Microwave Photoresistance in High-Density High-Mobility 2D Electron Systems at Large Filling Factors

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Irradiation on 2D electron systems has been shown to have remarkable consequences on the transport at large filling factors [1]. Indeed, recent experiments have discovered [2] that the magnetoresistance of a high-mobility 2D electron gas (2DEG) in GaAs/AlGaAs heterostructures subjected to microwave radiation of frequency ω exhibits oscillations governed by ratio ω/ω_c, where ω_c is the cyclotron frequency. Interest in this phenomenon was largely stimulated by unexpected observation of so-called zero-resistance states induced by microwave irradiation in very high mobility GaAs/AlGaAs heterostructures [3].

In this work we report an observation of microwave-stimulated giant magnetoresistance oscillations and zero-resistance state in GaAs quantum well with electron density of an order of magnitude higher then reported earlier. We discuss an application of this phenomenon for the frequency-sensitive sensors of the GHz and THz irradiation.

The interest in fabrication of the modulation-doped semiconductor structures with a high-density high-mobility 2DEG is ever increasing, since both aspects of fundamental physical properties and device applications are important. However, the possibility to increase the density of a 2DEG by simply increasing the dopant density in conventional GaAs/AlGaAs heterojunctions is limited, because a high dopant density increases the remote impurity scattering.

Both a high mobility and a high density of a 2DEG can be obtained simultaneously in the heavily modulation-doped GaAs quantum wells with AlAs/GaAs superlattice barriers [4]. The X-electrons arising in short-period AlAs/GaAs superlattice barriers smooth out the fluctuation potential of the doping impurity. As a result, the density of 2DEG in GaAs quantum well with AlAs/GaAs superlattice barriers can be considerably increased without decreasing the mobility as compared to conventional GaAs/AlGaAs heterojunctions.

Our samples were cleaved from the wafers of the high-mobility GaAs quantum wells grown by solid source molecular beam epitaxy on semi-insulating (001) GaAs substrates. The width of the GaAs quantum wells was 13 nm. AlAs/GaAs type-II superlattices served as barriers, which made it possible to obtain a high-density high-mobility 2DEG.

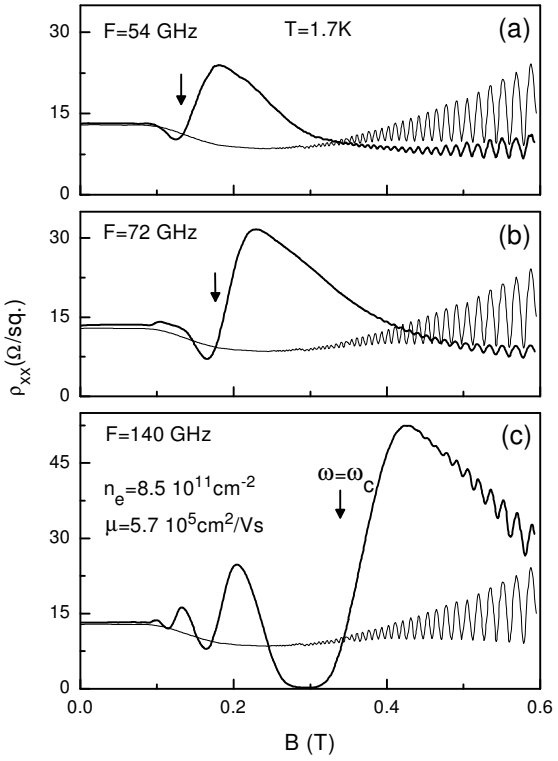

Fig. 1. Magnetoresistance ρ_{xx} of 2DEG in GaAs single quantum well with AlAs/GaAs superlattice barriers with microwave illumination on (thick line) and off (thin line) at T = 1.7 K for selected frequencies. The positions of the cyclotron resonance are marked by arrows.

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