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 Ga0.90Mn0.10As:Li0.01 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 \( \phi_H \) dependence of planar Hall resistance at 10 and 120 K. The in-plane hardest axis is along [110] ([110]) 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 [110] 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

Fig. 1. External in-plane magnetic field angle \( \phi_H \) dependence of planer Hall resistance \( R_{\text{Hall}} \) 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 \( H_U \).