Photonic-electronic terahertz frequency comb spectroscopy

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Abstract—We report a new approach to the terahertz frequency comb spectroscopy (TFCS) based on nonlinear mixing of a photonically generated terahertz pulse train with a continuous wave signal from an electronic synthesizer. Unlike the standard TFCS technique, this approach does not require a complex double laser system. It still retains the advantages of TFCS—high spectral resolution and wide bandwidth.

Keywords—THz spectroscopy; frequency comb

Terahertz frequency comb spectroscopy (TFCS) is a modern technique with a high potential for practical applications. TFCS is based on using photonically generated terahertz pulse trains whose Fourier spectrum is a series of harmonics of the pulse repetition frequency, i.e., a frequency comb. TFCS combines the merits of the two widely used spectroscopic techniques—broadbandness of the terahertz time-domain spectroscopy (THz-TDS) and high resolution of the frequency-domain spectroscopy with narrow tunable continuous-wave terahertz radiation (CW-THz spectroscopy). A typical TFCS spectrometer contains dual (pump and probe) femtosecond lasers with stabilized individual repetition rates and the frequency offset between them [1,2,3].

We propose and implement an alternative approach to realization of TFCS. In this approach, an electromagnetic terahertz comb is generated photonically—with use of a single femtosecond laser and photoconductive antenna (PCA), see Fig.1. The comb, transmitted through a sample, is heterodyned to the UHF frequency range via nonlinear mixing in a superlattice (SL) with a sinusoidal EHF signal from a frequency synthesizer [4]. The UHF replica of the terahertz comb is observed with an RF spectrum analyzer. Unlike the standard TFCS technique, this approach does not require a complex dual laser system. At the same time, it retains all the advantages of TFCS.

To evaluate the spectroscopic potential of the proposed technique, we measured the absorption spectrum of CF₃H. For this purpose, we filled a quartz cell (a 30-mm diameter and 150-mm length) with CF₃H. The entrance and exit windows of the cell are tilted at the Brewster angle. The cell was placed between the TPX lenses (Fig. 1). The results are shown in Fig. 2. The spectral resolution of our technique is defined by the repetition rate of the laser, i.e., 100 MHz, and exceeds the resolution of standard THz-TDs by the order of magnitude.

Fig. 1. Experimental setup.

Fig. 2. CF₃H absorption line.

REFERENCES