THz-wave tomographic imaging: An approach via CT reconstruction from limited projections

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***Abstract*—We constructed a preliminary tomographic imaging system using CW THz-source based on the concept of CT reconstruction with the projection angles limited. We demonstrate the feasibility using the paper phantom.**

I. Introduction

Although THz-wave has high transmissivity for some kinds of material, substantially-oblique incidence is subject to refraction on the surface because the refractive index is different from unity. Thus, it is difficult to obtain a complete set of projections over 180 degrees, which can be acquired in x-ray CT. This research considers acquisition of depth information from the viewpoint of CT reconstruction with the projection angles limited. For this purpose we constructed a preliminary THz-imaging system and investigated the feasibility using a sheaf of paper or a post-it available at a store as a sample.

II. Method

The schematic diagram of imaging system is shown in Fig. 1. The CW beam from THz-wave source (Virginia Diodes, Inc. 540 GHz) was amplitude-modulated by 30-kHz rectangular wave for lock-in detection. The thin beam collimated impinged on a sample placed on positioning devices. Here, the beam-diameter was held constant to about 0.5 mm in the sample range. The transmitted signal detected was, after amplification by a pre-amplifier, sent into a lock-in amplifier with the modulation wave from the function generator, and then fed to a PC through a DAQ card.

A post-it (66 sheets, about 6.5 mm in thickness) available at a store was used with three Chinese characters written therein as a sample, where they mean a Japanese abbreviation of "Faculty of Engineering, Yamagata University": the 1st, 2nd , and 3rd characters were written in an ordinary pencil on the 2nd, 33rd, and 66th sheets from the top, respectively. Initially, it was put so that the top surface was perpendicular to the incident beam. Then, it was scanned in the translational and rotational motion as follows:

In translation, the sample was raster-scanned in the rectangular range of 29×30 mm^2 at the translational step of 1 mm in the plane perpendicular to the incident beam using the *xy*-stages.

In rotation, it was rotated at the step of 1 degree using the rotational stage placed on the *xy*-stages so that the rotational axis was perpendicular to one and parallel to the other axes of the *xy*-stages. Here, we define the oblique angle θ as an angle between the vectors in the opposite direction of beam propagation and normal to the surface.

The translation and the rotation were alternated while changing oblique angle θ within the range from -30 to 30 degrees. As at each oblique angle the projected image was obtained. We reconstructed the 3-D tomographic image using the 61 2-D images. For reconstruction, we straightforwardly employed the filtered back-projection method with Shepp-Logan filter after some data-processing in spite of limited projections [1].

III. Result

Fig. 2 (a) shows the projected image at $\theta = 0$ degree. Fig.2 (b) to (d) show the cross-sectional image in the reconstructed 3-D image at the level corresponding to the 2nd, 33rd, and 66th sheets from the top sheet, respectively. These characters are satisfactorily reconstructed, although some artifacts form the other characters are observed.

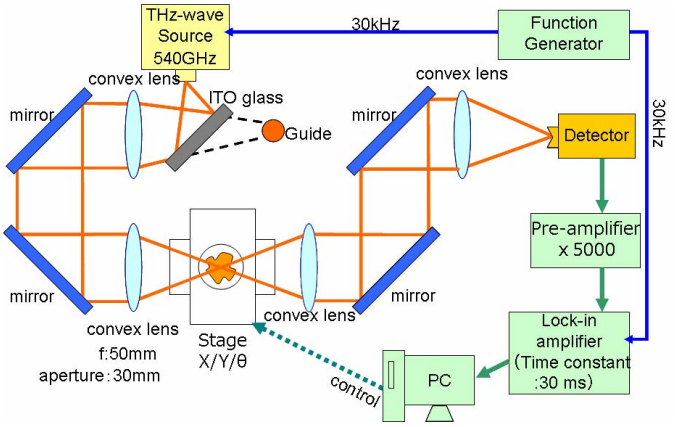
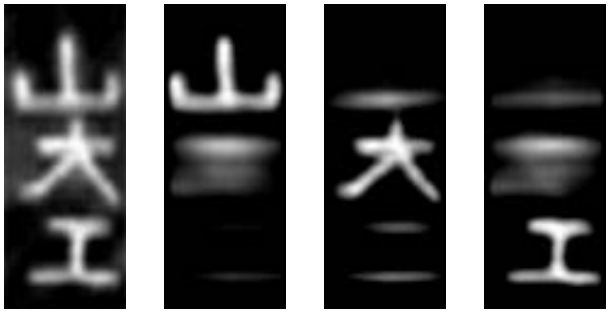


Fig.1 Schematic of the THz-imaging system



(a) (b) (c) (d)

Fig.2 (a) projection image at $\theta = 0$ degree, (b) cross-section at the level corresponding to the 2nd sheet, (c) the 33rd sheet, and (d) the 66th sheet

References

[1] C. Kak and M. Slanery, "Principles of Computerized Tomographic Imaging," New York: IEEE Press, 1987.

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