Spin-Polarized Field Effect Transistor (Spin-FET) (MRI:0215872:Thibado)

A new transistor for higher-order logic. Second-generation quantum devices (still in the research stage) are multi-functional; a single structure can accomplish a task that would normally require as many as ten conventional devices. A factor of ten reduction in the number of components naturally leads to a significant increase in speed as well as a reduction in power consumption. One of the most notable examples of this type of multifunctional quantum device is the spin-polarized field-effect transistor (spin-FET) - a transistor that uses the spin of the electron (i.e., its quantized magnetic moment) to produce a novel and technologically attractive function over a conventional transistor (see Fig. 1 below). A ferromagnetic metal contact is used to polarize the electron's spin as it enters the transport channel of the transistor. Once inside, the direction of the spin continuously rotates until it reaches the other ferromagnetic metal contact. The rotating electron spin produces oscillations in the current-voltage characteristics (see schematic diagram below). With 10 oscillations 8 spin-transistors would represent 10^8 = **100,000,000** different possible characters, compared to 2^8 for normal transistors.

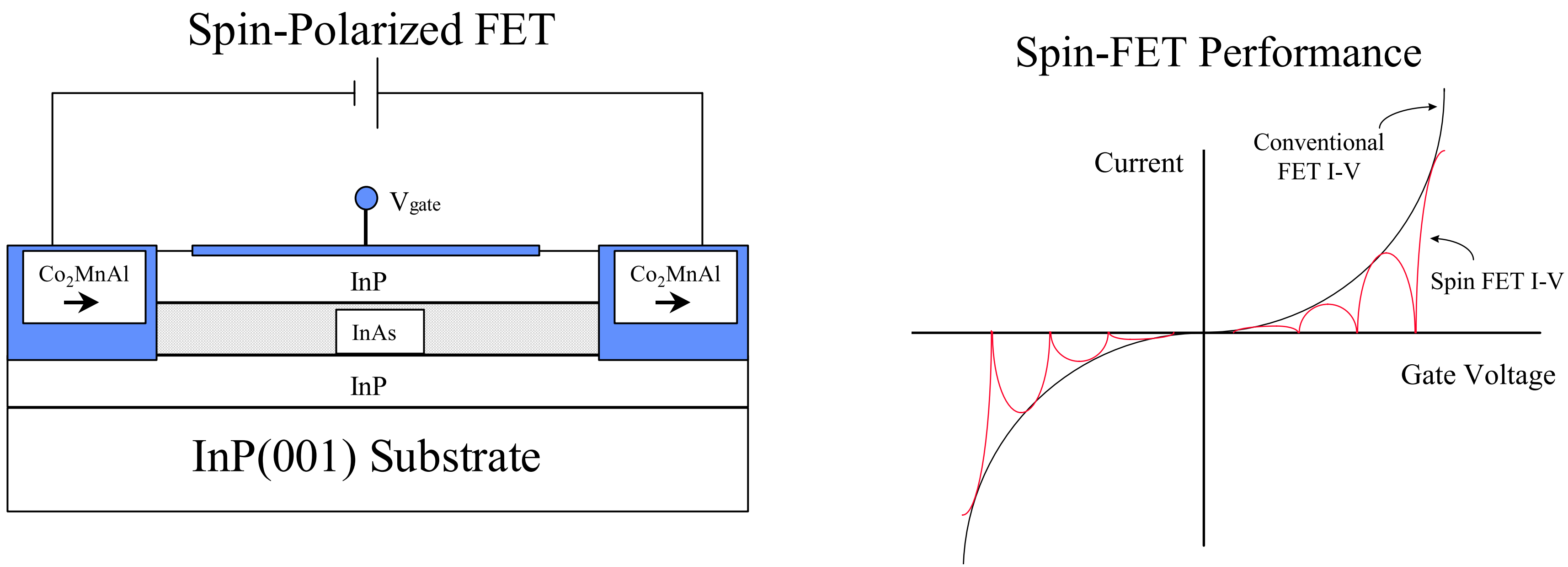
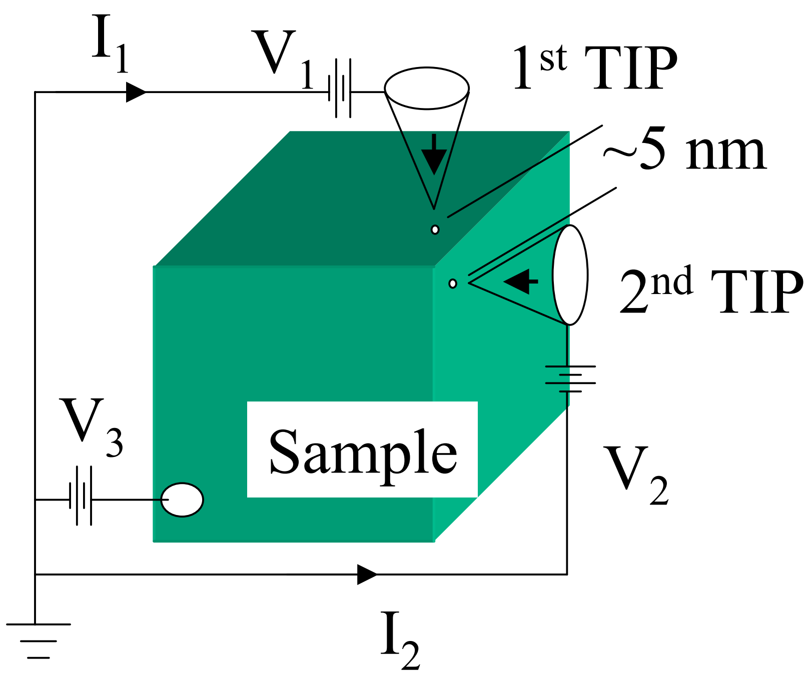


