Measurements of the electrical excitation of QH-devices in the real time domain

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We have performed real time measurements of the electrical excitation of Corbino devices (measured with impedance-matching circuit) in order to determine the excitation and relaxation times, the times necessary the system to change from a no dissipative (QH) state to a dissipative state. We have used Corbino devices (GasAs/AlGaAs heterostructure) of inner radius R_1 = 100 µm, outer radius R_2 = 150 µm and various mobilities.

The high performance of the pulse generator produces rectangular voltage pulses from +/-0.1V to +/-5 V, pulse widths from 5 ns to 500 ns and transition times of 1 ns for the rise time and 1.5 ns for the fall time. The time response of the sample is displayed on a digital oscilloscope with a very good time resolution (0.2 ns) and voltage resolution (1 mV).
We have used rectangular shapes of 90-180 ns pulse widths, 300 ns pulse period (ν = 3.3 MHz) and applied voltages in a range 0.2 V - 1.0 V. In this way we were able to determine sample response times from nearly 1.5 ns to 7 ns (see Fig. 1) according to previous time integrating measurements. By increasing the applied voltage the Landau levels are tilted more and more resulting in smaller tunnelling distance between the initial and final tunnelling states, therefore a higher tunnelling rate and consequently a smaller drift length of electrons which in other words means shorter response time.

According to the drift model, at constant drift length, the response time of the sample should be inverse proportional to the applied voltage, but our measurements yield other dependence. This is possibly due to the tunnelling that changes the size of tunnelling gap with the applied voltage. The time response profile as a function of applied voltage looks like a bell (see Fig. 2), for higher voltages an intra-Landau level scattering occurs while for lower voltages an inter-Landau level breakdown can be taken into account. The sample mobility seems to play an important role.

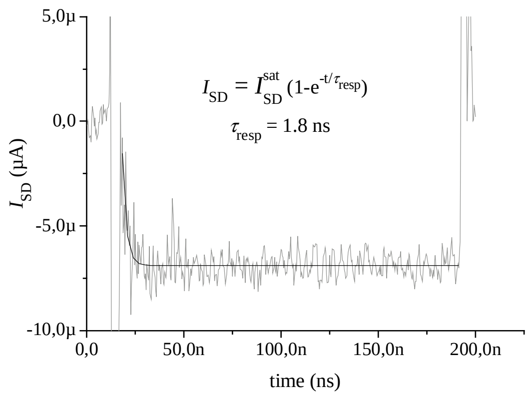

Fig. 1: The measured source-drain current versus time and the exponential fit function (the noise of the signal come from the cross talking between cables or the electronics).

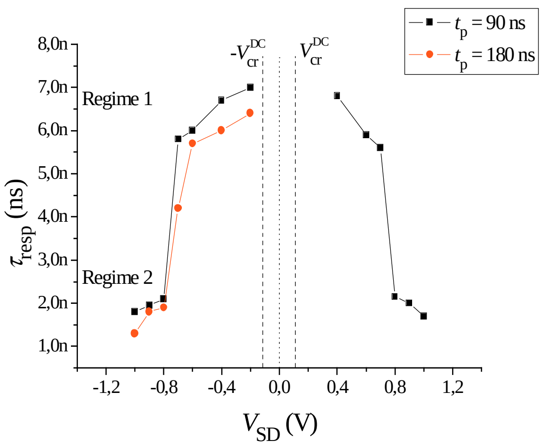

Fig. 2: Response time of the sample as a function of the applied source-drain voltage for different pulse width → slight smaller sample response time for larger pulse width.

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