Spin Valve Effect in Fe_3GeTe_2/Ni Heterostructure

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Since the experimental studies of two-dimensional (2D) van der Waals (vdW) magnetic materials began recently, those on magnetic devices based on only 2D materials have been widely investigated. However, the devices which consist of typical ferromagnetic metals and 2D magnetic materials as metal electrodes together have rarely been experimentally implemented, despite theoretical simulation studies. Fe_3GeTe_2 shows itinerant ferromagnetic behaviour with perpendicular magnetic anisotropy. Therefore, it has useful electrical and magnetic properties that are easy to utilize in conventional magnetic devices, such as the spin valve and magnetic tunnel junction. Fig. 1(a) shows the crystal structure of Fe_3GeTe_2/Ni heterostructure. Ni was deposited with the e-beam evaporator, and mechanically exfoliated Fe_3GeTe_2 was placed on the Ni electrode. All processes for the device fabrication were performed in a glove box under Ar gas atmosphere to avoid oxidation. In the heterostructure of 2D vdW magnetic material and the traditional magnetic 3d transition metal, spin valve effect without a spacer was confirmed because the Te cap and/or vdW gap played the role of the spacer. Since Fe_3GeTe_2 and Ni have perpendicular and in-plane magnetic anisotropy, respectively, it was expected that magnetization switching would occur in the low magnetic field region. As a result of previous study, magnetic switching occurred in the magnetic field of 0.2T for Fe_3GeTe_2 vdW homo-junction vertical spin valves [1]. On the other hand, it was observed that the Fe_3GeTe_2/Ni-based spin valve device exhibited a maximum resistance in an out-of-plane magnetic field of 35mT under the temperature of 1.8K, resulting in magnetization switching as shown in Fig. 1(b). It was confirmed that the coercive field (Hc) disappears around 220K, which is the Curie temperature of Fe_3GeTe_2, whereas at a temperature higher than that, the anisotropic magnetoresistance (AMR) effect of Ni becomes dominant. These findings highlight that the possibility of hybrid spin valve structures that can utilize only the advantages of vdW magnetic and conventional magnetic material.

References

[1] Ce Hu et al., Science Bulletin, 13 (2020) 1072-1077.

Figures

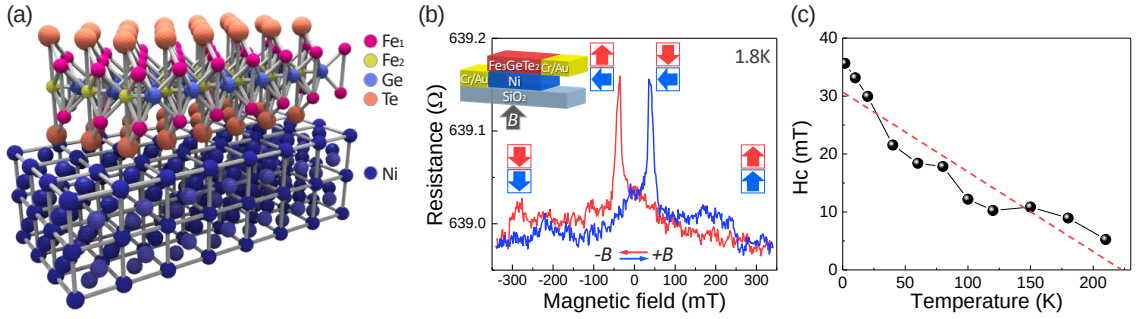

Figure 1: (a) Schematic view of Fe3GeTe2/Ni heterostructure. (b) Magnetoresistance of the spin valve as a function of the perpendicular magnetic field measured at 1.8K. (c) Decrease of Hc with increasing the temperature.