Zürcher Hochschule
für Angewandte Wissenschaften

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Hardware-software integration and validation of a compact, time-resolved, optical-pump terahertz-probe spectroscopy system

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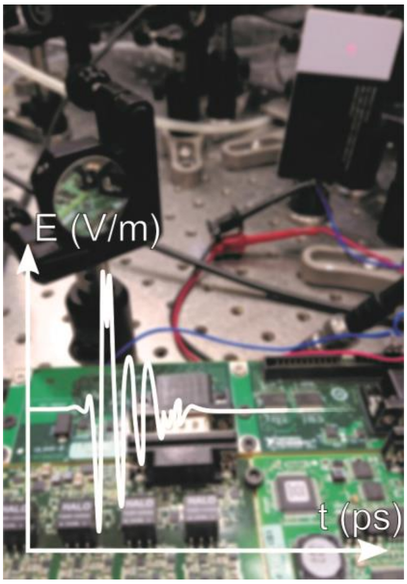
Terahertz (THz) photonics is a fast-growing field with very promising applications in non-destructive material testing, imaging and material identification/spectroscopy. During the last two decades, many different approaches to generate THz waves for research and industrial applications have been suggested. Presently, most commercial and laboratory THz time-domain spectroscopy systems record spectra up to few THz only. The experimental system developed in this thesis, however, can measure frequencies up to 20 THz, as it benefits of the combination of organic crystals (DSTMS) and a compact femtosecond laser used for generation and detection.

The scope of this thesis is the validation of the frequencies, linearity and sample parameter extraction of the basic ultra-broadband THz time-domain spectrometer. In addition, the setup has been extended with an optical-pump option to perform THz characterisation of optically excited semiconductors.

The results show an excellent linearity of the spectrometer, which is a prerequisite for a reliable sample parameter extraction, including the thickness and the complex refractive index. The measured frequencies of narrow water absorption lines are in agreement with literature absorption spectrum, thus successfully validating this spectrometer over the full 20 THz bandwidth with an accuracy of 2.7 GHz. Thickness measurements of samples in reflection geometry enable measurement of samples thinner than 50 µm with a relative error of 1 %. Simultaneous refractive index and thickness measurement of about 0.5 mm thick germanium wafers with an accuracy of 0.1 % is demonstrated in transmission geometry. The conductivity changes of a germanium sample when optically excited in the newly developed optical-pump THz-probe system are clearly observed as the THz transmission changes by more than 50 % in the low THz frequency range.

The performed work demonstrates advanced capabilities of the compact THz time-domain spectroscopy system implemented as a bench setup at the ZHAW with potential further improvements in detection electronics optimisation in order to minimise the laser noise influences and considerably improve the systems signal-to-noise ratio. In addition, further development of data extraction algorithms will allow for better accuracy in thickness and material parameter extraction, which is interesting for various research and industrial applications.



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