BB05

Domain Wall Pinning Strength Tuning in the Planar Submicron-sized Magnetic Y-wire

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As nanofabrication techniques made it possible to realize magnetic nanostructures, understanding the magnetization processes of these structures is of fundamental interest, and key issue to the next generation spinelectronic devices such as magnetic domain wall memory and magnetic logic circuit.[1] In a narrow sub-micrometer magnetic wire, domain wall (DW) propagation is crucial to the magnetization reversal process because DW nucleation and propagation are energetically more stable than the coherent spin-rotation in the long magnetic stripe. We have studied the junction geometry effect of the three-terminal magnetic device upon the domain wall (DW) propagation and pinning at the junction area, where the devices consist of two input wires and one output wire. The submicron sized Y-wire junctions were fabricated using electron-beam lithography and lift-off techniques, where the wire width is 200 nm and the junction area includes the tapered input wires.[2] The device consists of giant-magnetoresistance (GMR) spin-valve of NiFe/Cu/NiFe multilayeres. DWs are injected from the input wire injection pad, where DWs are pinned strongly depending on the Y-jucntion geometry. In this study, we have investigated the tapered input wire width effects on the DW pinning strength, which is estimated by measuring GMR ratio. As the tapered width is narrower, the DW pinning strength is enhanced. This is caused by the fact that DW energy scales with wire width.

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BB06

Spin-Current Interference in a Non-Magnetic Nano-Ring

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Recent progress in nano-fabrication techniques allows us to fabricate a lateral spin-valve structure consisting of both ferromagnetic and non-magnetic wires withnanometer width. In such a device, a spin current has been reported to be injected into a non-magnet by using non-local geometry [1]. Since the spin current is not associated with a conventional electron charge current, it should not suffer from spin scattering, which has been an obstacle to realize a spintronic devices. In this study, we have fabricated a non-magnetic nano-ring and have observed spin-current interference.

Two ferromagnetic nano-wires (thickness: 30 nm and width: approximately 100 nm) were first fabricated on thermally oxidized Si substrates by electron beam lithography with lift-off. Non-magnetic Cu nano-ring (thickness: 80 nm, outer diameter: below 600 nm and width: about 70 nm) was then similarly fabricated. Here a conventional electron charge current is introduced from the left ferromagnetic nano-wire (Py, permalloy) to inject a spin current into a non-magnetic nano-ring as schematically shown in Fig. 1. The spin current is detected as a voltage drop across the right ferromegnet and the non-magnetic ring by using lock-in techniques. During the measurement, the spin current splits into two along the two paths in the nano-ring, and the spin current that passes the upper path experiences the Larmor precession induced by a perpendicular magnetic field generated by a dc current application. This provides a phase difference between the spin currents flowing the two paths, causing an interference effect.

In this device, oscillations in the non-local spin-current signals are observed dependent upon the magnitude of the perpendicular field induced by the dc current as shown in Fig. 2. This effect is further extended by reducing the scale of the device, i.e.effective spin-current path. We will also discuss quantum interference effects, which may be obtained additionally.

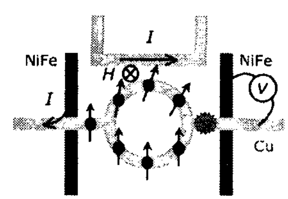

Fig. 1. Schematic configuration of the spin- current interference device.

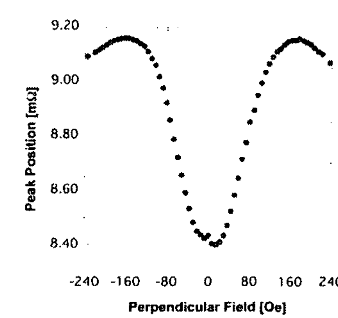

Fig. 2. DC-current-induced magnetic field dependence of non-local peak positions observed in the Cu nano-ring at 4 K.

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