$FeO_y/SrTiO_3$ 界面における二次元キャリアガスの電気的ゲート制御

Electrical gate control of the two-dimensional carrier gas at the FeO_y/ $SrTiO_3$ interface

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The *n*-type two-dimensional (2D) electron gas (2DEG) at the $LaAlO_3/SrTiO_3$ (STO) interface [1] has been attracting much attention due to its high-mobility and rich physics. Yet, its complementary system, the *p*-type 2D hole gas (2DHG), remains largely unknown and difficult to create [2]. In our previous work [3], by depositing a sub-nm Fe layer on STO substrates, we demonstrated the realization of both 2DHG and 2DEG with ultrahigh mobilities (up to 24000 cm^2/Vs for hole carriers) at the STO interface, whose carrier type can be controlled by the Fe thickness. This discovery potentially provides a universal platform for oxide-based electronics, but the properties and formation mechanism of the 2D carrier gas remain elusive.

In this work, using a back-gate field-effect transistor configuration, we demonstrate that the carrier type and mobility of these 2D carrier gases can be effectively controlled by gate voltage (V_G) application. The samples were made by depositing Al (1 nm)/Fe (0.075–0.4 nm) on STO substrates at 50°C using molecular beam epitaxy (MBE) [Fig. 1(a)]. The samples were then patterned into 100×400 μm^2 Hall bars, and electrodes for transport measurements were formed by sputtering an Al layer and a lift-off process [Fig. 1(b)]. In all samples, the carrier type is transformed from *n*-type to *p*-type when V_G is swept from –12 to 25 V [Fig. 1(c)], where the threshold gate voltage $V_{G\text{-}TH}$ of the carrier-type switching varies by samples. The non-linear Hall effect results imply a co-existence of both electrons and holes in the 2D gas. By fitting the two-carrier model to the observed Hall resistance curves, we successfully estimated the density and mobility of the carriers as a function of V_G. Our results provide insights into the complicated band structure and the formation mechanism of 2DHG at the FeO_y/STO interfaces, which will be discussed in detail in the meeting.

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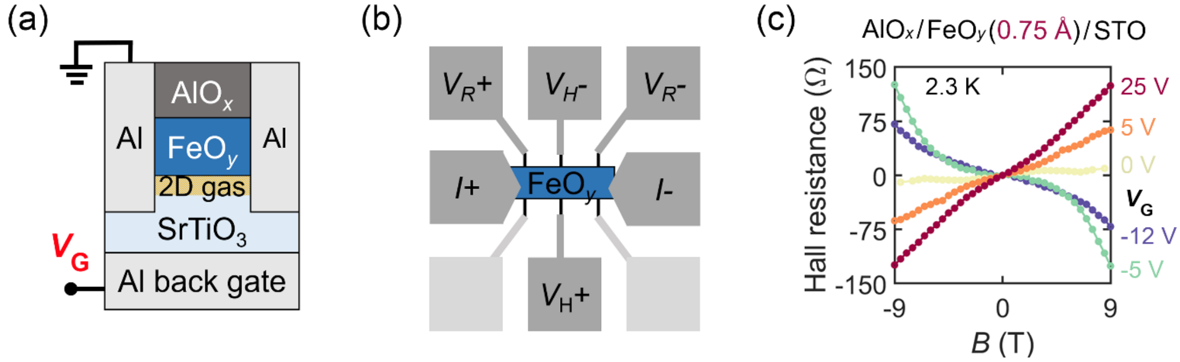

Fig. 1. (a) Schematic cross-sectional structure of the AlO_x/FeO_y/STO samples with an Al back-gate and contact pads. (b) Top view of the devices for Hall measurements. (c) Hall resistance *vs* magnetic field (*B*) measured at 2.3 K. By changing the gate voltage V_G on AlO_x/FeO_y(0.75 Å)/STO from negative to positive, the conduction type changes from *n*-type to *p*-type.