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Ferrimagnetic Fe_xMn_{1-x} thin films on GaAs(001)

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Abstract

We have successfully grown epitaxial Fe_xMn_{1-x} thin films on GaAs(001) substrate by using MBE(molecular beam epitaxy), exhibiting ferrimagnetic ordering at 750 K. In Fe_xMn_{1-x}(x=0.5) thin film, the coercivity field was 310 Oe and the magnetic moment from the saturated magnetization was 3.17 μ_B at 10 K. The coercivity fields increased with Mn concentrations decease. The crystal structure of Fe_xMn_{1-x}(x=0.8, 0.7, 0.6, and 0.5.) thin films was α-Mn(A12) with a=8.83~8.89 Å.

1. Introduction

The epitaxial growth of ferromagnetic (FM) metal film on semiconductor is important for spintronic device fabrication. The epitaxial growth of Fe thin film has been achieved on GaAs(110) and GaAs(001) at 175 ℃ and room temperature, respectively [1]. However, the interaction at the interface between Fe and GaAs forms the interlayer of nonmagnetic $Fe_3Ga_{2-x}As_x$[2], which is believed to introduce defects and deep levels which may scatter spin polarized carriers. Ferromagnetic MnAs with T_C= 318 K has been grown on GaAs(001)[3]. $Fe_{1-x}Mn_x$ alloys have various crystal phases such as α, γ, α-Mn, β-Mn, and ε. For x<0.2, the alloys form the bcc α-phase (a= 2.89 Å) which is ferromagnetic at room temperature [4], and for 0.2<x<0.6 the alloys from the fcc γ-phase (a=3.63 Å) which is antiferromagnetic with T_N= 520~540 K [5]. The γ-phase $Fe_{50}Mn_{50}$ has been used as a pinning layer in an exchange biased spin valve. Note that manganese (Mn) is known to be the most complex element. α-Mn(A12) is antiferromagnetic with T_N= 375 K and has a complex crystal structure with 58 atoms in a cubic unit cell (a= 8. 91 Å)[6].

2. Experiment

We grew Fe_xMn_{1-x} (x=0.8, 0.7, 0.6, and 0.5.) thin films directly on GaAs(001) substrate) at the substrate temperature of T_S=300 ℃ by molecular beam epitaxy (MBE. The film thickness was 1000 Å. We

recognized that Fe_xMn_{1-x} thin films were an easily oxidizable metal alloy at room temperature, thus following by a 50 Å GaAs capping layer on Fe_xMn_{1-x} thin film. The growth was monitored with RHEED (reflection high-energy electron diffraction).

3. Results and conclusion

We have grown epitaxial Fe_xMn_{1-x} thin films on GaAs(001) substrate by using MBE(molecular beam epitaxy), exhibiting ferrimagnetic ordering at 750 K. In Fe_xMn_{1-x}(x=0.5) thin film, the coercivity field was 310 Oe and the magnetic moment from the saturated magnetization was 3.17 μ_B per Fe at 10 K. The coercivity fields increased with Mn concentration. The crystal structure of Fe_xMn_{1-x}(x=0.8, 0.7, 0.6, and 0.5.) thin films were α-Mn(A12) with a=8.83~8.89 Å.

4. Reference

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