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Detection of hole spin transport in Ge using lateral spin-valve structures

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Detection of hole spin transport in *p*-Ge is quite challenging because the strong influence of the spin-orbit interaction in the valence band leads to very short hole spin relaxation times (τ_S < ~1 ps at 300 K).[1] Although electrical detection of spin-polarized holes in *p*-Ge has been reported by a three-terminal method,[2] the reliability of the measurement is still an open question.[3] Here we present hole spin-transport measurements in a *p*-Ge(111) layer using a Cu-based nonlocal lateral spin valve (LSV) with a *p*-Ge(111)/Fe_3Si heterointerface.[4, 5]

By performing reliable nonlocal measurements for the fabricated Fe_3Si/Cu/*p*-Ge(111)/Fe_3Si LSV (LSV with *p*-Ge), we observed a hysteretic nonlocal spin signal (ΔR_S) at various temperatures. Figure 1 shows the temperature dependence of the ΔR_S for the LSV with *p*-Ge (red closed circles), together with that for a conventional Fe_3Si/Cu/Fe_3Si LSV (LSV without *p*-Ge) (black open squares). As measurement temperature increases, the magnitude of ΔR_S rapidly decreases at ~60 K and disappears at ~150 K. For the LSV without *p*-Ge, on the other hand, ΔR_S has ordinary temperature dependence. Using a general one-dimensional spin diffusion model,[6] we can understand that the temperature dependence of the ΔR_S for the LSV with *p*-Ge originates from spin accumulation and relaxation in *p*-Ge and the τ_S at 10 K is roughly estimated to be ~41 ps. We infer that the relatively long τ_S is attributed to the suppression of spin relaxation at the *L* point in the valence band.

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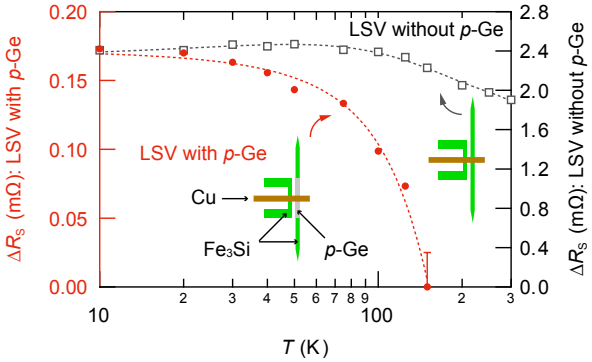

Fig. 1 Temperature dependence of ΔR_S for an LSV with *p*-Ge (red closed circles), together with that for an LSV without *p*-Ge (black open squares).