Terahertz inspection of dielectric and composite materials using Synthetic Aperture Focusing Technique

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***Abstract*— Nondestructive evaluation using terahertz frequency electromagnetic waves is becoming more and more popular. Similar operating principle allows the use of inverse algorithms derived from the ultrasonic technique (UT). In this paper algorithm and results of synthetic aperture focusing technique (SAFT) applied to pulsed terahertz inspection of dielectric and composite objects are presented. The results of both measurements and FDTD simulations are processed by implemented SAFT algorithm.**

Keywords—Nondestructive evaluation; THz frequency electromagnetic waves; synthetic aperture focusing technique

I. Introduction and Experiment Description

Pulsed terahertz inspection is utilized in dielectric materials, aerospace and wind turbines composites inspection [1]. Synthetic Aperture Focusing Technique (SAFT) is common method in ultrasonic testing (UT) [2]-[3]. During SAFT processing transducer's focal point acts as virtual source (VS) of spherical wavefront propagating in upper and lower direction in a limited angle (Fig. 1a). Such virtual source is scanned over examined object in order to obtain B-scan signal. Next, the SAFT processing is done by summing of appropriately delayed signals from each VS position (in time domain) or by back propagation of signals in Fourier space (in frequency domain). SAFT was also utilized in terahertz imaging, but mostly for conducting phantoms placed in free space [4].

SAFT processing was verified using three models: point scatterers in free space and in dielectric slab, real life defects of composite materials (delaminations and lack of adhesive). The measurements were carried out using pulsed terahertz spectroscope TRay4000 in the reflection setup.

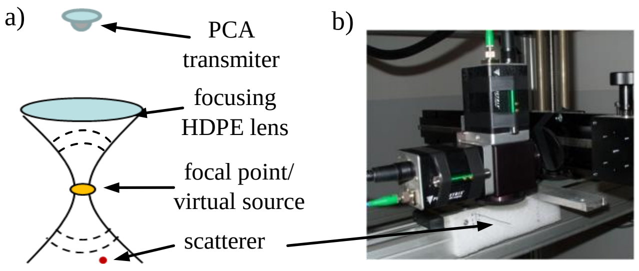

Figure 1: Focusing geometry of SAFT with virtual source (a). Photo of measurement setup in experiment with wire targets in free space (b).

II. Results and Conclusions

The results of wire targets (point scatterers in measurement plane) inspection are presented in Fig. 2. The responses of objects in SAFT processed B-scan signal are similar regardless to their distance to focal plane of the transducer. The results of dielectric slab and composite materials terahertz inspection and their processing using modified SAFT will be presented in full paper. SAFT will be applied in order to extend the depth of focus and increase probability of detection of hidden defects.

Pulsed terahertz examination combined with synthetic aperture focusing seems to be promising composite materials inspection technique.

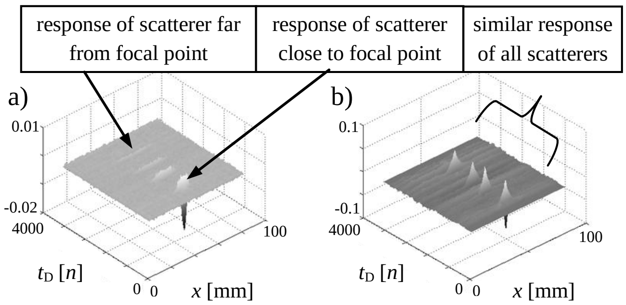

Figure 2: Results of terahertz measurements of wire targets in free space: a) B-scan signal before SAFT application, b) B-scan signal after SAFT processing.

References

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