Fig. 1. (left panel) Possible spintronic device structure.
(right panel) I-V characteristics for both a convention transistor and a spin-FET.

Two Ferromagnetic Metal STM Tips Form the Source and Drain (MRI:0215872:Thibado)

Relocatable Spin-Injection Contacts. One of the most difficult challenges in achieving "spintronic" devices is the ability to transfer the polarized electrons from the ferromagnetic material into the non-ferromagnetic semiconductor without significantly degrading their polarization. This problem was solved using vacuum tunneling [Thibado et.al, Science **292**, 1518 (2001)]. For our spin-FET, two STM tips will be used such that their electron spins point toward the sample, but are mounted at right angles to each other, as shown in the illustration below (Fig. 2). In this novel geometry, the two spin-polarized electron sources can be placed within a few nanometers of each other. By separately biasing the sample and tips, we are able to produce a three-terminal device: the first tip represents the source, the second tip represents the drain, and the sample represents the channel/gate.



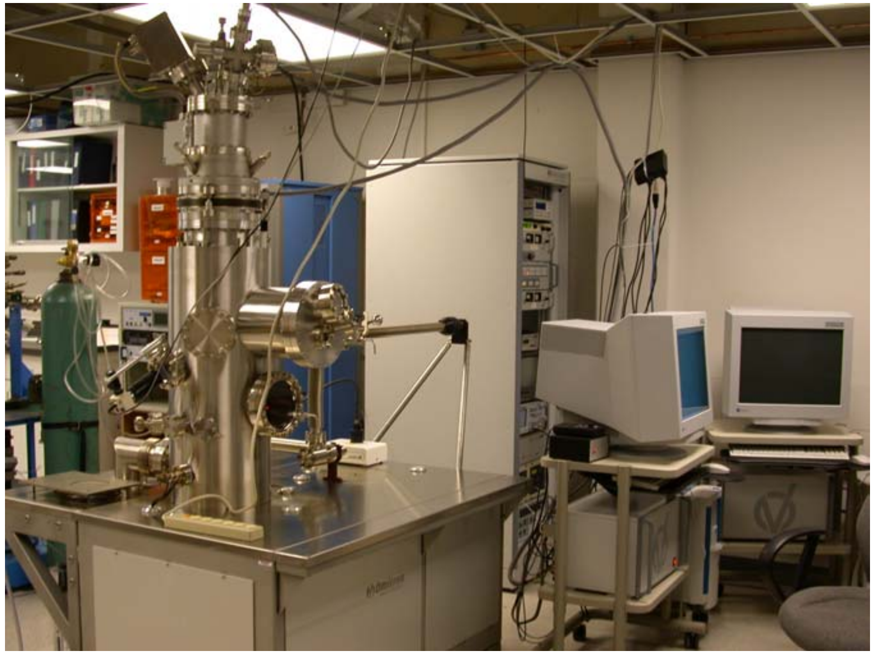


Fig. 2.
(Left Panel) Schematic diagram showing the two STM tips held at right angle on the double-cleaved GaAs sample.
(Right Panel) Photograph showing the low temperature STM vacuum chamber with two control units for the two STMs.