Ferromagnetic transition in $Ge_{1-x}Mn_xTe$ semiconductor layers

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$Ge_{1-x}Mn_xTe$ is a magnetic semiconductor exhibiting ferromagnetic transition driven by the RKKY indirect exchange interaction *via* very high ($p=10^{19}$-10^{21} cm^{-3}) conducting hole concentration. In this material a ferroelectric structural transition from the rock salt (high temperature) to the rhombohedral (low temperature, ferroelectric) phase also takes place. So far $Ge_{1-x}Mn_xTe$ alloys were mostly studied in the form of quenched bulk polycrystals and sputtered thin layers of crystal quality not sufficient for the experimental analysis of the interplay of structural and ferromagnetic transitions. In this work, we discuss magnetic and structural properties of epitaxial monocrystalline layers of $Ge_{1-x}Mn_xTe$.

The layers of $Ge_{1-x}Mn_xTe$ ($x<0.2$) were grown on BaF_2 (111) substrates by molecular beam epitaxy technique employing effusion cells for GeTe, Mn and Te. X-ray diffraction (XRD) analysis performed at room temperature revealed the monocrystalline (111)-oriented rhombohedral (ferroelectric) crystal structure of $Ge_{1-x}Mn_xTe$ layers in the entire range of Mn content studied. The content of Mn ions in $Ge_{1-x}Mn_xTe$ layers was determined from the energy dispersive X-ray fluorescence analysis and confirmed by the analysis of the Vegard law in XRD measurements. The examination of the magnetic properties of the layers carried out in a broad temperature range T=1.9-200 K by superconducting SQUID magnetometry and ferromagnetic resonance (FMR) measurements revealed the ferromagnetic transition with the Curie temperature in the range 10-100 K depending on the Mn content and the hole concentration. Contrary to polycrystalline GeMnTe layers, we observe (both in FMR and SQUID measurements) in GeMnTe monocrystalline layers an easy magnetization axis directed along normal to the layer plane. This experimental observation is discussed in terms of both crystal lattice distortion and thermal strain effects present in the layers.

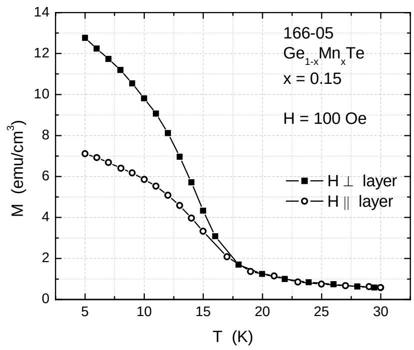

Fig. 1. Temperature dependence of magnetization for $Ge_{1-x}Mn_xTe$ (x=0.15) layer (thickness 0.25 μm).

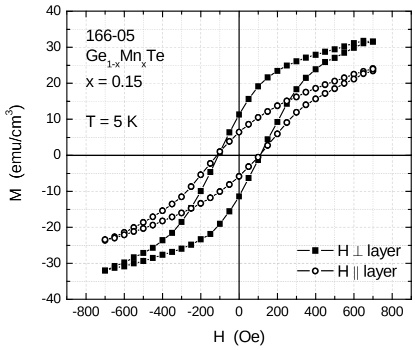

Fig. 2. Magnetic hysteresis loops of $Ge_{1-x}Mn_xTe$ (x=0.15) layer.

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