Mid-infrared Optical Properties of Epitaxial $Sn_{1-x}Mn_xTe$ Layers (x≈0.04)

Jakub Polaczyński [1,2], Andrzej Witowski [1], Michał Szot [2], Monika Zięba[2] and Tomasz Story[2]

[1] *Faculty of Physics, University of Warsaw, Pasteura 5, 02-093 Warsaw, Poland*
[2] *Institute of Physics, Polish Academy of Sciences, Al. Lotników 32/46, 02-668 Warsaw, Poland*

SnTe, the narrow-gap semiconductor, has recently reattracted scientific attention as it was proved to belong to the new class of materials, called *topological cristalline insulators* [1]. Moreover, it was shown that it's ternary alloy, $Sn_{1-x}Mn_xTe$, exhibits carrier-induced ferromagnetism [2]. Comparing to SnTe, it also has improved thermoelectric properties [3]. Nevertheless, no report concerning optical properties of this alloy was published to date. In this work, we present results of optical studies of $Sn_{1-x}Mn_xTe$ in the mid-infrared region.

The samples under investigation consist of epitaxial layers of $Sn_{1-x}Mn_xTe$ (x≈0.04) deposited on BaF_2 (111) substrate by Molecular Beam Epitaxy. They exhibit high intrinsic concentration of holes ($p \sim 10^{20}$ cm^{-3}, as established from Hall effect measurements) which can be controlled by changing of the Te flux during the growth. The thickness of layers is about 1 μm. Room temperature reflectivity and transmission spectra between 200 meV and 800 meV were measured using Bruker 113v Fourier Transform Infrared spectrometer.

As in the case of SnTe, optical properties of $Sn_{1-x}Mn_xTe$ are determined by the presence of free carriers. The reflectivity spectra are dominated by plasma effects, which are also responsible for the low-energy cut-off in trasmission. The behaviour of the high-energetic part of the transmission spectra is given by Burstein-shifted interband transitions. Applying the formalism of the free-carrier dynamic dielectric function (Drude model) allows us to theoretically describe the reflectivity spectra, taking also into account the geometry of the samples. Combined with the Hall concentration, this model enables us to determine the hole-effective mass (m^*=0.2-0.3 m_0 for the lowest and highest concentration, respectively), which is higher than the values obtained for SnTe ($m^* \sim$ 0.1-0.2 m_0 in the studied concentration range) from similar measurements [4]. The shape of the fundamental absorption edge can be described only if Fermi-Dirac distribution is taken into account (Burstein effect). Uncertainity of the estimated value of the Fermi level does not allow to determine the energy gap.

The dependence of the refractive index of $Sn_{1-x}Mn_xTe$ on energy was established from the interference fringes. Because of the proximity of inter-band transitions, this dependence cannot be explained if only free-carrier effects are included into dielectric function. For this reason, we extend our model by the bound-carrier part, based on the modified Sellmeier law. Thus determined energy of the band-to-band transition exhibits good agreement with the values observed in the transmission spectra.

[1] T. H. Hsieh *et al.*, *Nat. Comm.* **3**, 982 (2012)
[2] A. J. Nadolny *et al., J. Mag. And Mag. Mat.* **248,** 134 (2002)
[3] G. Tan *et al*., *J. Am. Chem. Soc.* **137**, 11501 (2015)
[4] R. F. Bis and J. R. Dixon, *Phys. Rev. B* **2**, 1004 (1970)