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A Fabrication of Epitaxial Ferromagnetic Spin injector and detector on InAs 2DEG system by clustor MBE

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1. Introduction

The semiconductor spintronics has the great potential for microelectronics technology due to high speed, high density, low power consumption and nonvolatile attributes. Since Datta and Das[1] proposed spin polarized field effect transistor(Spin FET), the spin transport from a ferromagnetic into a semiconductor such as Si[2] and GaAs[3] has been significantly investigated. In this study, we grow an epitaxial Fe layers on inverted high electron mobility transistor structure(i-HEMTs) including InAs two dimensional electron gas(2DEG) by using semiconductor-metal cluster molecular beam epitaxy(MBE). Growth characteristic, electrical property, and magnetic anisotropy will be discussed.

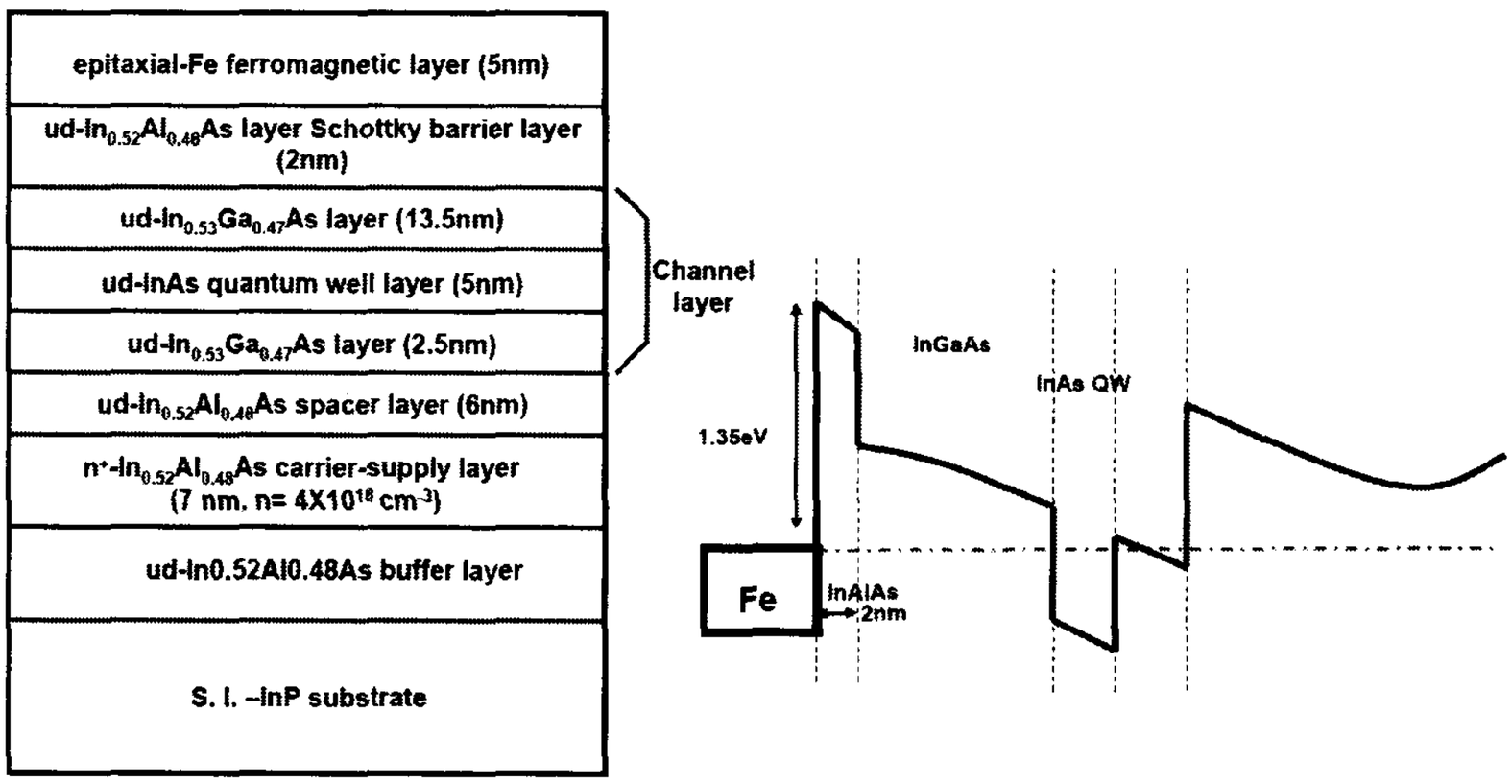

Fig. 1. Schematic layer structure and band diagram of an Fe on InAs 2DEG inserted HEMTs.

