Prediction of enhanced Edelstein effect in InGaAs double quantum well

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V. M. Edelstein predicted current-induced spin polarization in two-dimensional electron gas in the presence of the Rashba effect [1]. The number of spins per unit area induced by the Edelstein effect is given by $\sum_i \langle \sigma_y \rangle_i / A = e \frac{m^*}{\pi\hbar^2}\frac{\alpha}{\hbar}\tau E_x$ (α : Rashba coefficient). This value, divided by the current density (as given by the Drude model $j_x = \sigma E_x$), is dependent only on α and Fermi energy E_F. $\sum_i \langle \sigma_y \rangle_i / (A j_x)$ is evaluated to be $0.87 \times 10^9\ \mathrm{cm^{-1}A^{-1}}$ in our InGaAs/InAlAs single quantum well (SQW), which is equivalently about 1 $\mathrm{spin/\mu m^2}$ using $j_x = 10\ \mathrm{Am^{-1}}$, where $m^*\alpha/m_e = 1.48 \times 10^{-13}$ eVm and $E_F = 91.8$ meV.

Recently, we have proposed that (001) InP lattice-matched $In_{0.53}Ga_{0.47}As/In_{0.52}Al_{0.48}As$ double quantum well (DQW) system can act as an enhancing module for the Edelstein effect for the underlying quantum well (QW1) as in Fig. 1, in the presence of the Interband Rashba effect [2]. Here, we investigate the gate and in-plane magnetic field dependences of the electrical resistance and Edelstein effect of our DQW system based on the Generalized Spin Diffusion Equation [3, 4].

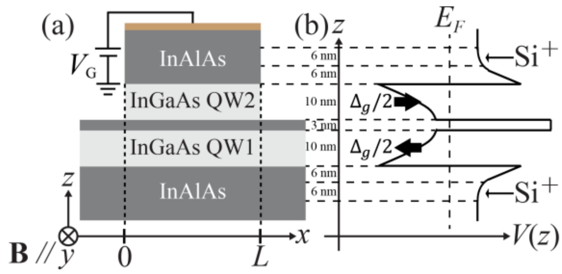

Fig. 1 (a) Layer structure of the DQW module and (b) the corresponding potential profile. Δ_g is additional site potential by gate. Virtual ground in (a) is assumed at the Fermi level E_F in (b).

Notably, our simulation implied that the actual value of the inter-well coupling (t_{coup}) can be as large as 2.0 meV, whereas our 1D Poisson-Scrödinger simulation predicted $t_{\mathrm{coup}} = 0.5$ meV. Further analyses showed 20 times enhancement in the Edelstein effect relative to the corresponding value for the SQW system. The authors thank Dr. A. Sawada, Prof. S. Datta, Dr. S. Sayed and Prof. J. C. Egues for informative discussions. This work was supported by JSPS KAKENHI Grant Number 16H01045.

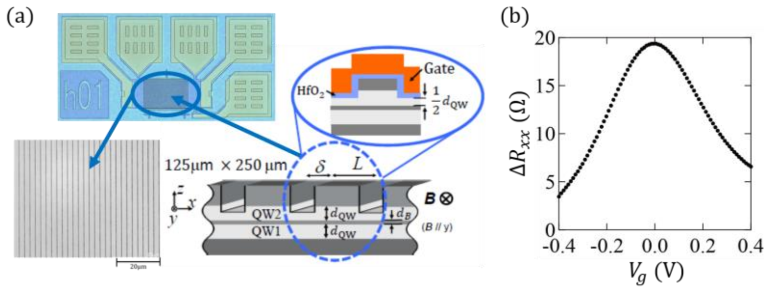

Fig. 2 (a) The array of the DQW modules fabricated as Hall bar sample. The device length $L = 0.8\ \mu$m and ditch length $\delta = 0.2\ \mu$m. (b) Experimental result of the difference resistance between the sample in (a) and the underlying QW1 layer.

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