Spin blockade in *k*-space and Rashba resonance in a double well structure

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In spintronics, the concept of artificial materials founded on the quantum confinement of kinetic motion[1], would be extended to manipulate the electron spin. Also the concept of topological number[2] shed light on the spin-orbit energy gap, hence the spin-orbit engineering (SOE) has come into our view. A hint to utilize stacking structure for SOE[3] is that the internal electric field is reversed by doping to the barriers hence the sign of Rashba-type spin-orbit interaction in adjacent quantum wells. This leads to a kind of spin-blockade in the momentum(*k*-) space under the momentum conservation in vertical tunnelings.

To confirm this experimentally, we prepared two double-well samples with AlInAs/GaInAs heterointerfaces (barriers: 6 nm, wells: 10 nm). One of them is doped n-i-p-i-n and the other does not have any intentional doping.

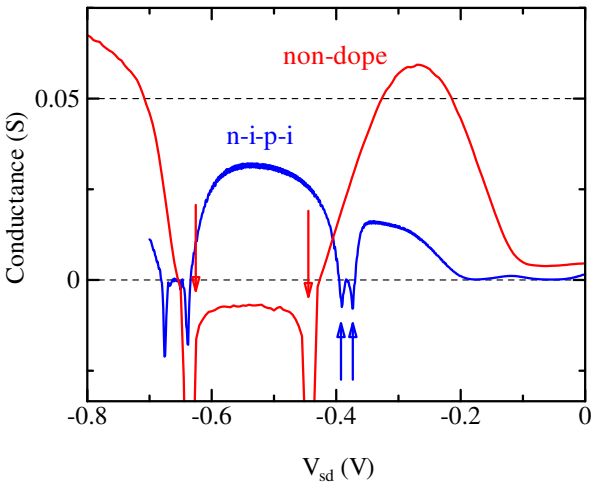

Figure 1: Differential conductance of the two devices. The blue line is for n-i-p-i doping and the red one for no doping.

Figure 1 shows the I-V characteristics of the two kinds of devices with 200 $(\mu m)^2$ cross section with and without n-i-p-i-n doping for the negative bias region. All the dips in the differential conductance dI/dV have splittings due to the bonding - anti bonding separation of the degenerate states. It is apparent that the non-doped structure has higher differential conductance and a much larger level separation. The level separation corresponds to the coupling between the two quantum wells. Hence the smallness of the level separation in n-i-p-i doped structure means some blockade mechanism is working.

We infer the mechanism is the designed single-electron spin-blockade. This could be further confirmed in the spin resonance but the magnetoresistance so far reported also constitutes evidence for the blockade.

Figure 2 shows the zero-bias conductance of an n-i-p-i sample with a cross section of 50 $(\mu m)^2$ as a function of microwave, which is applied through a planer waveguide placed underneath the sample. The microwave magnetic field is perpendicular to the quantum wells and hence in the resonance condition for the Rashba field. The clear peak structure around 2.6 GHz indicates the resonance and is giving the information on the Rashba coupling strength.

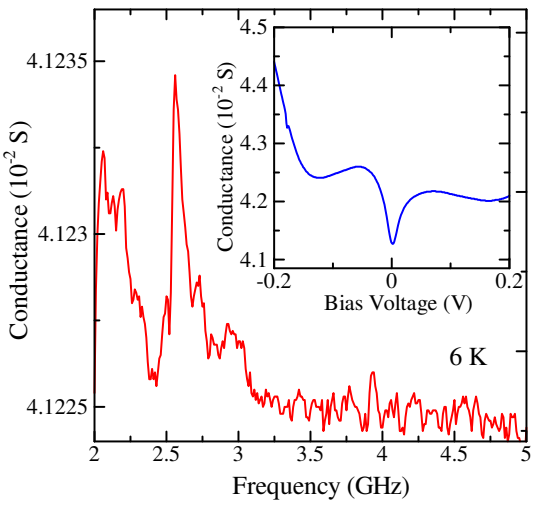

Figure 2: Microwave frequency dependence of zero-bias differential conductance of the nipi device. The inset shows bias dependence.

References

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[2] C. L. Kane and E. J. Mele, Phys. Rev. Lett. 95, 146802 (2005).
[3] T. Koga et al., Phys. Rev. Lett. 88, 126601 (2002).