Germanium spintronics developed by semiconductor technologies

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Because of high intrinsic electron and hole mobility, germanium (Ge) is promising for a new channel material in next-generation complementary metal oxide semiconductor (CMOS) transistors. Recently, the operation of Ge-CMOS transistors was reported at last.[1)]

Up to now, we have focused on the integration of spintronic technologies with Ge by using novel crystal growth techniques.[2)] First of all, high-quality Heusler-alloy films were grown by molecular beam epitaxy at room temperature.[3)] Next, a newly developed delta-doping method was utilized for achieving electrical spin injection and detection.[4)] Using Ge-based lateral spin-valve (LSV) devices with a heavily doped transport layer (~10^{19}cm^{-3}), we clearly detected spin transport and obtained relatively short spin diffusion lengths of ~ 800 nm at low temperatures.[5)] Finally, for Ge-based spin-based MOSFET, gate-stack structures were developed only by low-temperature fabrication processes.[6)] Despite a process less than 300°C, the Al_2O_3/GeO_2 structures can operate as a gate-stack for a Ge spin-MOSFET structure. We would like to simultaneously utilize the techniques of the spin injection/detection and of the gate-stack fabrication in a single device structure.

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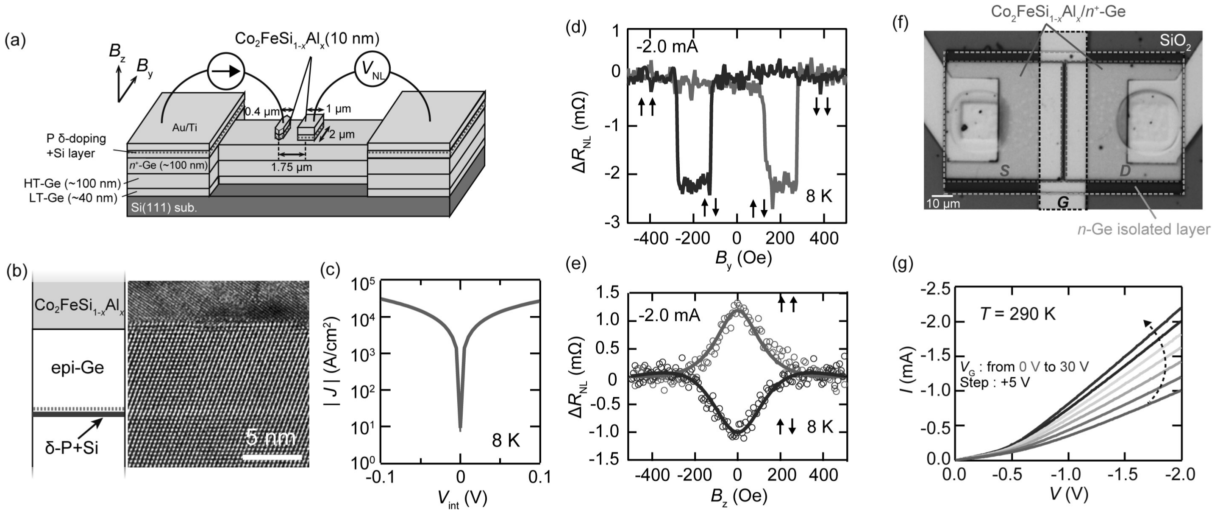

Fig.1 (a) Schematic of a Ge-based LSV with Heusler-alloy spin injector and detector. (b) TEM image of the detla-doped P layer with Si near the Heusler/Ge heterointerface. (c) *J-V* characteristic of the Heusler/Ge Schottky tunnel contact (d) Nonlocal spin signal at 8 K. (e) Hanle-effect curve at 8 K. (f) Top-view of the fabricated Ge-spin MOSFET structure. (g) *I-V* characteristics with gate-voltage applications.

Reference

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