Evaluation of spin orbit interactions and its application for complementary spin logic devices

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The spin-orbit interaction (SOI) is one of the major concerns in the field of spin transistor devices because spin precession can be controlled by SOI parameter [1]. In a semiconductor channel SOI is divided into two terms, Rashba and Dresselhaus terms. The Rashba spin-orbit interaction (RSOI) is induced by the structural inversion symmetry and the Dresselhaus spin-orbit interaction (DSOI) is resulted from bulk inversion asymmetry. Detection and application of RSOI has been researched, however, DSOI has not because these two effects are phenomenologically inseparable so extraction of individual field is not simple. The Rashba field is always perpendicular to the wavevector but the orientation of the Dresselhaus field depends on the crystal orientation of channel [2]. Thus, for the various crystalline orientations we measured the Shubnikov-de Haas oscillations in an InAs quantum well system. Values for the Rashba parameter of 6.73×10^{12} eVm and for the Dresselhaus parameter of 0.57×10^{12} eVm were sequentially extracted and also the gate dependences of the two parameters were determined. Using InAs quantum well system, gate control of conductance oscillation was experimentally presented [1]. Due to the different alignment between Rashba and Dresselhaus fields (B_R and B_D), the spin precession behavior depends on the crystal direction in a spin-FET structure. For example, the total field can be expressed as $B_R + B_D$ for the [110] direction and as $B_R - B_D$ for the [1−10] direction. When the channel length is 1 μm, the precession angle is 550° for the [110] direction and 460° for the [1−10] direction, respectively [3]. Using the two spin transistors with different crystal directions, which play roles of n- and *p*-type transistors in conventional charge transistors, we propose a complementary logic device.

References

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