FAR-INFRARED MAGNETOSPECTROSCOPY ON
EPITAXIAL ZERO-GAP AND WIDE-GAP
SEMICONDUCTOR LAYER SYSTEMS

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Abstract

Far-infrared magnetotransmission measurements have been performed on
MBE-grown HgTe and CdTe epilayers. The results on the HgTe samples can
be understood by the standard Pidgeon-Brown model for bulk HgTe. For
the CdTe layers, transitions were only observed under illumination by visible
light. The spectra are dominated by the $1s \rightarrow 2p$ transition of the shallow
hydrogen-like impurity. These transitions are persistent with a life time of
the order of magnitude of one second.

1 Introduction

Far-infrared (FIR) spectroscopy is a powerful tool for the investigation of a large
variety of effects in semiconductors. Due to the photon energies between 1 meV
and 25 meV, interband transitions in zero- and small-gap semiconductors can be
investigated as well as cyclotron resonance (intra-band transitions) and impurity
transitions both in shallow and deep impurities [1]. Besides the Fourier spectrometer,
FIR discharge and gas lasers are today widely used.

In this paper, some results gained with the FIR laser system installed at the
Hochmagnetfeldanlage (High Magnetic Field Facility) at the Technische Universität
Braunschweig are presented. The experimental set-up is shown in fig. 1. A CO$_2$
 laser (Edinburgh PL4) pumps a wave-guide gas laser. The FIR beam is modulated
using a mechanical chopper and coupled to the sample chamber by overmoded
brass wave guides. All transmission measurements described in this paper were
performed in Faraday geometry. The sample temperature for most of the measurements is 1.8 K, 4.2 K (LHe) or 77 K (LN2). In one case, the transmission was measured while the sample was slowly warming up. The temperature of the sample was then measured using a calibrated carbon resistor in close contact to the sample. The transmitted signal was measured by an external germanium bolometer or by an external FIR photoconducting detector system (described in [2]). The signal was subsequently processed by standard lock-in technique.

In the case of the wide-gap semiconductor (CdTe; $E_{\text{gap}} = 1.6 \text{ eV}$) under investigation, resonances were visible only after illumination by visible light. The light was coupled in by a Schott glass fiber wave guide.

The magnetic field was either supplied by a 12 Tesla superconducting magnet or a Bitter coil with a nominal peak magnetic field of 18 Tesla.

HgTe and indium-doped CdTe epitaxial layers were grown by a Riber molecular-beam epitaxy (MBE) system at the Universität Würzburg. The HgTe layers were grown along the [111] direction on Cd$_{0.96}$Zn$_{0.04}$Te substrates. The CdTe epilayers were made using the photo-assisted molecular beam epitaxy (PAMBE) method on nominally undoped [100] CdTe substrates with an illumination power density of 25 mW/cm$^2$. The electrical properties of the samples were determined immediately after growth by van der Pauw measurements (table 1 and table 2).

2 Measurements on HgTe-on-CdTe Epilayers

For a long time, the semimetal HgTe is of considerable interest to researchers due to its peculiar electronic properties and its potential technical applications for infrared detectors. FIR magnetospectroscopy turned out to be a particularly powerful instrument for the evaluation of the bandstructure properties of both bulk [3] and, more recently, MBE-grown HgTe [4], since both interband and intraband transi-