

Generation and detection of pure spin currents through epitaxial Ge/Fe₃Si heterostructures

○Makoto Kawano¹, Kohei Santo¹, Soichiro Oki¹, Shinya Yamada¹, Takeshi Kanashima¹,
and Kohei Hamaya^{1,2}

(1. Osaka Univ., 2. JST-CREST)

E-mail: makotokawano141@s.ee.es.osaka-u.ac.jp

We have so far demonstrated the epitaxial growth of Ge layers on $D0_3$ -ordered Fe₃Si films on a Si(111) substrate ($\rho \sim 1000 \text{ } \Omega\text{cm}$) by using low-temperature molecular beam epitaxy (see the inset of Fig. 1).[1] Although we expect that the Ge/Fe₃Si heterostructure will open new perspectives for next-generation Ge-based spintronic devices, spin-dependent transport properties through the Ge/Fe₃Si high-quality heterointerfaces have not been clarified yet. Here we present the generation and detection of pure spin currents in a Cu-based lateral spin valve consisting of the Ge/Fe₃Si heterostructure.

Figure 1 shows schematics and dimensions of a fabricated lateral spin valve. Two Ge contacts on two Fe₃Si electrodes were patterned by using conventional electron-beam lithography and Ar⁺ milling techniques.[2] The sides of the Ge/Fe₃Si heterostructures were insulated by RF-sputtered SiO₂ layers. After that, a wire-shaped Cu channel with a thickness of 70 nm was fabricated by conventional lift-off techniques. Non-local spin valve measurements were carried out using standard AC lock-in techniques ($\sim 200 \text{ Hz}$, $\sim 1.0 \text{ mA}$).

Figure 2 shows a representative non-local spin-valve signal measured at 10 K. We observe a clear hysteretic behavior although the spin signal is smaller than that in our previous Cu/Fe₃Si lateral spin valves.[2, 3] It is noteworthy that pure spin currents flow through the $\sim 150 \text{ nm}$ Cu channel and the $50 \sim 100\text{-nm}$ -thick Ge layers. We will also discuss temperature evolution of spin-dependent transport properties through the Ge/Fe₃Si heterointerfaces.

This work was partially supported by Grant-in-Aid for Scientific Research on Innovative Areas 'Nano Spin Conversion Science' (No. 26103003) from JSPS, and Grant-in-Aid for Scientific Research(A) (No. 25246020) from JSPS. M.K. and S.O. acknowledge JSPS Research Fellowships for Young Scientists.

[1] M. Kawano *et al.*, Appl. Phys. Lett. **102**, 121908, (2013).

[2] S. Oki *et al.*, Appl. Phys. Lett. **103**, 212122, (2013).

[3] K. Hamaya *et al.*, Phys. Rev. B **85**, 100404(R), (2012).

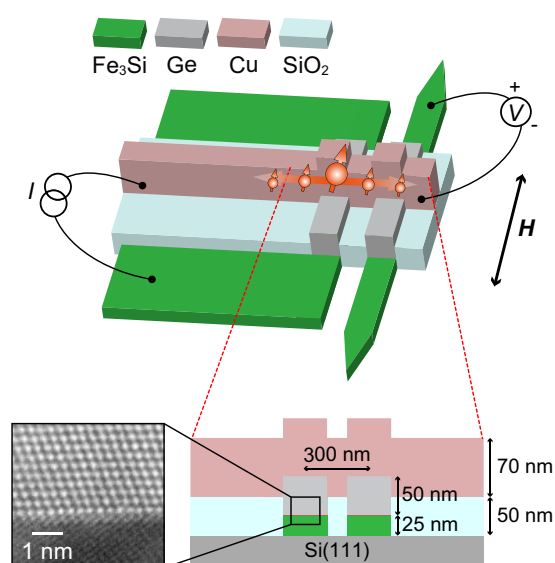


Fig. 1 Schematics and dimensions of a Cu/Ge/Fe₃Si lateral spin valve. The inset shows a representative high-resolution cross-sectional transmission electron microscope image of the Ge/Fe₃Si heterostructure.

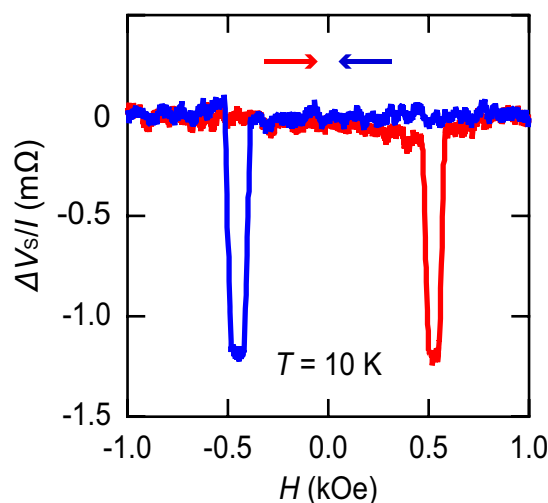


Fig. 2 A non-local spin signal measured at 10 K.