Measurement and simulation of I-V properties of triple barrier resonant tunnelling diodes

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Abstract
One of the most important issues in spintronics research is the production of spin polarized currents. In the past, magnetic materials such as ferromagnets have been used to produce spin polarized currents. However, the magnetic fields associated with these materials can lead to unwanted effects such as stray magnetic fields. Hence, we propose to make a spin filter utilizing only non-metallic materials. By combining the triple barrier resonance tunnelling structure (TB-RTS) and the Rashba spin-orbit coupling effect, we can realize a usable spin polarized current source, where we match the spin-dependent resonance levels to lift the spin degeneracy. As a preparation for performing the experimental proof of the principle for this proposal, I have been studying the I-V properties of “non-doped” TB-RTS's that were made with InAs layers as quantum wells and AlSb layers as barriers. I also have been performing theoretical simulations of these devices to understand the experimental I-V curves we obtained at 300K, 77K and 4.2K.

Introduction/Motivation
What is a triple barrier resonance tunnelling diode (TB-RTD)?
• It consists of three barriers, forming two quantum wells.
• After tuning the gate voltage, the energy levels in the two wells will match up allowing electrons to tunnel through and current to flow.

Device and Experiment
• Our TB-RTD samples utilize AlSb for barriers and InAs for the quantum wells. Prof. Keita Ohtani carried out the growth and fabrication of our samples at Tohoku University.
• Expected results
  - We expect a single peak in the negative and positive regions of the I-V profiles of the samples, however, we expect the I-V profiles to be not symmetric with respect to zero biasing due to the asymmetry in the quantum wells.
  - To determine the I-V profiles, we swept the gate voltage between -4.0V and 1.5V at temperatures ranging from 300K to 4.2K.

Results
• Obtained I-V curves for samples at 300K, 77K and 4.2K.
  - Single peak was observed in the positive bias region, an additional peak was found in the negative bias region of the I-V curve. Apparent two peaks at 77K are probably due to some artificial effects in the measurement circuit, most likely not due to spin splitting.

Simulations
• Used Transfer Matrix Method to calculate the transmission coefficients as a function of energy for a given bias voltage, which revealed details of the level matching.

Simulation
By varying the bias voltage, we can find where level matching occurs.

Conclusions
Simulation accounts for both peaks observed in experiment. Simulations in Fig 5 (a) and (b) agree with the experimental results better than those in Fig. (c) and (d).

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