Magneto-resistive memory in ferromagnetic (Ga,Mn)As nanostructures

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We investigated three-arm nanostructures fabricated from monocrystalline $Ga_{0.96}Mn_{0.04}As$ layer of 15 nm thickness grown by a low-temperature molecular-beam epitaxy method on the (001) face of semi-insulating GaAs substrate. The layer became ferromagnetic below 60 K owing to the ordering of magnetic moments of Mn ions, mediated by mobile holes. The nanostructures were shaped, by means of electron-beam lithography patterning and chemical etching, like three strips of 200 nm width and 3 to 5 μm length joined in one point, which formed an angle of 120° between each close pair of arms (Fig. 1). The arm terminals were supplied with Ohmic contacts thus forming a three-terminal device in which an electric current can be driven through any of the three pairs of arms.

The structure while being in the ferromagnetic state exhibits interesting magnetoelectric properties. Spontaneous magnetization direction in each arm results from a compromise between magnetic shape anisotropy and magnetocrystalline anisotropy. A region of inhomogeneous magnetization has to appear at the junction which can be described in terms of domain walls between each pair of arms. A domain wall contributes to the resistance of each pair of arms at a rate depending on the degree of spin misalignment in the wall.

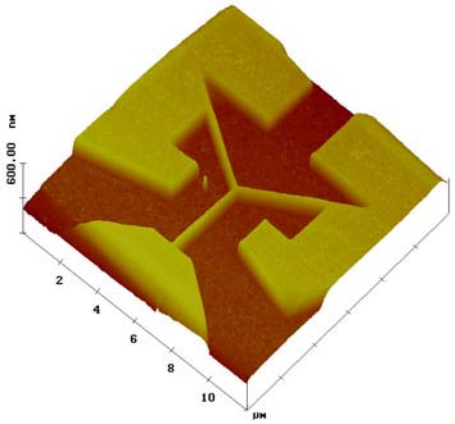

Fig. 1. AFM micrograph of the three-arm nanostructure.

We demonstrated in this structure the effect of remnant magnetoresistance, which consists in that its zero-field resistance depends on the direction of previously applied magnetic field [1]. The structure can thus work as a two-state device, a basic element of nonvolatile memory. It represents also a three-terminal device that has two complementary outputs, which means that when one pair of arms is in the high-resistance state, another one is in the low-resistance state, and *vice versa*.

[1] T. Figielski, T. Wosiński, A. Morawski, A. Mąkosa, J. Wróbel, and J. Sadowski, Appl. Phys. Lett. **90** (2007) 052108

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