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Weak ferromagnetism in semiconductor MnTe thin films grown by molecular beam epitaxy

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Abstract: MnTe layers of high crystalline quality were successfully grown on Si(111) and Al2O3(0001) substrates by molecular beam epitaxy (MBE). Under tellurium-rich condition with the substrate temperature around 400 , a layer thickness of 700 Å as the growth rate of 1.1 Å/s could be easily obtained. We have investigated the structural, 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 Al2O3(0001) substrates by X-ray diffraction (XRD) revealed a hexagonal structure of polycrystal for MnTe/Si(111) and epitaxial growth for MnTe/Al2O3(0001). Investigation of magnetic and transport properties of MnTe thin films showed anomalies unlike antiferromagnetic powder MnTe materials. The temperature dependence of the magnetization data taken in zero-field-cooling (ZFC) and field-cooling (FC) conditions indicates three magnetic transitions at around 21, 49, and 210 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. The great irreversibility between ZFC and FC magnetization is shown in both polycrystalline and epitaxial growth thin films. Magnetization measurements indicate ferromagnetic behavior with hysteresis loops at 5 and 300 K both polycrystalline and epitaxial MnTe thin films. In electro-transport measurements, the temperature dependence of resistivity revealed a noticeable semiconducting behaviors and showed conduction via variable range hopping (VRH) at low temperature. Magnetoresistance (MR) property at 2 and 100 K showed positive MR response (nearly parabolic) centered at H = 0. The core level binding energy and valence band spectra of MnTe thin films showed that the compounds are the ionic in character than related metal compounds.