Local Electron Density near the 2DES Boundary formed by Side-gate Voltage in the Quantum Hall Regime

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Spatial distribution of the edge states in the quantum Hall (QH) effect has been investigated by the magnetocapacitance technique. The relation between the edge states and electron distribution at the sample boundary in the QH regime has been discussed.

A schematic view of the sample is shown in Fig 1. The six multi-gate of thin wires are fabricated on the surface of GaAs/AlGaAs heterostructure. The width of gate is 0.6 μm and the separation length is 0.4 μm. The tunable confinement potential is induced by applying negative side gate (see Fig. 1) voltage. The single wire gate fabricated at the center of the two dimensional electron system (2DES) is used as a reference, which is free from the electric field by the side gate voltage. We have measured the capacitance between a 2DES and each thin wire gate at 0.4 K with applying negative voltage to the side gate. The observed capacitance shows oscillations as a function of the magnetic field and shows minima at the QH plateaus.

When negative voltage is applied to the side gate, the electron density near the side gate is reduced, and the positon of magnetic field at the capacitance dips (QH plateaus) shift to that of the lower position. From the magnetic field of capacitance dip, we can estimate local electron density under the wire gate with the spatial resolution of the order of the wire gate width. We can observe the extent of compressible and incompressible strips by magnetocapacitance measured with each wire gate.

Electron distribution near the boundary of 2DES has been investigated, which is governed by the confinement potential made by side gate volgate. We can evaluate the local electron density from the magnetic field of capacitance minima at QH plateaus. The normalized local electron density is obtained by the ratio of the magnetic fields of QH plateus between B_i and B_{ref} as

$$\frac{n_i}{n_{ref}} = \frac{B_i}{B_{ref}}. \tag{1}$$

The n_i is the local electron density under i th wire gate from the side gate. B_i is the magnetic field where the capacitance shows the half value of that in the zero magnetic field. The electron density n_{ref} is obtained by using the center gate, which may be not affected by the side gate voltage. Figure 2 shows the electron density as a function of a distance from the boundary determined by side gate voltage. We compared the experimental result of local electron density profile to that of calculated ones [1]. It is found that the confinement potential is much gentle and the electron density at the interior region (more than 10 microns far from the side gate) is affected by side gate voltage.

References

[1] I.A.Larkin and J.H.Davies. *Phys.Rev.B*, **34** (1995) 4332.

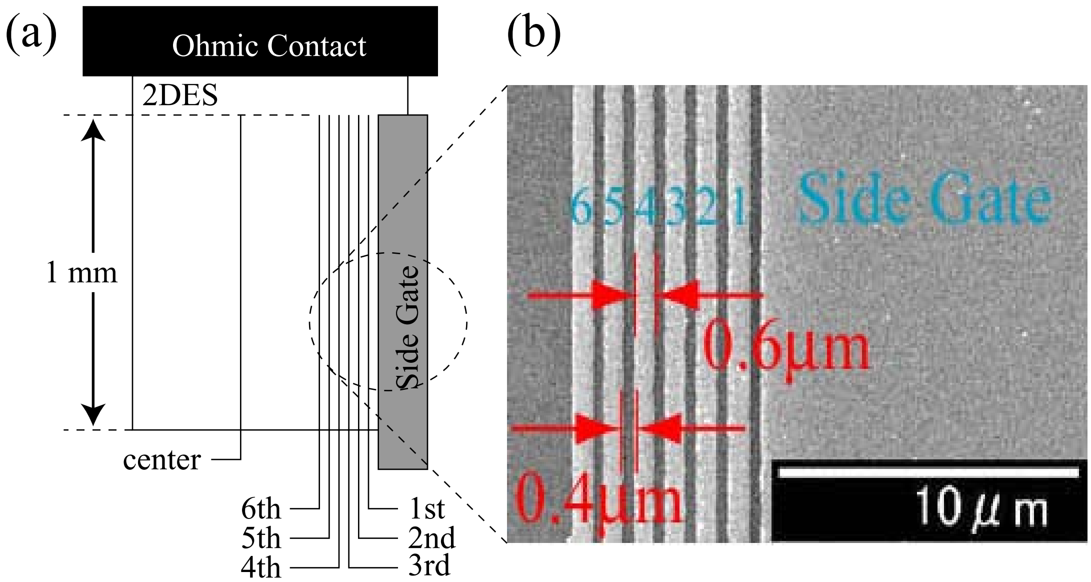

Figure 1: (a) Schematic view of the sample. (b)The SEM image of the side gate and wire gates. The thin wire gates ($1 \sim 6$) are used with the local capacitance measurements. By applying negative bias voltage to a side gate, the confinement potential is formed near the side gate boundary.

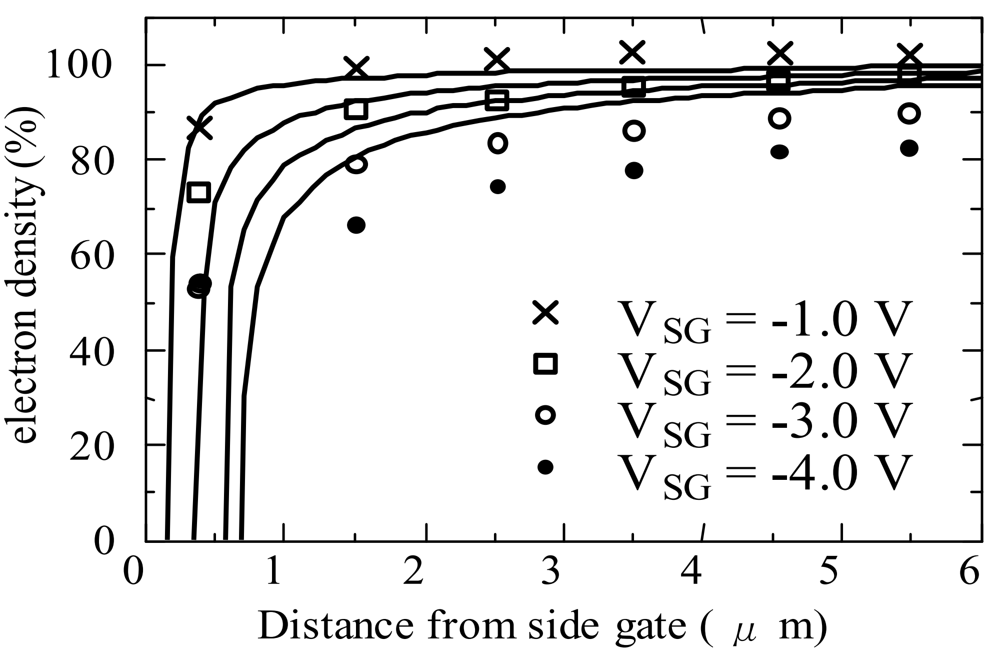

Figure 2: Electron distribution at the several V_{SG} near the sample boundary normalized by a bulk electron density. The dots in the figure are experimental results evaluated by the magnetocapacitance measurements. The curves are calculated ones by using the theoritical model [1].