Magnetic phase diagram of topological $Sn_{1-x}Mn_xTe$ layers

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$Sn_{1-x}Mn_xTe$ is a IV-VI semimagnetic (diluted magnetic) semiconductor known to exhibit both the properties of topological crystalline insulators and carrier-induced ferromagnetism. We carried out an extensive technological program of molecular beam epitaxial growth of $Sn_{1-x}Mn_xTe$ layers and summarize our findings in the form of magnetic phase diagram for ferromagnetic transition temperature and magnetic anisotropy constants for layers grown under different MBE conditions. The $Sn_{1-x}Mn_xTe$ were grown under varying stoichiometry regimes on various substrates: BaF_2, with either (111) or (001) orientation, and GaAs/CdTe (001). Magnetization measurements were carried out with a superconducting quantum interference device (SQUID). For magnetic anisotropy studies we applied ferromagnetic resonance (FMR) technique. We found that most of $Sn_{1-x}Mn_xTe$ layers studied with concentration of conducting holes ($p \leq 3x10^{20}cm^{-3}$) undergo a ferromagnetic transition with T_C below 10 K. In particular, by growing the $Sn_{1-x}Mn_xTe$ layer with nominal concentration 4.5 at.% under various Te flux, we demonstrated the control between paramagnetic and ferromagnetic properties. The magnetic anisotropy observed directly in magnetization measurements as well as in the angular dependence of the FMR resonance field confirmed the easy magnetization axis in the plane of the layer as expected for ferromagnetic layers with dominant shape (dipolar) anisotropy and smaller crystal direction dependent contributions of single ion anisotropy. The largest magnetic anisotropy field of the order of 1 kOe is observed for (001) oriented layers with factor of two reduction for (111)- oriented layers on BaF_2.

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