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New quantum wire field effect transistor

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Abstract. We present field effect transistor with stand-alone quantum wire channel based on V-groove GaAs/AlGaAs heterostructure grown metal organic chemical-vapour-deposition.

Electron transport in one-dimensional (1D) systems has been extensively studied both experimentally and theoretically. The most striking feature of 1D transport is revealed in the ballistic limit, where the conductance is quantized in units of $G_0 = 2e^2/h$. This quantization has been observed in two-dimensional electron gas (2DEG) systems further confined to 1D by means of an electrostatic potential in a point contact geometry. In these structures, the 1D electron channels are adiabatically connected to the 2D electron reservoirs. However, other structures, which use “rigid” confinement potential (e.g., etched stripe structures [1], over-grown constrictions [2], and T-shaped cleaved-edge overgrown wires [3]), all show ballistic quantized conductance that significantly deviates from the G_0 values.

In this work we demonstrate field effect transistor fabricated on V-groove GaAs/ $Al_xGa_{1-x}As$ heterostructure produced by metal-organic-chemical-vapour-deposition (MOCVD). This technique produces very long QWR’s in heterostructures with hard wall confinement and large mini band separation. To provide electrons to sidewalls and QWR selectively doped AlGaAs layers were grown on both sides of thin epi-layer of undoped

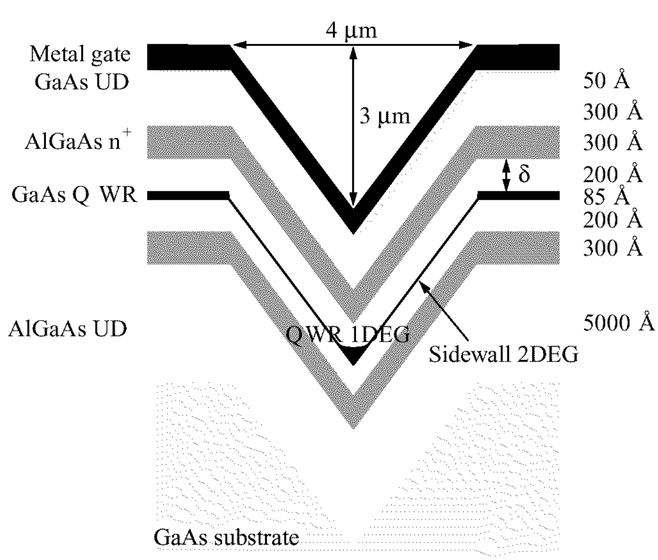

Fig. 1. Schematic cross-sectional picture of a QWR heterostructure.

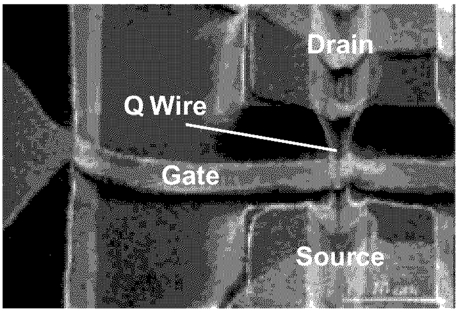

Fig. 2. SEM image of the device.

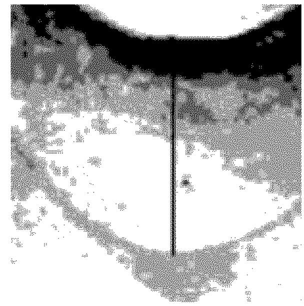

Fig. 3. Cross-sectional TEM images of a QWR heterostructure.

GaAs separated by 20 nm spacers (Fig. 1). To ensure good leads to QWR we fabricated AgGe ohmic contacts to 2DEG. 4 μm top Schottky gate was placed across the channel to control electron density (Fig. 2). The TEM image (Fig. 3) shows that for 8.5 nm GaAs layer in planar part the size of the QW in the sidewalls is less than 4 nm at the top of the V-groove. The transverse dimensions of the QWR are 18 nm by 75 nm.

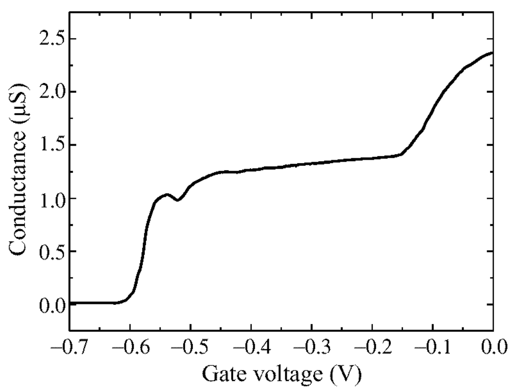

Fig. 4. Conductance vs gate voltage at 4.2 K.

The magneto-conductance measurements were performed on two different type of devices: one with planar two-dimensional electron gas (2DEG) and another with etched planar 2DEG. Both devices have cut-off gate voltage $\sim$0.5 V. The typical conductance of the second type device versus gate voltage at 4.2 K is shown in Fig. 4. By studies of the conductance in magnetic field of different orientation it have been shown that above the cut-off gate voltage the transport is determined by short one dimensional channels connected by tunnel junctions.

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