Electron-Phonon interaction in a doped GaAs single quantum well

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The polaron effect, observed in polar and ionic crystals, arises due to the predicted electron-phonon interaction through the Frölich mechanism, which couples free electrons with LO phonon mode. It has been claimed to be "observed" experimentally in bulk crystals and also in two dimensional systems (2DEG), results obtained mostly by infrared transmission experiments. However, it is difficult to analyze properly the data close to TO-LO band (reststrahlen band) where the sample becomes opaque and strong dielectric effects distort the absorption peaks.

We studied the polaron coupling in high density 2DEG in order to understand what happens to this interaction in high density and high mobility electron gas. Preliminary results [1] on samples doped at the level of 1.2×10^{12} cm^{-2} did not reveal any interaction. We have resumed cyclotron resonance (CR) experiments on a lower doped GaAs/AlAs single quantum well 13 nm with carrier densities of $7.4 \times 10^{11} cm^{-2}$. This sample exhibits an electron mobility higher than 100 m^2 /V.s. The main obstacle for studying the polaron interaction close to resonant condition (total opaqueness of the substrate material for infrared radiation in the reststrahlen band) has been significantly suppressed by lifting off the quantum structures from their native GaAs substrate and by depositing them on a silicon substrate which is 'transparent' in this energy range. Only a band of 2 meV wide around the GaAs TO phonon energy remains obscured by the strong phonon absorption [1]. The measurements were performed using a Fourier transform spectrometer in magnetic fields up to 28 T, the infrared radiation being detected by a silicon bolometer at 1.8 K. In order to analyze properly the data, we had to mimic the full dielectric response of the structure using transfer matrix formalism.

As reported in [1] for a higher electron concentration, we do not observe any kind of coupling with longitudinal optical phonons in Faraday configuration with the field perpendicular to the 2D plane (Fig. 1:open squares). However, when the sample is tilted with respect to the magnetic field, a clear coupling is seen but around a mode below the LO phonon energy (Fig.1:full dots). This mode corresponds to the hybrid intersubband-LO phonon mode in the doped QW (ω_{Li}). In this configuration in a layered system, the LO phonons become infrared active [2] and we can observe both LO and TO absorptions (Fig.1: crosses). We discuss the possible coupling mechanisms between the CR mode and the Li mode.

[1] A. Poulter, J. Zeman et al., Phys. Rev. Lett. 86, (2001), 336
[2] D.W. Beerman, Phys. Rev. 130, (1963), 2193

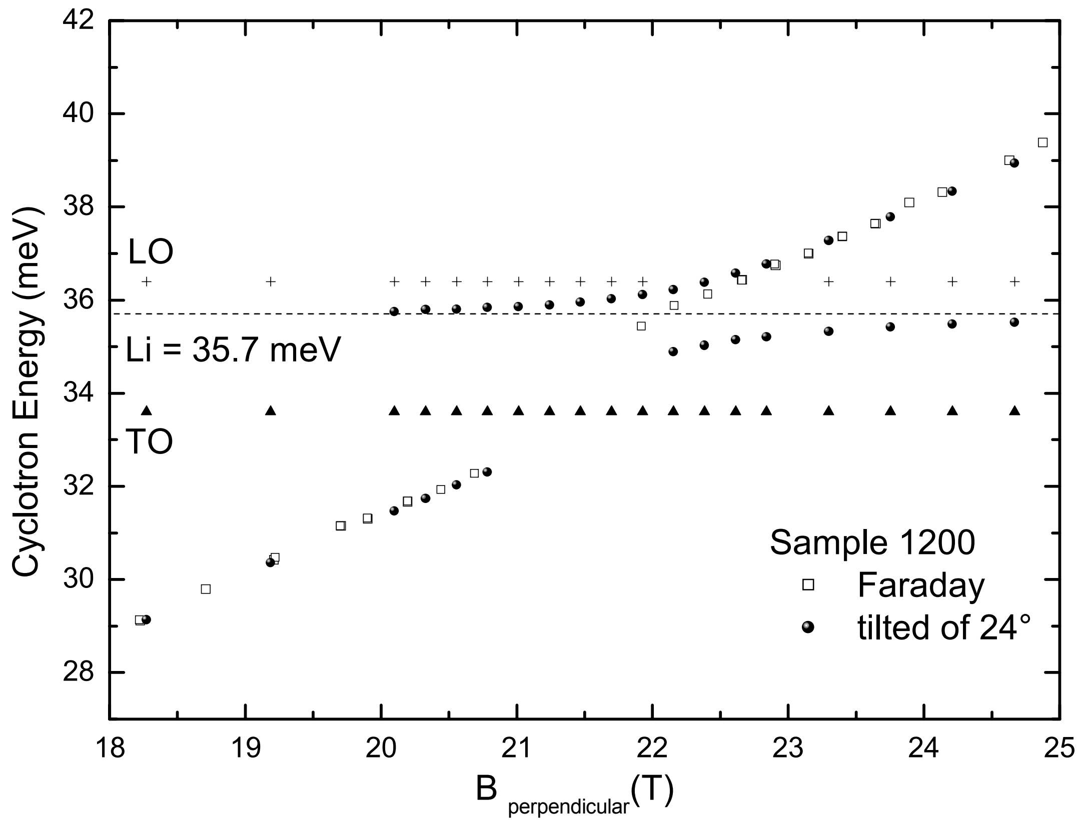

Fig. 1 : Magnetic field dependence of the cyclotron resonance absorption line in the GaAs optical phonons range of energy, in Faraday configuration (open squares) and in tilted configuration (full dots). Are also shown the measured LO absorption (cross), TO absorption (full triangles) and the calculated Li energy (dashed line)