2. Experiment details

All epitaxial layers including the ferromagnetic metal were grown by two Riber C21 MBE systems which connecter through an UHV tube. First, we grew lattice matched

$In_{0.52}Al_{0.48}As/In_{0.53}Ga_{0.47}As$ layers on a semi insulating InP(100) substrate as shown in Fig. 1. Prior to InAs 2DEG channel growth, Si-doped InAlAs carrier supply layer was grown with 4×10^{18} cm^{-3} concentration. The substrate temperature was decreased 455℃ to 415℃ to maximize the InAs critical thickness up to 5nm. The sample is transferred to metal MBE without vacuum break, followed by 5nm thick Fe layer at 200℃ with the growth rate of 0.017 μm/hr. 3nm thick Al caping was subsequently grown at room temperature to prevent oxide formation.

3. Results and discussion

In the prepared sample, the electron mobility was 11,000 and 60,000 cm^2/Vs at 300 and 77K, respectively, with a corresponding N_S of 1.3×10^{12} cm^{-2} by van der pauw method. The RHEED pattern verifies the formation of single crystal bcc Fe. In Fig. 2, alternating gradient magnetometer(AGM) hysteresis loop shows in-plane fourfold symmetry with easy and hard axes corresponding to the [-110] and [110] directions, respectively. Mr/Ms values are 0.8 and 0.1 in cases of easy and hard magnetization axes which indicates strong uniaxial magnetic anisotropy. The experimental results indicate that ferromagnetic Fe layer is an evident candidate for spintronics device applications.

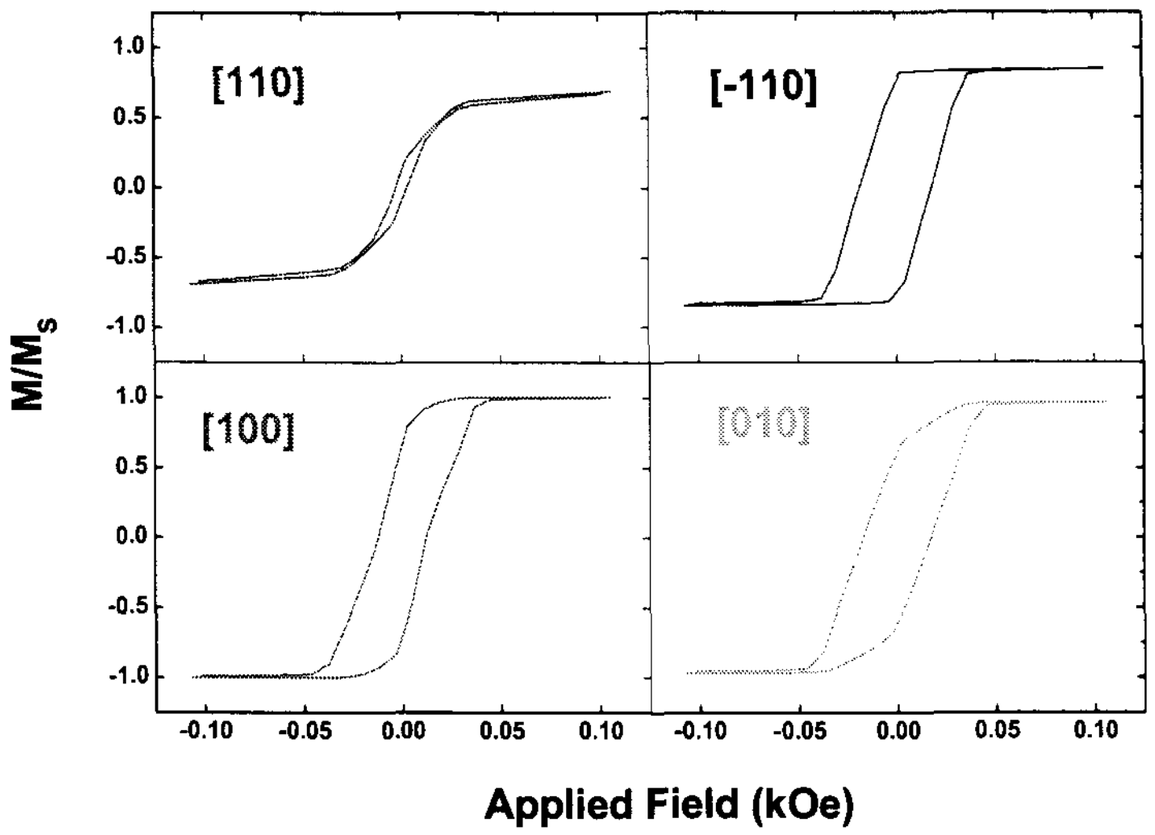

Fig. 2. Normalized AGM loop of 200℃ grown 5nm thick Fe on HEMTs. External magnetic field applied along the four principal in-plane axes of InP(100) substrate.

4. References

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