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Growth and magnetism in amorphous $Ge_{1-x}Mn_x$ Semiconductor thin films

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1. Introduction

Studies on diluted magnetic semiconductors (DMSs), such as Mn-doped the III-V and the II-IV, the IV compound semiconductors have been recently carried out by other researchers [1-3] because these materials have electronic and magnetic properties that are promising for spintronic application. However, these new materials have magnetic ordering or Curie temperature (T_C) below room temperature. For this reason, they have been focused on how to increase T_C in these materials. There are some studies on Mn_xGe_{1-x} system which can be obtained high T_C but including intermetallic compounds and clusters such as Ge_3Mn_5 [4]and Ge_8Mn_{11}[5] respectively.
In this work, we have grown amorphous Mn_xGe_{1-x} ferromagnetic semiconductor by thermal evaporator with the expectation that will increase T_C without secondary phases and clusters.

2. Experimental

Amorphous Mn_xGe_{1-x} ferromagnetic semiconductor thin films were deposited at low temperature of 373K on (100)Si wafer by using a thermal evaporator. Manganese and Germanium were co-evaporated at a growth pressure of 10^{-5}Torr. The deposition thickness of the films measured by α-step was obtained as 500nm. The components of Mn and Ge in the films were measured using an energy dispersive X-ray spectroscopy (EDS). The structure of the films was estimated by conventional x-ray diffractometer (XRD) and transmission electron microscopy (TEM). The magnetic properties were evaluated using vibrating sample magnetometer (VSM) and superconducting quantum interference device (SQUID). The electrical resistivity of the films was measured at room temperature by using a standard four-point probe and Hall measurement.

3. Result and discussion

Mn_xGe_{1-x} semiconductors thin films were grown by vapor deposition at temperature of 373K with Mn concentration in the range from 3 to 51at%. The electrical resistivites of Mn_xGe_{1-x} semiconductor thin films measured at room temperature are ranging form $5x10^{-4}$ to 1.1Ωcm and decrease with increasing Mn concentration. The Mn_xGe_{1-x} films have p-type carriers and range from 10^{17} to $10^{20}cm^{-3}$. Figure1 shows that the amorphous Mn_xGe_{1-x} semiconductor thin films have ferromagnetic properties, showed hysteretic loops behavior and signification remanence. The saturation magnetization is high of 100emu/cc at 5K for amorphous $Mn_{0.12}Ge_{0.88}$ ferromagnetic semiconductor thin films with Curie temperature around 150K. However, when Mn concentration exceeds 30at%, the deposited films were crystallized and the magnetism of these deposited films are dominated by Mn phase in the films. XRD patterns in figure 2 shows the deposited films are amorphous until Mn concentration achieve to 17.3at%when Mn concentration in the films exceeds 30at% the films appear Mn diffraction peaks.

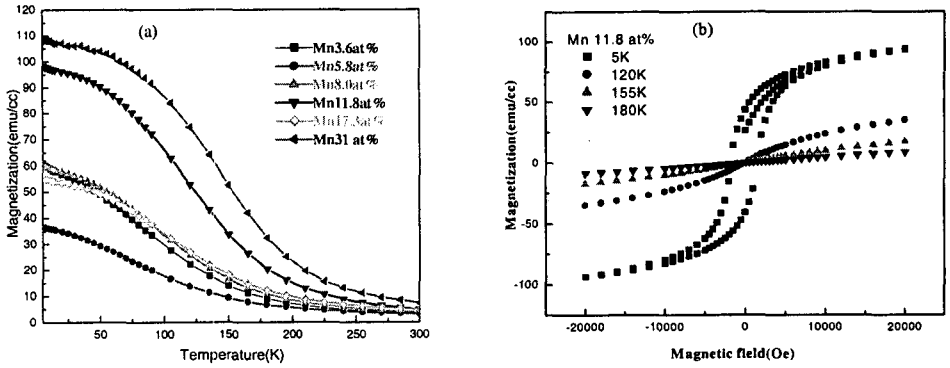

Fig.1. (a) Temperature dependence of the magnetization for several Mn_xGe_{1-x} semiconductor thin films with various Mn concentrations.
(b) The M-H loops at various temperatures for $Mn_{0.12}Ge_{0.88}$

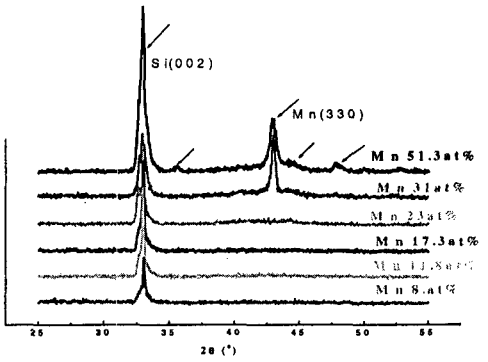

Fig. 2. X-ray diffractometer traces for amorphous and crystalline $Ge_{1-x}Mn_x$ films. Crystalline are indicated by arrows.

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