

PD06

Magnetic and Electrical Properties of Annealed Amorphous Ge_{1-x}Mn_x Semiconductor Thin Films Grown by Thermal Vapor Deposition

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Amorphous Ge_{1-x}Mn_x semiconductor thin films grown by low temperature vapor deposition were annealed, and their electrical and magnetic properties have been studied. The amorphous thin films are 1,000 ~ 5,000 Å thick. Mn concentration of thin films was determined using an energy dispersive X-ray spectroscopy. Amorphous Ge_{1-x}Mn_x semiconductor thin films were annealed at 300°C, 400°C, 500°C, 600°C and 700°C for 3 minutes in high vacuum chamber. Structural analysis was carried out by using an X-ray diffractometer and a transmission electron microscope. Surface morphology was examined by using an atomic force microscope. The electrical properties were measured using a Hall effect device and a standard four-point probe. Magnetization characteristics were analyzed by using a magnetic property measurement system. X-ray diffraction analysis reveals that as-grown Ge_{1-x}Mn_x semiconductor thin films are amorphous and are crystallized by annealing. Crystallization temperature of amorphous Ge_{1-x}Mn_x semiconductor thin films varies with Mn concentration. Amorphous Ge_{1-x}Mn_x semiconductor thin films have p-type carriers and the carrier type is not changed during annealing, but the electrical resistivity increases with annealing temperature. Magnetization characteristics show that the as-grown amorphous Ge_{1-x}Mn_x thin films are ferromagnetic and the Curie temperatures are around 130K. Curie temperature and saturation magnetization of annealed Ge_{1-x}Mn_x thin films increase with annealing temperature. Magnetization behavior and X-ray analysis implies that formation of ferromagnetic Ge₂Mn₃ phase causes the change of magnetic and electrical properties of annealed Ge_{1-x}Mn_x semiconductor thin films.

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PD07

Magnetic Properties of Self-organized InMnAs Nanodots

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Epitaxial-grown InAs quantum dots have attracted lots of interests because of their controllable morphology and self-assembling ability [1]. Recently, Mn-doped InAs quantum dots grown by MBE have been reported to have a room-temperature ferromagnetism [2]. However the magnetic properties of InMnAs nanodots, whose morphology can be well controlled by growth condition, still need further investigation.

In the present work, In_{0.9}Mn_xAs (x=0.12-0.40) nanodots with a maximum height at 5nm-50nm were grown on (001) semi-insulating GaAs substrates by MBE with a substrate temperature (T_s) at 350-400°C. The surface reconstruction of the samples during growth was monitored in situ with the reflecton high-energy electron diffraction (RHEED). The RHEED pattern changed from a 2×4 streaky pattern for high-temperature GaAs buffer to a 1×1 spotty pattern for InMnAs nanodots. Surface morphology was investigated by both AFM (Fig. 1) and FE-SEM.

Magnetic properties were measured by a DC-SQUID magnetometer. For most of the samples, two Curie temperatures are detected from the M-T curves. According to the Stranski-Krastanov growth mode, the two magnetic phase transitions are considered as the Curie temperature of 2D growth mode (T_{2D}) and 3D growth mode (T_{3D}), respectively (shown in Fig. 2). T_{2D} is found to be quite independent on Mn doping and surface morphology, and it is about 45K. The stableness of T_{2D} can be explained with the limit of dissolving for Mn in epitaxial-grown InAs. For the samples with enough Mn doping, T_{3D} is also quite stable (about 310K). However when Mn doping is as few as 20%, T_{3D} can decrease to 260K.

AFM and SEM images indicate that T₂ is the key to the morphology. At relative lower T_s, the average size of the nanodots is smaller and the density is higher. In this case, the M-T relation is similar to that of thin film. And at relative higher T_s, the average size is much larger, and the average distance between dots are much larger. In this case, the M-T relation shows a spin-glass-like behavior.



Fig. 1. AFM image of sample 2.

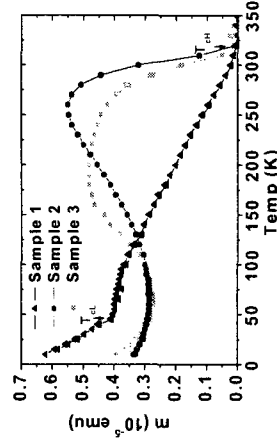


Fig. 2. M-T curves of three samples with different morphologies.

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