Room-temperature magnetoresistance in *p*-Ge based vertical spin-valve devices with a Co_2FeSi layer

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For future semiconductor (SC) spintronic applications with low power consumption, vertically stacked CoFe/Ge//Fe_3Si trilayer structures on a Si platform have been explored [1]. Recently, we observed clear magnetoresistance (MR) effect related to spin-dependent transport through *p*-type Ge layer in the CoFe/Ge/Fe_3Si vertical spin-valve devices [2]. However, the MR ratio at room temperature was less than 0.1 %. Here, we utilize one of the Heusler alloys, Co_2FeSi, with high spin polarization of 0.5-0.8 [3] as an electrode in the vertical device structure.

We grew all-epitaxial CoFe/Ge/Co_2FeSi structures on a Fe_3Si buffer layer by combining solid phase epitaxy (SPE) and molecular beam epitaxy (MBE). After that, we processed the CoFe/Ge/Co_2FeSi/Fe_3Si structures into spin-valve devices, as illustrated in Fig. 1(a), by conventional electron-beam lithography and Ar ion milling techniques. A scanning electron micrograph of a fabricated device is shown in Fig. 1(b). The area of the top CoFe electrode and the intermediate Ge layer is ~0.44 μm^2. Figure 1(c) shows a representative MR curve at 300 K. We can see a hysteretic feature depending on parallel and anti-parallel magnetization states between top and bottom FM electrodes. As shown in Fig. 1(d), an evident minor loop can also be observed. Thus, the observed MR curves are derived from the spin-dependent transport through the *p*-Ge layer. Note that the obtained MR ratio at room temperature is 0.35 %, one order of magnitude larger than those in our previous work [2]. This value is the largest room-temperature MR ratio through SC intermediate layers.

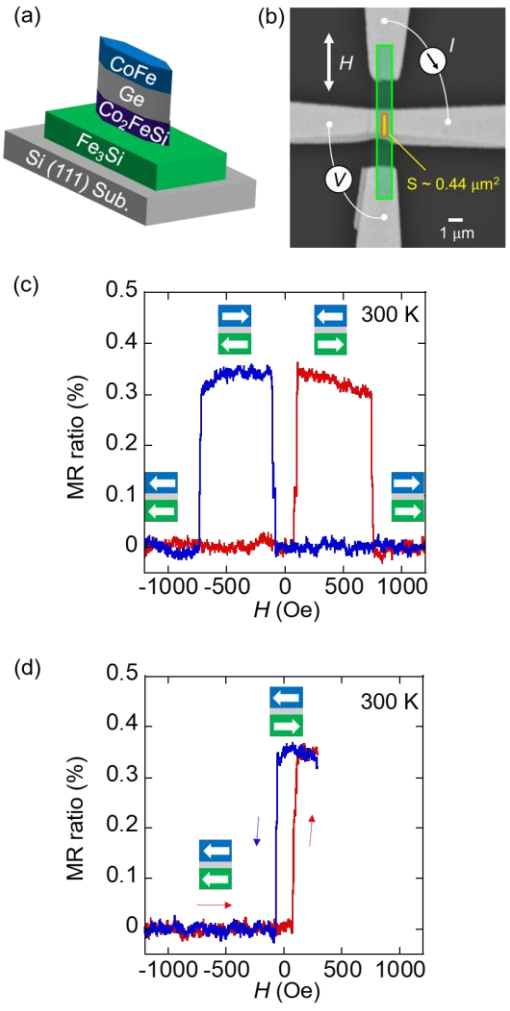

Fig. 1. (a) Schematic and (b) scanning electron micrograph of the fabricated CoFe/Ge/Co_2FeSi/Fe_3Si vertical spin-valve devices. (c) MR and (d) minor-loop curves at 300 K.

This work was partly supported by JSPS KAKENHI (16H02333, 17H06120 and 19H05616).

References

[1] S. Sakai *et al.*, Semicond. Sci. Technol. **32**, 094005 (2017).
[2] M. Kawano *et al.*, Phys. Rev. Mater. **1**, 034604 (2017).
[3] K. Hamaya *et al.*, Phys. Rev. B **85**, 100404(R) (2012).