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Effect of High Annealing Temperature on Magnetoresistance under Oxygen Atmosphere to Mn-doped Ge

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Recently, the large magnetoresistance (*MR*) has been reported, which ascribed spin-dependent scattering to carriers hopping between the nanoscale ferromagnetic clusters (NFC) based on the magnetization of the original and final clusters [1,2]. In the case of diluted magnetic semiconductors (DMSs) Mn- doped Ge, *MR* was enhanced by NFC such as pure Mn, $Mn_{11}Ge_8$ or $MnGe_2$ *etc.*, which can be formed when samples were thermally annealed or under nature grown [1-4].

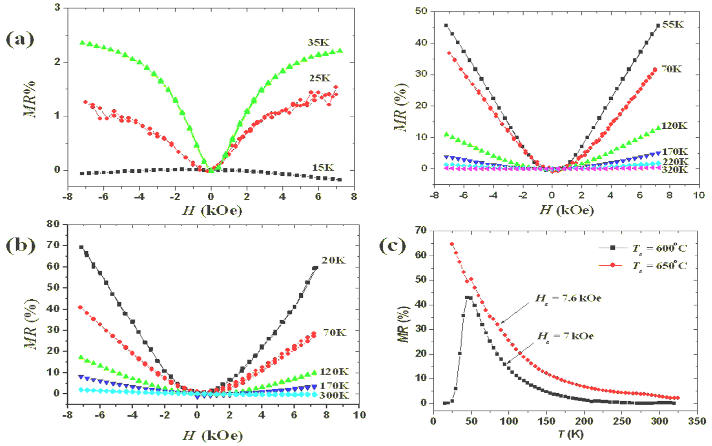

Fig. 1. *MR* responds at selected temperature of 1.38% Mn- doped Ge: (a) *MR* of samples with T_a = 600°C, (b) MR of samples with T_a= 650°C, and (c) temperature dependence *MR* of post-annealed samples at 600°C and 650°C.

In this work, we report on the enhanced *MR* of Mn-doped Ge by annealing under oxygen at high temperature (T_a). The negative MR is showed negligibly for as-grown samples (less than 0.17% at 20K) which are consistent with the uniform composition and the non-local ferromagnetism [5]. In contrast, a large MR was usually found at low temperature in the disorder or inhomogeneous semiconductor due to orbital effect and/or spin effect [5]. After thermal annealing under oxygen at 600°C for one hour, *MR* was changed from small negative value at low temperature to large positive value at high temperature. Annealed at 650°C for one hour, *MR* almost showed large positive value. The "transition" point in temperature dependence of *MR* around 45K was ascribed to interact between NFC of Mn_3O_4 with DMSs ferromagnetic matrix. The Mn_3O_4 clusters may be generated by reaction of interstitial Mn (Mn_I) with oxygen when samples were annealed. The passivation of MnI has been also reported for Mn-doped GaAs when it was annealed under oxygen, but no information about mechanism related to Mn oxide was reported [6].

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AT06

Room-temperature Ferromagnetic Property in MnTe Semiconductor thin Film Grown by Molecular Beam Epitaxy

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Among the 3d transition metal binary compounds, MnTe is a particularly interesting material because of its marked magnetic and electronic behaviour [1,2]. MnTe layers of high crystalline quality were successfully grown on Si(111) and Al_2O_3(0001) substrates by molecular beam epitaxy (MBE). Under tellurium-rich condition and the substrate temperature around 400 °C, a layer thickness of 700 Å with the growth rate of 1.1 Å/s could be easily obtained. We have investigated the structure, magnetic and transport properties of MnTe layers by using x-ray diffraction (XRD), superconducting quantum interference device (SQUID) magnetometry, physical properties measurement system (PPMS), and x-ray photoelectron spectroscopy (XPS). Characterization of MnTe layers on Si (111) and Al_2O_3(0001) substrates by X-ray diffraction (XRD) revealed a hexagonal structure of polycrystalline growth for MnTe/Si(111) and epitaxial growth for MnTe/Al_2O_3(0001), respectively. Investigation of magnetic properties of MnTe thin films showed anomalies unlike antiferromagnetic bulk MnTe materials. The temperature dependence of the magnetization data taken in zero-field-cooling (ZFC) and field-cooling (FC) conditions exhibits sharp magnetic transitions at around 50 K in polycrystalline thin film. On the other hand, the epitaxial thin film showed only one blurred magnetic transition at around 50 K. These magnetic transitions are attributable to a magneto-elastic coupling in the thin films. Magnetization measurements indicate ferromagnetic behavior with hysteresis loops at 5 and 300 K both polycrystalline and epitaxial MnTe thin films. The coercivity values (H_c) at 5 and 300 K are H_c= 55 and 44 Oe in the polycrystalline film and H_c= 27 and 5 Oe in the epitaxial film, respectively. In electro-transport measurements, the temperature dependence of resistivity revealed a noticeable semiconducting behaviors and showed a conduction via variable range hopping (VRH) at low temperature. From XPS results, we assume that the origin of ferromagnetism in samples may be due to the breaking of superexchange antiferromagnetic correlations between Mn spin moments arising from Tellurium vacancies.

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