Temperature dependent direction of in-plane uniaxial magnetic anisotropy in (Ga,Mn)As codoped with Li

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We reported that (Ga,Mn)As codoped with Li shows pronounced in-plane uniaxial magnetic anisotropy.[1] In this work, we investigate the temperature dependence of the in-plane anisotropy in (Ga,Mn)As:Li.

We grow a 20 nm-thick $Ga_{0.90}Mn_{0.1}As:Li_{0.01}$ layer at 250°C by molecular beam epitaxy on a semi-insulating GaAs (001) substrate through a GaAs buffer layer. After the growth, the layer is annealed in the air at 250°C for 1 hour, and is processed into a Hall bar along [110]. The Curie temperature of the present (Ga,Mn)As:Li is ~145 K.

Figure 1 shows the in-plane magnetic field angle ϕ_H dependence of planar Hall resistance at 10 and 120 K. The in-plane hardest axis is along [110] ([$\bar{1}$10]) at 10 K (120 K), which is consist with the results of magnetization measurements. The results are fitted by the relationship between magnetization angle and planar Hall resistance with in-plane biaxial and uniaxial anisotropy fields (H_B and H_U) as adjustable parameters. The fitted curves (solid lines in Figs. 1(a) and (b)) reproduce the experimental data well except for the regions in the vicinity of the hard axes. Figure 2 summarizes the temperature dependence of H_B and H_U. The magnitude of the biaxial anisotropy field decreases with increasing temperature, as reported for (Ga,Mn)As.[2] The direction of the uniaxial anisotropy field changes from [$\bar{1}$10] to [110] around 75 K with increasing temperature. The temperature dependent direction of uniaxial anisotropy seems to be common behavior for (Ga,Mn)As codoped with charged impurities,[3,4] suggesting that the impurities affect the positions of Mn in (Ga,Mn)As.[5]

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References

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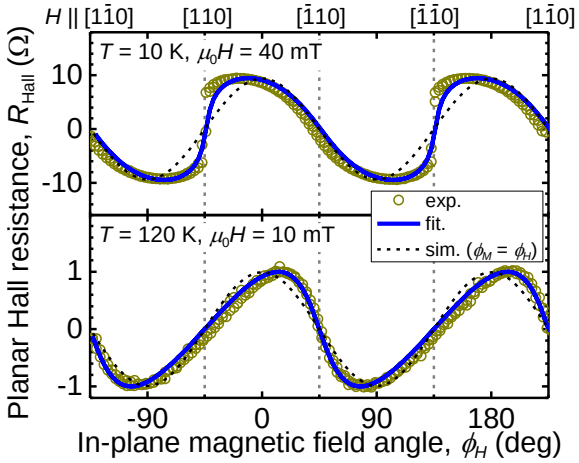

Fig. 1. External in-plane magnetic field angle ϕ_H dependence of planer Hall resistance R_{Hall} at (a) 10 K and 40 mT, and (b) 120 K and 10 mT.

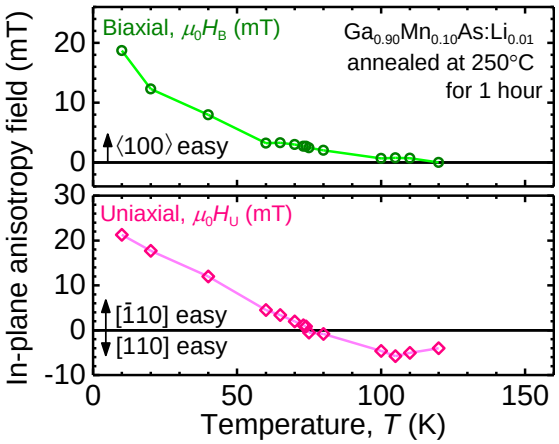

Fig. 2. Temperature T dependence of in-plane biaxial and uniaxial anisotropy fields, H_B and H_U.