Experimental setup for holographic multiwavelength phase imaging

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Abstract—We demonstrate experimental set-up allowing to measure terahertz (THz) pulse field spatial distribution at some distance behind the object in time-domain layout. Feature of the set-up is that we scan the diffraction field of an object placed in the THz wide collimated beam producing direct registration of temporal shapes of pulse at every scan point.

Keywords—THz imaging, time-domain layout, raster scan.

In works on phase imaging scanning, object is usually situated in the THz beam waist [1]. Such scan allows to record spectral amplitude-phase characteristics of the object, but requires precise placement of the object into the beam waste. Terahertz pulse time domain holography (THz PTDH) [2] introduced several years ago shows itself as perfect method for overall-object phase retrieval technique. In comparison with beam waist scanning technique it allows to reconstruct object spectral properties by registering spatial-temporal distribution of the THz field at some distance behind the object, without the need of its accurate placement. After THz registration would be realized with fast-IR camera, allowing to record the whole wavefront at one shot, this method would approach real-time operation, until its implemented, we use raster-scanning of terahertz wavefront with a pinhole.

In the optical setup (Fig. 1), laser beam of femtosecond laser FL using beam splitter BS is divided into the probe beam and the pump beam. Probe beam by mirror system is directed onto photoconductive antenna. The pump beam passes through delay line, goes into the THz generator, consisting of InAs crystal, placed in a strong (2.4 T) magnetic field. Produced THz radiation is collimated and then is focused by terahertz lens in a photoconductive antenna for time-domain detection. Mechanical chopper modulates THz beam to allow signal to noise increase by using lock-in amplifier. Using the delay, we change THz and optical pulse overlap on the antenna, thus converting THz electric field into output voltage. Measured voltage is then numerically processed to reconstruct THz wavefront.

In our experiments to obtain images of the spatial-temporal distribution of the terahertz field, we used the raster scanning method with small aperture in wide collimated beam thus measuring the temporal shape of THz electric field E(t) for each point of wavefront. The aperture is set after the object at distance of 5 mm, and is moved by the controlled linear XY translator. Scan area is $32\times32$ points, scan size is $24\times24$ mm, aperture size is $1.5 \times 1.5$ mm. After THz diffracted field registration, we need to reconstruct the object by any of previously described methods [2].

In conclusion, we demonstrated experimental setup for holographic multiwavelength phase imaging with possibility to change parameters for different phase objects.

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Fig. 1. The experimental set-up. FL- femtosecond laser (pulse duration $\tau=20$ fs, $\lambda=810$ nm, repetition rate 70 MHz, $W_{p}=300$ mW), BS- beam splitter, M1-M3- mirrors, L- lens, D- aperture, $L_{a}$- lens for terahertz optics, DL-delay line, OMM-opto-mechanical modulator, A- photoconductive antenna.

