig.1. In this structure, the electron transport properties have been studied such as the anisotropy of electron mobilities with measured direction [2] and the suppression of exchange enhancement of spin gap in quantum Hall regime [3] were reported. In the optical study, the lasers with this structure in the active layer were oscillated at room temperature [4].

In this work, the cyclotron resonance (CR) experiment on this structure is investigated in order to study electronic properties of 2DES in laterally modulated potential. In a uniform system subjected to a magnetic field B perpendicular to the plane of 2DES, Landau levels are degenerate with the center of the cyclotron orbit. This gives rise to sharp Landau levels with a high degeneracy of eB/h per spin. An additional potential modulation in a plane perpendicular to the magnetic field lifts this degeneracy into Landau bands (LB). Then, a multi-dip structure or a broadening of the CR spectra is predicted [5].

From another point of view, in a homogeneous system CR spectra are not influenced by electron-electron interactions, which is known as Kohn's theorem [6]. However, in a lateral potential modulation Kohn's theorem is broken and electron-electron interactions directly modify CR spectra. In fact, Zhao et al. [7] observed broadening and splitting of CR spectra in the 2DES in the presence of a lateral surface superlattice potential by a grid metal gate. They speculated this anomaly is attributed to electron-electron interactions.

We have investigated two LSL samples with well layer thickness Lw=7 and 10 nm. Two unmodulated samples with Lw=7 and 10 nm have been also investigated, which are grown on the (100)-oriented GaAs substrates for reference of CR experiment. We name the (775)B samples M7 and M10 and the reference samples R7 and R10. The CR experiments were performed with a far-infrared Fourier transform spectrometer which allowed us to measure the transmittance as a function of frequency. The magnetic field is horizontally applied up to 10 T by the split pair superconducting magnet. Samples were cooled down to 5 K.

CR spectra for sample M10 and M7 are shown in Fig.2 for several values of the magnetic field. Vertical lines in Fig.2 indicate resonance positions of CR spectra in sample R10 and R7 for reference. The line shape of CR spectra of sample M10 varies with the applied field due to double dip structure. The spectra show anticross behavior around B=7.5 T. No deviation of resonance positions of sample M10 from those of sample R10 appears, except for the effect of the anticross behavior. In sample M7, more complicated spectra of CR are obtained. We discuss several possible speculations on the behavior of CR spectra. These are the generation of LB due to the lateral potential modulation, the resonant subband-Landau level coupling induced by potential modulation and the effect of electron-electron interaction reintroduced by breakdown of the translational invariance. More details will be discussed in the conference.

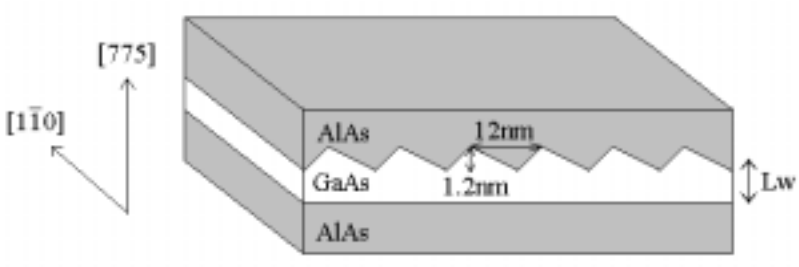

Fig.1 The schematic view of GaAs/AlGaAs LSL structure formed on (775)B oriented GaAs substrate by MBE. The corrugation of upper interface has a lateral period of 12 nm and a vertical amplitude of 1.2 nm.

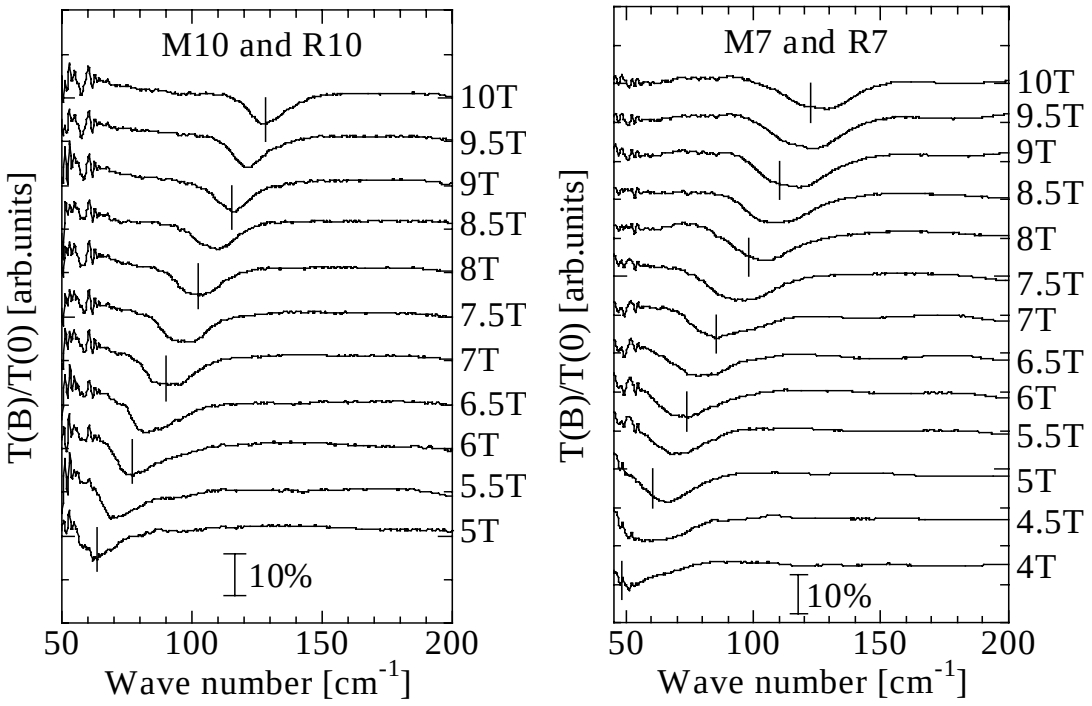

Fig.2 CR spectra for sample M10 and M7 with several magnetic fields. Vertical lines indicate resonance positions of CR spectra in sample R10 and R7 for reference.

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