Continuous Wave Sub-Terahertz Lensless Holographic Reflective Imaging

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***Abstract*—We propose a simple setup involving standard commercially available sub-terahertz electronic source and camera in reflection layout. The setup is designed for imaging amplitude and phase objects. The construction allows for quick installation and potentially almost-realtime operation. Initial reconstruction results demonstrate resolution of about three wavelengths.**

I. Introduction

TERAHERTZ (THz) waves are non-destructive and non-ionizing, and development of compact turn-key THz systems is of high-demand nowadays. Photonic THz setups, despite providing exceptional apparatus for fine spectroscopic and imaging applications [1], require the use of ultrafast lasers; even though the majority of commercial setups are based on fiber laser systems, they still require proper conditions and maintenance for long-tern operation. With the development of THz electronic sources (e.g. IMPATT diodes) and array detectors, sub-THz frequency band, that is particularly interesting for biomedical applications, has became more approachable.

Several application-driven imaging systems based on IMPATT diode and array detector technology have been proposed [2], [3], however in most cases they also require precise alightment of the numerous quasi optical elements and can not provide both high resolution and stand-off operation simultaneously.

In this study, we design and implement a compact continuous wave (CW) sub-THz holographic setup, that works in reflection regime. The whole setup, apart from transmitter and detector comprises only two quasi optical elements, and can be relatively quickly implemented and adjusted to experimental needs. We demonstrate the reconstruction of an amplitude reflecting object, however, the use of similar setup for imaging of liquids and phase relief is also highly feasible.

II. Experimental setup and results

TeraSense 292 GHz IMPATT diode source and TeraSense Tera-1024 camera were used as the key components of the setup. For beam collimation, off-axis parabolic mirror was used. Collimated beam illuminated the object under study at an angle of about 30 degrees, and the zero order reflection was directed into the camera with a flat golden mirror. Scattered light from the object also reached the camera sensor plane, carrying higher spatial frequencies and acting as an object wave in the holographic setup. To assure the interference, zero order beam was attenuated to the extent of the order of the scattered wave. Aluminium plate plate perforated with 3 mm holes was used as an imaged object. CW THz holographic reconstructions have previously been demonstrated in a number of works [4]–[7], that employed various THz sources: gas laser, quantum cascade laser, electronic multiplier, and free electron laser. As in most works, angular spectrum method was used for reconstruction here.

The setup for CW sub-THz lensless imaging in reflection geometry and the results of the reconstruction of binary amplitude object are shown in figure 1.

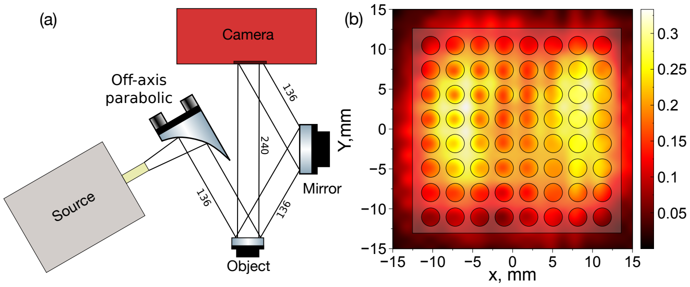

Fig. 1. (a) Lensless imaging setup, (b) Reconstruction of the object (part of the object is shown semi-transparent on top of the reconstructed sctructure).

Object features, separated by about 3.33 mm from each other are clearly recovered at a major part of the object area.

III. Conclusion

Lensless holographic sub-THz CW setup was used to image the amplitude object in reflection geometry. Numerical reconstruction of the object demonstrates spatial resolution $\approx 3\lambda$, which makes this kind of setups a perspective approach for development of future compact THz imaging solutions.

IV. Acknowledgements

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