28p-A8-9

# InSb Quantum Wells with Excellent Gate Controllability

M. M. Uddin,[1*] H. W. Liu,[2,3] K. F. Yang,[2] T. D. Mishima,[4] M. B. Santos,[4] K. Nagase,[2] and Y. Hirayama[1,2,5]

[1]*Department of Physics, Tohoku University, Sendai, Miyagi 980-8578, Japan*
[2]*ERATO Nuclear Spin Electronics Project, Sendai, Miyagi 980-8578, Japan*
[3]*State Key Laboratory of Superhard Materials and Institute of Atomic and Molecular Physics, Jilin University, Changchun 130012, People's Republic of China*
[4]*Homer L. Dodge Department of Physics and Astronomy, University of Oklahoma, 440 West Brooks, Norman, Oklahoma 73019-2061, USA*
[5]*WPI Research Center, Advanced Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan*
*E-mail: mohi_cuet@yahoo.com

The typical narrow-gap semiconductor InSb is a potentially exciting materials for next-generation high-speed electronics and spintronic devices due to its high room-temperature mobility (77000 $cm^2/Vs$), long ballistic transport length, and large spin-orbit coupling [1]. The manipulation and control of electron spins in a spin field-effect transistor and the demonstration of nuclear spin coherence in a nanoscale region (e.g., quantum point contact) entail a gated InSb quantum well (QW). More recently, we have revealed the importance of layer structure on the property of gate control of the InSb QW with atomic-layer-deposited (ALD) gate dielectrics [2].

Here, we present a gated InSb QW with high performance of gate control. Our measurements have been performed on a 20-nm-wide InSb QW with ALD-$Al_2O_3$ gate dielectrics. The dependence of electron density ($n_s$) of the InSb QW on gate bias ($V_g$) is shown in Fig. 1(a). It is clear that the density can be tuned by a very small $V_g$, indicating a good gate control ratio of $dn_s/dV_g = 3.2 \times 10^{15}\ m^{-2}V^{-1}$ (estimated in the range of $-0.4V \leq V_g \leq -0.1V$). This dependence is fitted well by using the self-consistent of Schrödinger and Poisson (SP) simulation (red line). The SP simulation suggests that the Fermi level ($E_F$) is weekly pinned at the oxide-semiconductor interface and the Schottky barrier height $\phi_B$ shows a sensitive response to $V_g$, thereby resulting in a giant $dn_s/dV_g$ ratio. The traps charge density at the interface is estimated to be ~ $1.4 \times 10^{10}$ charge/$cm^2$. Longitudinal resistivity ($\rho_{xx}$) and Hall resistivity ($\rho_{xy}$) of the InSb QW at $V_g = 0V$ are shown in Fig. 1(b), in which no apparent signature of the parallel channel is observed (in contrast to the findings in the sample of Ref. [2]).  A good interface and large bandgap of the $Al_{0.1}In_{0.9}Sb$ top layer is assigned to account for this improvement. The present results show potential for fabrication of InSb-based nanodevices.

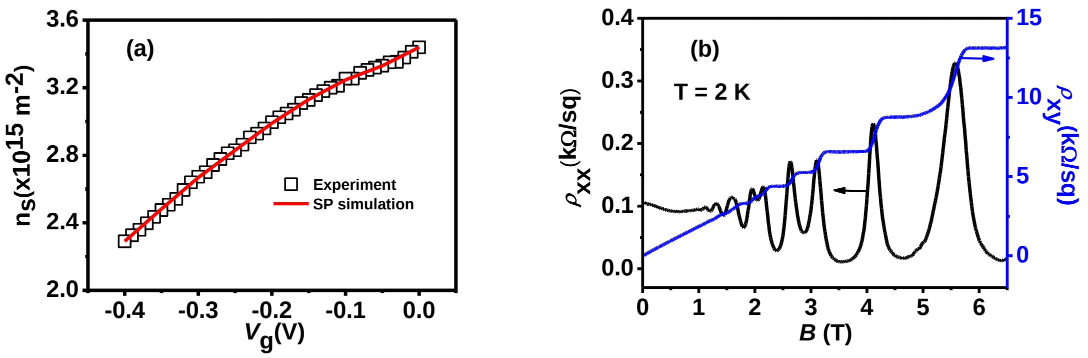


Fig.1. (a) Electron density ($n_s$) of the InSb QW as a function of gate bias ($V_g$) at 2 K. The red solid line is a fit from the SP model. (b) $B$-dependent $\rho_{xx}$ and $\rho_{xy}$ of the InSb QW at $V_g = 0$ V.

References:
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