Spin transport in non-degenerate *n*-Ge

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Recently, we experimentally clarified that the donor-driven intervalley transition of electrons dominants the spin-flip scattering mechanism for heavily doped (degenerate) *n*-Ge [1,2]. It should be noted that, for degenerate *n*-Ge, the spin diffusion length is almost independent of external temperature [1] and dependent strongly on donor concentration [2] less than ~ 100 K. For Ge spintronics devices, spin transport properties in non-degenerate *n*-Ge should also be explored. Here, we investigate spin transport in non-degenerate *n*-Ge by four-terminal (4T) nonlocal measurements.

We fabricated lateral spin-valve (LSV) devices with $Co_2FeAl_{0.5}Si_{0.5}$/*n*-Ge Schottky-tunnel junctions to observe the spin transport. A scanning electron micrograph of a fabricated LSV device and the terminal configuration of 4T-NL measurements are shown in Fig. 1(a). Temperature-dependent resistivity and carrier concentration of the *n*-Ge spin-transport layer indicate non-degenerate semiconductor-like electrical properties [Fig. 1(b)]. When in-plane (B_y) magnetic fields are swept, a clear NL spin signal ($\Delta R_{NL} = \Delta V_{NL}/I$) can be observed at 8 K [inset of Fig. 1(c)]. NL Hanle-effect curves owing to the spin precession were also observed for both magnetic configurations (not shown here). To determine λ_{Ge}, we measured ΔR_{NL} for LSV devices with various *d* [Fig. 1(c)]. From a one-dimensional spin diffusion model [3], λ_{Ge} for non-degenerate *n*-Ge can be estimated to be ~1.66 μm, which is 2-3 times larger than those in degenerate *n*-Ge at 8 K [1,2]. Figure 1(d) shows the temperature dependence of λ_{Ge} for non-degenerate *n*-Ge, together with that for degenerate *n*-Ge [1]. Unlike the feature for degenerate *n*-Ge [1], the value of λ_{Ge} decreases with rising temperature even less than ~ 100 K. We will discuss the details of the spin relaxation mechanism in non-degenerate *n*-Ge.

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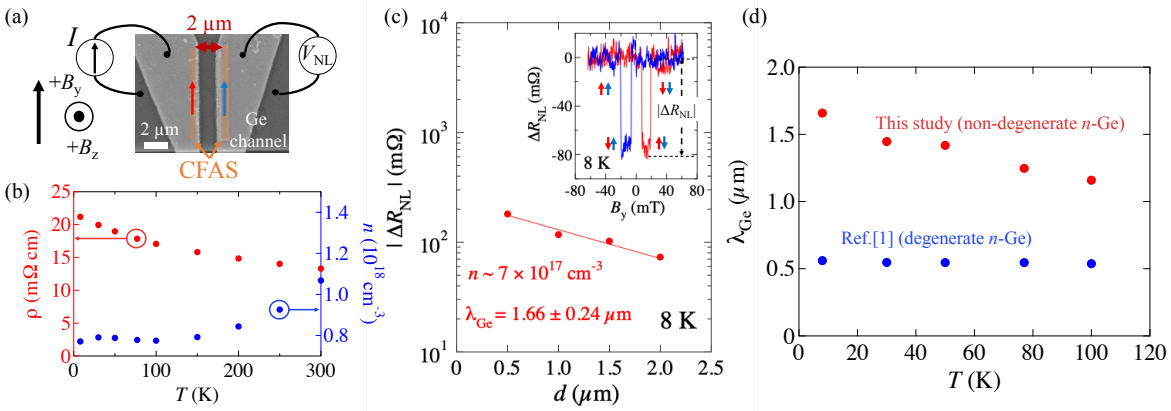

Figure 1 (a) SEM image of a fabricated CFAS/*n*-Ge based LSV. (b) The temperature dependence of ρ and *n* in the *n*-Ge layer. (c) *d* dependence of $|\Delta R_{NL}|$ for the LSVs with n~7×10^{17} cm^{-3} at 8 K. The inset shows the NL spin signal at 8 K. (d) Temperature dependence of λ_{Ge}, estimated from *d* dependence of NL signals.

References

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