Magnetoresistance in InMnAs/ InAs heterojunctions

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1. Introduction

The effect of alloy composition and temperature on the large positive magnetoresistance of *p*-$In_{1-x}Mn_xAs$/*n*-InAs dilute magnetic semiconductor (DMS) heterojunctions was investigated. The junction magnetoconductance with magnetic field and current parallel is well-described by an analytical expression for the total conductance G_{tot} for the two spin split bands [1]. From the junction magnetoconductance an effective g-factor due to giant Zeeman effect was determined for varying Mn concentration. The effective *g*-factor increases with increasing Mn concentration from 98 to 131 for x_{Mn} = 0.01 to x_{Mn} = 0.06. There is excellent agreement between the calculated curve for the g-factor and the experimentally derived values [2]

2. Results and Discussion

The influence of two factors Mn concentration and junction temperature on the magnetoresistance properties of DMS *p*-InMnAs/*n*-InAs magnetic diodes was studied. We find that the magnetoresistance of the heterodiode under forward bias can be increased by increasing the Mn ion concentration and decreasing the temperature. The measured dependence of diode conductance on alloy concentration and temperature supports the previously proposed two-channel spin transport model for the positive junction magnetoresistance.

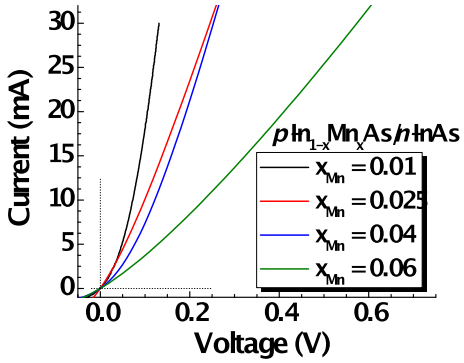

Figure 1: *The current- voltage characteristics of the InMnAs/ InAs diodes measured for different Mn concentrations at 300 K.*

To form the p+-n junction for these studies, ~100-300 nm thick *p*-$In_{1-x}Mn_xAs$ layer was deposited on an undoped *n*-InAs substrate using atmospheric pressure metalorganic vapor phase epitaxy (MOVPE) under conditions. Figure 1 shows the zero-field current-voltage (*I-V)* characteristics at 300 K for the InMnAs/InAs heterodiode for four Mn concentrations *x*. Over the measured bias range, the magnetic diode shows rectifying behavior, with a high ratio of forward current to reverse current, typical of semiconductor diodes under bias. In addition, the I-V curves exhibit characteristic turn-on voltage that seems to be dependent on Mn concentration. The junction resistance increases with increasing Mn content.

3. Conclusions

We have determined the effect of temperature and Mn concentration on the large positive junction magnetoresistance of *p*-$In_{1-x}Mn_xAs$/*n*-InAs magnetic diodes. As the Mn concentration is increased the positive magnetoresistance increases. The increase is attributed to an increase in the giant Zeeman effect, whereby the exchange term which depends on the Mn concentration is much larger than the band contribution to the g_{eff} factor. The effective *g*-factor increased with increasing Mn concentration; a thirty per cent increase is observed for x_{Mn} = 0.01 to x_{Mn} = 0.06. Furthermore decreasing the temperature from 300 to 50 K decreases the external magnetic field, from 3 to 0.8 T, required to reduce heterojunction conductance by one half.

4. Open Questions

- The nature of the ferromagnetic interaction in transition metal doped narrow gap semiconductors
- Origin of giant magnetoresistance and nature of spin selective scattering
- Can higher Tc materials be synthesized from narrow gap III-V semiconductors?

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References

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