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Epitaxial $(Mn_{0.66}Cr_{0.33})_2As$ and $(Fe_{0.66}Mn_{0.33})_2As$ thin films: magnetic and structural properties

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Abstract

We grew $(Mn_{0.66}Cr_{0.33})_2As$ and $(Fe_{0.66}Mn_{0.33})_2As$ thin films directly on n-type Si (100) substrate by molecular beam epitaxy (MBE) at the substrate temperature, T_S=300 ℃. The growth was monitored with RHEED (reflection high-energy electron diffraction). We have observed streaky RHEED patterns, indicating the layer-by-layer growth of $(Mn_{0.66}Cr_{0.33})_2As$ and $(Fe_{0.66}Mn_{0.33})_2As$ thin films. We found that the crystal structure of $(Mn_{0.66}Cr_{0.33})_2As$ and $(Fe_{0.66}Mn_{0.33})_2As$ thin films were the tetragonal Mn_2As type with a=3.745 Å and a= 3.70 Å. $(Mn_{0.66}Cr_{0.33})_2As$ thin film shows spin-glass behavior below 130 K, while $(Fe_{0.66}Mn_{0.33})_2As$ alloy shows ferrimagnetic ordering at around room temperature.

1. *Introduction*

Recently, Epitaxial ferromagnetic or ferrimagnetic thin films on semiconductor substrates have attracted much interests[1]. For the possibility of incorporating these materials into integrated spintronic devices. The manganese based metallic compounds are examples of materials of interest for such applications. Arsenide (As) of transition metals with formula M_2As(M=Mn, Fe, Cr) usually crystallize in three different crystal structure types such as hexagonal *P62m*, tetragonal *P4/nmm* or orthorhombic *Pmma*[2]. The most stable state crystal structure type of M_2As(M=Mn, Fe, Cr) is tetragonal with the lattice constants are a=3.769 Å/c= 6.278 Å, a=3.627 Å/c= 5.973 Å, and a=3.620 Å/c= 6.330 Å, respectively[3]. The tetragonal M_2As(M=Mn, Fe, Cr) shows antiferromagnetic ordering at 573, 325, and 393 K, respectively[4]. Note the magnetic properties strongly depend on crystal structure. Recently, It is reported that FeMnAs showed antiferromagnetic ordering at 470 K with the magnetic moment of -3.36 μ_B per Mn.

2. Experiment

We grew $(Mn_{0.66}Cr_{0.33})_2As$ and $(Fe_{0.66}Mn_{0.33})_2As$ thin films directly on n-type Si (100) substrate by molecular beam epitaxy (MBE) at T_S=300 ℃. The film thickness is above 1000 Å. The growth was monitored with RHEED (reflection high-energy electron diffraction).

3. Results and conclusion

In order to characterize the crystal structure, we performed X-ray diffraction measurement. We observed that $(Mn_{0.66}Cr_{0.33})_2As$ and $(Fe_{0.66}Mn_{0.33})_2As$ thin films grew along (110) direction on Si (100) and the crystal structure was Mn_2As type tetragonal (*P4nmm*) with the lattice constants are a=3.745 Å and a=3.70 Å, respectively. The peak positions of Mn_2As type $(Mn_{0.66}Cr_{0.33})_2As$ and $(Fe_{0.66}Mn_{0.33})_2As$ thin films (220) direction and Si(400) direction 2θ angle is matched, corresponding to JCPDS(Joint Committee for Powder Diffraction Standards) data base. We have investigated the magnetic properties using SQUID (Superconducting Quantum Interference Device). $(Mn_{0.66}Cr_{0.33})_2As$ thin film showed spin-glass ordering at 130 K, while $(Fe_{0.66}Mn_{0.33})_2As$ thin film showed ferrimagntic ordering at around room temperature.

4. Reference

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