Investigation of gate controllability in InGaAs/InAlAs double quantum wells towards the spin-filter application

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In this study, we investigated the gate controllability of four samples of InGaAs/InAlAs double quantum well (DQW), where the doping densities are varied among samples (Table 1). The InGaAs/InAlAs DQW can be used for building a non-magnetic spin-filter based on the Rashba effect [1]. The Rashba coefficient α also varies from sample to sample since α depends on the sheet career density [2]. When the potential profile of the DQW is globally symmetric about the middle barrier layer as shown in Fig. 1, only one spin component at the Fermi energy [**k** = (k_F, 0)] can be put in the resonance level between the QW1 and QW2 by the applied gate voltage V_g or in-plane magnetic field B_y. For realizing the globally symmetric potential profile, it is inevitable to investigate the characteristic of each sample experimentally in addition to the design of heterostructures based on the Poisson- Schrödinger self-consistent solutions.

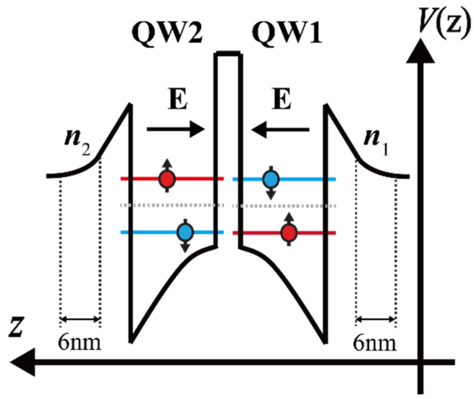

Fig. 1 the potential profile of the DQW

We measured Shubnikov-de Hass (SdH) oscillations at 1.5K with various V_gs. Then, we obtained the sheet career densities (N_{S1}, N_{S2}) associated with the first and the second subband level by the analyses of SdH data. In Fig. 2, we show the gate voltage (V_g) dependence of the total sheet career density (N_{Stot}) about one of our samples, IQE1-2, where N_{Stot} = N_{S1} + N_{S2}. We find that N_{Stot} is controlled by V_g as predicted theoretically. Only IQE1-2 among all the sample shows this ideal characteristic. We define the gate efficiency P as the ratio of the experimental gate capacitance to the theoretical one for the comparison among all the samples (Table 1).

References:

[1] S. Souma, *et al.*, arXiv; 1304. 6992 (2013).

[2] S. Faniel, *et al.,* Phys. Rev. B **83**; 115309 (2011).

	n_1 ($\times 10^{24} m^{-3}$)	n_2 ($\times 10^{24} m^{-3}$)	P (%)	α ($\times 10^{-12}$eV·m)
KH3-5	4.0	4.5	91	4.22
IQE1-1	3.5	5.0	69	3.26
IQE1-2	2.5	4.0	100	2.18
KH4-4	3.5	5.0	63	3.41

Table 1 n_1 and n_2 are the doping condition (see Fig. 1), P is the gate efficiency and α is the Rashba coefficient of the investigated samples.

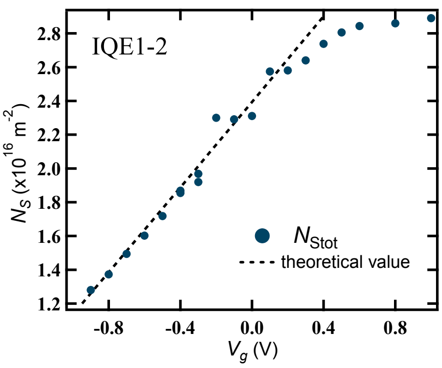

Fig. 2 V_g dependence of N_{Stot}