MBE Growth, Magnetic and Structural Properties of $Sn_{1-x}Mn_xTe$ Layers

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$Sn_{1-x}Mn_xTe$ is a IV-VI diluted magnetic (semimagnetic) semiconductor exhibiting ferromagnetic, spin glass or paramagnetic properties depending on conducting hole concentration and Mn content [1]. In bulk crystals grown by the Brigdman method the thermodynamic solubility limit of Mn in rock-salt SnTe crystals is x=0.12. The corresponding ferromagnetic Curie temperatureisabout 20 K for optimal hole doping [1]. In the early studies of thin $Sn_{1-x}Mn_xTe$ layers grown by molecular beam epitaxy (MBE) the single crystal rock-salt phase was observed only for quite low Mn content $x\leq0.04$[2].Recent renewal of interest in SnTe-based semiconductor alloys is related to the discovery of topological crystalline insulator states at (001) and (111) surfaces of bulk SnTe crystals [3], with a variety of new theoretical proposals concerning ultrathin SnTe layers and SnTe-based materials with nonzero magnetization [4]. In this work, we study the growth of $Sn_{1-x}Mn_xTe$ layers by MBE under various stoichiometry regimes known to determine carrier (hole) concentration and magnetic properties.

$Sn_{1-x}Mn_xTe$ monocrystalline layers of the thickness of about 0.7 micron were grown by MBE on cleaved BaF_2 (111) substrate using SnTe, Mn and Te effusion cells to vary both Mn content (x=0, 0.015, 0.03, 0.05, 0.09) and crystal stoichiometry controlled by additional Te flux. The X-ray diffraction analysis of the layers ($x\leq0.05$) revealed the expected (111) growth direction and the rock-salt crystal structure with the lattice parameter following the Vegard law. For the layer with the highest Mn content (x=0.09) additional diffraction peaks were found and assigned to inclusion of $Sn_{1-x}Mn_xTe$ with (001) crystal orientation and inclusions of antiferromagnetic MnTe. Magnetic properties of the layers were examined by electron paramagnetic resonance (EPR) studies carried out over temperature region T=3-300 K. The layers grown under close to stoichiometry regime revealed Curie-Weiss paramagnetic properties with the EPR angular dependence indicating only a weak dipolar anisotropy effects. For $Sn_{1-x}Mn_xTe$ layers grown under excess tellurium regime a ferromagnetic transition was observed at helium temperatures.

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