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Gated Hall Effect in a Hybrid Ferromagnet-Semiconductor Device

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A novel spintronic device based on hybrid ferromagnet/semiconductor microstructures has recently attracted considerable interest due to the possibility of device applications such as magnetic field sensors, integrated non-volatile memory cells, and logic gate. In a Hybrid Hall device, magnetic fringe fields from the edge of a single, patterned ferromagnetic film generate a Hall voltage in a micron-scaled InSb semiconductor Hall cross junction. 1 ㎛ thick InSb films were thermally evaporated onto insulating Si substrates and 3 ㎛-wide cross junction was fabricated by standard microfabrication techniques using the InSb thin film. After the junction patterning steps, a 200 nm thick Si_3N_4 insulating layer was deposited in order to electrically isolate InSb layer from a ferromagnetic element. A 50 nm thick FeCo film (FM) was deposited in a dc magnetron sputtering system and then patterned by standard optical lithography and lift-off process.

We found a hysteric behavior in the R_H-H curve as shown in Fig. 1. This is believed to originate from the strong local magnetic field emanating from the edge of the FeCo film, when an applied magnetic field was parallel to the substrate. The Hall sensitivity of the hybrid cross junction was found to be 4.5 Ω/Oe, which is approximately two hundred times higher than that (0.025 Ω/Oe) in the cross junction without a ferromagnetic element obtained when applied external magnetic fields were perpendicular to the plane of the cross junction. Our results demonstrate that the local fringe field from a ferromagnetic element inducing a Hall voltage improves the Hall sensitivity.

Further improvement in Hall voltage and Hall sensitivity in hybrid ferromagnet/semiconductor microstructures can be achieved by adding an electrostatic gate reducing carrier density and increasing resistivity.

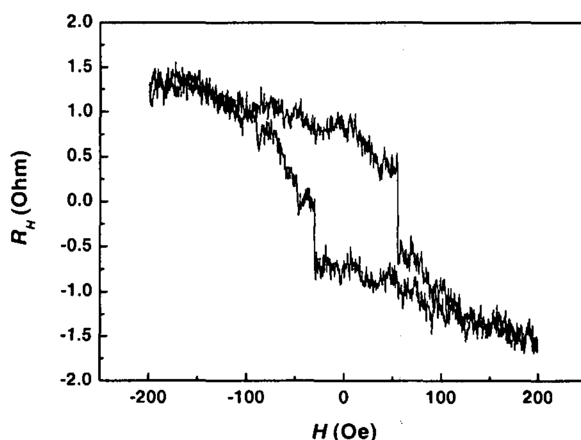

Fig. 1. The variations of Hall resistance (R_H) against in-plane magnetic fields in the InSb cross junction with a ferro magnetic element.

Reference

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