Magnetoconductivity of a Resonant Terahertz Detector Based on a Mercury Cadmium Telluride Epitaxial Layer

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Although mercury cadmium telluride has been studied for more than 50 years now, only recently there were fabricated crystals of enough quality to reveal fascinating phenomena like observation of Dirac fermions in bulk crystals [1] and topological transitions in quantum wells [2].

Parameters of HgCdTe-based structures may be tuned by doping, temperature, pressure or magnetic field. Sensitivity of the band structure to magnetic field B makes HgCdTe a good candidate for a tunable detector. Compared with another B-tunable THz detector, i.e., a low-doped InSb, its effective mass is even smaller. This leads both to an advantage – a strong dependence of resonant transitions energy on magnetic field, and to a disadvantage –a very strong magnetoresistance. Our experience with InSb detectors [3] shows that their strong magnetoresistance has to be taken into account in analysis of their THz response, otherwise the interpretation of experimental results would be incorrect.

In the present paper we studied a magnetoconductivity tensor of a HgCdTe epitaxial layer with cadmium concentration corresponding to a band gap of about 10 meV at 4 K. The sample, supplied with indium contacts in a van der Pauw geometry, was cooled down and Hall effect measurements were carried out at two temperatures – 2 K and 100 K with magnetic field up to 1 T. The calculated conductivity tensor σ was then analyzed with a standard magnetotransport theory assuming a multicarrier conductivity. At 100 K, σ was very well described by mixed electron and hole conductivity. However, at 2 K the considered model did not give such satisfactory results: the main features were reproduced by three carrier types (electrons and two types of holes), but there were visible deviations indicating that the model has to be corrected. Possible directions of the model improvement are taking into account a strong non-parabolicity of this small-gap material and a non-uniformity of the sample.

We examined resonant optical response of the sample at 4 K by measuring transmission of THz radiation of several frequencies emitted by a molecular laser. We found sharp signatures of cyclotron resonance transitions which are clearly visible at B as small as 0.05 T. It proves that a narrow-gap HgCdTe can be used as a resonant THz detector at magnetic fields at which InSb detector shows only non-resonant transitions.

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