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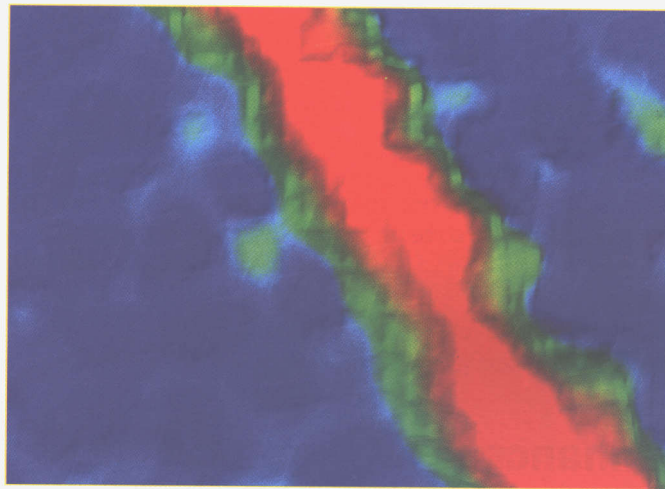
July/August 2001

Spin control

Physicists at the University of Arkansas have successfully injected a spin-polarized current into a semiconductor from a ferromagnetic metal at 100K. Using GaAs (110) planes Vincent LaBella and co-workers achieved an injection efficiency of 92% - in other words, the majority of electrons remained in their spin-polarized state after injection [*Science* (2001) 292, 5521, 1518-1521].

Crucial to the realization of practical spintronics is the control of spin injection.

Previously injection was achieved by applying an electric field across a semiconductor and ferromagnet. Although this process can pull polarized electrons from the ferromagnet into the semiconductor, it is highly inefficient with most electrons reverting to a random mix of spins. Instead, the scientists used single-crystal ferromag-



STM image of the GaAs (110) surface. (Courtesy of Vincent LaBella)

netic nickel wire as the tip of a scanning tunneling microscope to act as the source of polarized electrons. At the Fermi energy there are only spin-down electrons in the nickel wire - so the injection current is guaranteed to be spin-polarized. Using spin-polarized tunneling induced luminescence microscopy (SP-TILM), the

researchers were able to measure polarization to confirm that the electrons had retained their spin. The technique also allows surface topography of the semiconductor to be correlated simultaneously with the degree of spin disruption. The researchers found that the injection efficiency was reduced by a factor of six at a 10 nm [1-11]-oriented step. The high

efficiency of spin injection achieved by LaBella *et al* can be accounted for by the fact that (110) GaAs has very few steps in it. "This demonstrates that defects at interfaces of materials are extremely detrimental to injection efficiency," explains LaBella. In other recent research [*Nature* (2001) 411, 6839, 770-772], D Awschalom at University of California, Santa Barbara, and colleagues from Penn State report rises in spin injection of 500-4000% in semiconductor material. The researchers looked at GaAs/ZnSe heterostructures to investigate the effect of electrical bias on spin transport. Spin-coherent injection rose 500% in biased structures and 4000% when a p-n junction provides a built-in bias; demonstrating that spin current is controllable by electrical or magnetic fields - an important step forward for spintronics.



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