19p-E7-13

Li を共添加した(Ga,Mn)As の電界効果

Electric field effects on Li codoped (Ga,Mn)As

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At the last meeting, we reported the molecular beam epitaxy of Li codpoped (Ga,Mn)As layers and their magnetic properties before and after annealing. The results showed that annealed (Ga,Mn)As layers codoped with Li show similar Curie temperature T_C with that of annealed (Ga,Mn)As without Li.[1] In this work, we investigate magnetotransport properties of Li codoped (Ga,Mn)As as well as electric-field effects on them.

We grow a 5 nm-thick $Ga_{0.92}Mn_{0.08}As:Li_{0.01}$ layer on a semi-insulating GaAs (001) substrate through a GaAs buffer layer at 250°C. The layer is annealed at 250°C for 10 minutes after the growth and processed into a Hall bar with 30 μm width and 150 μm length by photolithography and wet etching. A 50 nm-thick Al_2O_3 gate insulator is deposited on the channel by atomic layer deposition at 130°C, and Au (50 nm)/ Cr (5 nm) gate electrode is formed by evaporation and lift-off technique.

Figure 1 shows gate electric field E_G dependence of sheet conductance R_{sheet}^{-1} at room temperature. Provided that the device is ideal parallel type capacitor, the carrier mobility μ is given by $\mu = -[d(R_{sheet}^{-1})/dE_G]/(\kappa\varepsilon_0)$ and carrier concentration p by $p(E_G) = (\mu e t R_{sheet})^{-1}$, where κ is relative permittivity of Al_2O_3, ε_0 the permittivity of vacuum, e the elementary charge, and t the channel thickness. We determine μ and p to be 1.1 cm^2/Vs and 6.3×10^{20} cm^{-3}, respectively.

Figure 2 shows external out-of-plane magnetic field H dependence of sheet resistance R_{sheet} and Hall resistance R_{Hall} under gate electric field E_G of +3, 0, and -3 MV/cm at temperature T of 20 K. Observed magnetoresistance and nonlinear Hall resistance indicate that (Ga,Mn)As codoped with Li shows similar magnetotransport properties to those of (Ga,Mn)As. The electric-field effect dependent magnetotransport properties suggest that (Ga,Mn)As with Li shows carrier-induced ferromagnetism as same as (Ga,Mn)As.

This work was supported in part by JSPS through the FIRST program as well as R&D for Next-Generation IT of MEXT.

Reference

[1] 都澤 章平ほか，第 74 回応用物理学会秋季学術講演会，17p-C15-2，(2013).

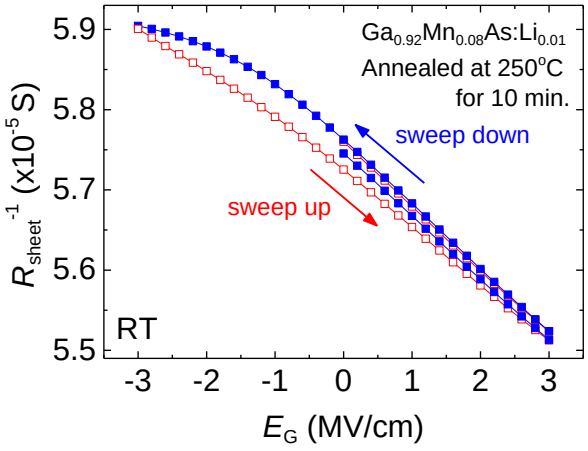

FIG. 1. Gate electric field E_G dependence of sheet conductance R_{sheet}^{-1} measured at room temperature.

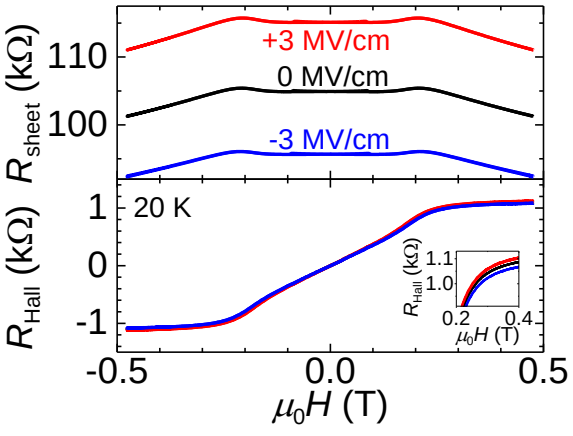

FIG. 2. External magnetic field H dependence of sheet resistance R_{sheet} (top pannel) and Hall resistance R_{Hall} (bottom panel) under gate electric fields E_G of +3, 0, and -3 MV/cm at 20 K, where μ_0 is permeability of vacuum.