Study of Electron-LO Phonon Scattering in Wide GaAs Quantum Wells Utilizing Hot Electron Spectroscopy

C. Pacher, G. Fasching, M. Kast, G. Strasser, E. Gornik

Electron-LO phonon scattering in wide GaAs quantum wells is experimentally studied. New results from a hot electron spectroscopy study utilizing a three terminal device (3TD) are reported. In the past we have used 3TDs to study different transport phenomena, like the onset of diffusive miniband transport in superlattices [1], quantum mechanical anti reflection coatings for miniband transport [2], and increased the energy resolution of this spectroscopy technique to approx. 10 meV [3]. A further decrease of the FWHM of the injected electron distribution compared to Ref. [3] gave us the possibility to study different scattering mechanisms in GaAs energy resolved by simple current measurements.

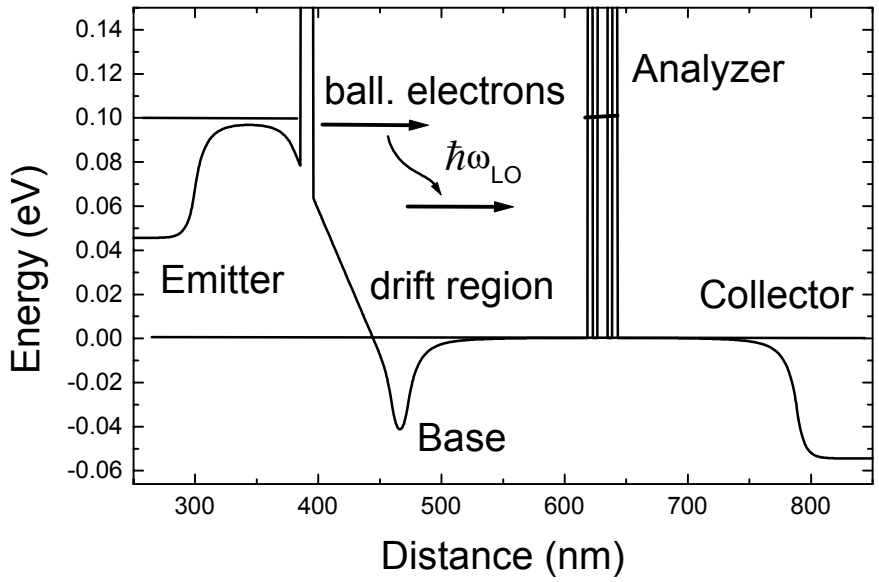

Fig. 1: Calculated conduction band diagram of a three terminal device.

In a 3TD, hot electrons are injected through a $Al_{0.3}Ga_{0.7}As$ tunnel barrier into a GaAs drift region. These hot electrons are tunable in their energy by the applied voltage between the emitter contact (E) and the base contact. After traversing the drift region, where they undergo various scattering mechanisms, the hot electrons hit an energy filter with a FWHM of 1 meV. In a third contact, the collector (C), the electrons which have been transmitted through the filter are detected as collector current. From the ratio $\alpha = I_C/I_E$ of the measured currents at T = 4.2 K an energy-resolved spectrum of the electron distribution is obtained.

In our experiments we observed resonances in the emitter current which are due to electron injection into bound states in the drift region. Due to scattering these resonances persist in the calculated transfer ratio $\alpha=I_C/I_E$ and gave us the possibility to directly measure elastic scattering in the highly doped base layer and LO phonon scattering in the drift region energy resolved. Since the LO phonon scattering takes mainly place between different bound states we also get information on the q-dependence of the LO phonon scattering. In the experiments we used three different lengths (150 nm, 250 nm, 400 nm) for the drift region to study the LO phonon scattering in more detail. The mentioned resonances in the emitter current are most pronounced for the shortest sample (150 nm), less pronounced for the 250 nm sample and vanish for the longest sample (400 nm). The reason is the different energy spacing of the bound states, which is 9.7meV, 5.8meV and 3.6meV, respectively. In the latter case, the energy separation is smaller than the energy distribution leading to smooth transfer ratio. A first estimate, considering only the amplitudes of the ballistic peaks, leads to a LO phonon scattering time of 324 fs in wells with a width between 150 and 250 nm, and to 161 fs for wells with a width between 250 and 400 nm. This is a clear evidence for the confinement dependence of the LO-phonon scattering rate.

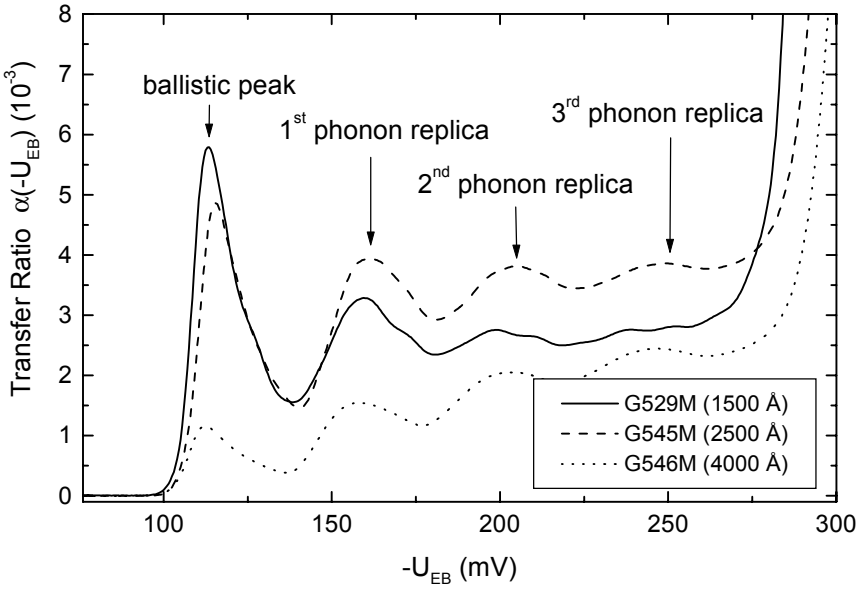

Fig. 2: Transfer ratios vs. emitter bias of the analyzer for three different drift region lengths.

References

[1] C. Rauch et al., *Phys. Rev. Lett.* **81**, 3495 (1998).

[2] C. Pacher, *et. al.*, *Appl. Phys. Lett.* **79**, 1486 (2001).

[3] M. Kast, C. Pacher, G. Strasser, and E. Gornik, *Appl. Phys. Lett.* **78**, 3639 (2001).