REVERSING THE SIGN OF ELECTRICALLY-INJECTED SPIN POLARIZATION AT FINITE BIAS

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Introduction

A scheme for electrically injecting spin-polarized electrons into a semiconductor is central to the notion of spin-based semiconductor electronics, or 'semiconductor spintronics'. We have recently demonstrated this in lateral Fe-GaAs spin transport devices, and have used magneto-optical Kerr rotation to image the injection, transport, and accumulation of electron spin polarization in these devices [1]. In this work, it was observed that 1) a non-zero electron spin polarization can be *injected* from a Fe/GaAs Schottky tunnel barrier contact that is reverse biased (electrons flow from Fe into GaAs), and 2) a nonzero electron spin polarization can be *accumulated* near a Fe/GaAs contact that is forward biased (electrons flow from GaAs into Fe). Curiously, the sign of both injected and accumulated electrons was the same, against simple expectations based on reciprocity and linear response.

Experimental

Here we now use similar lateral spin transport devices to study the sign of the injected and accumulated spin polarization in GaAs as an explicit function of bias across a Fe/GaAs Schottky tunnel barrier. A photograph of one such device is shown in Figure 1. Images of the injected /accumulated spin polarization are also shown in Fig. 1. The images are 80 x 80 microns, as indicated by the dotted square region on the photograph. Now, the sign of the spin polarization in GaAs clearly switches when going thru zero bias, as expected from linear response. Majority spins are injected, and minority spins are accumulated at low forward bias. However, at larger forward bias the sign of the accumulated spins reverses.

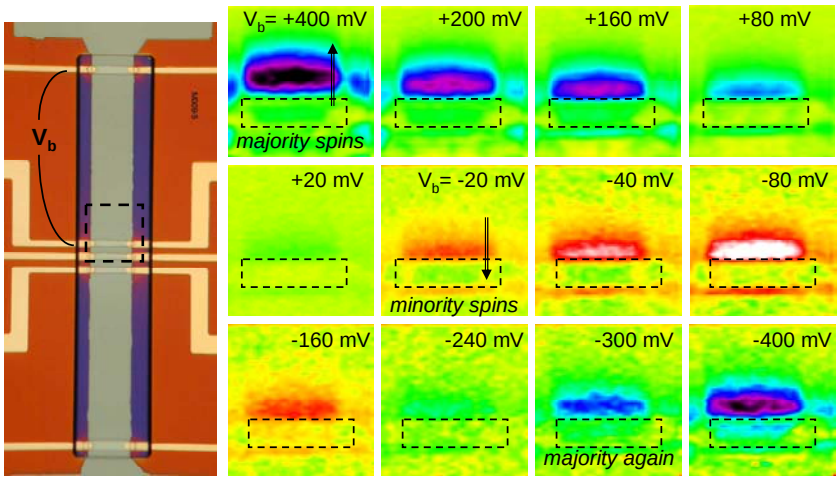

Figure 1: Images of the electron spin polarization injected/accumulated at a Fe/GaAs electrical contact as a function of bias across the contact.

Figure 2 shows explicitly how the spin polarization in GaAs depends on the applied bias. At approximately -240mV bias, the sign of accumulated spins reverses. At this point it is not understood completely why this ocurrs. Arguments based on the spin-dependent tunneling coefficients may explain this switching at finite bias. It is unlikely that the energy-dependent density of states in Fe plays a determining role, because other samples show similar behavior except that the reversal occurs on the *injection* side. It may also be possible that tunneling via resonant interface states plays a role.

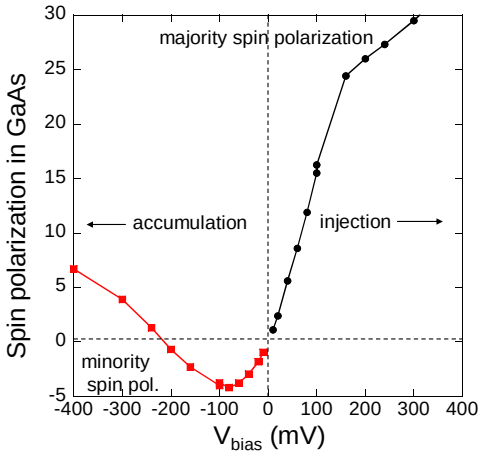

Figure 2: Electron spin polarization in GaAs vs. electrical bias across Fe/GaAs contact.

References

[1] S. A. Crooker *et al.*, Science **309**, 2191 (2005).