3D Terahertz Imaging for the Control of Aeronautics Composite Multilayered Structures

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***Abstract*—We present results from a TDS imaging system for non-destructive evaluation of aeronautics composite materials, like glass fiber laminate and sandwich structures. Time-of-flight information from reflection measurements allows for 3D reconstruction of test sample volumes. Clear identification and spatial positioning of defects like delamination and foreign inclusion is possible.**

I. Introduction And Background

Within the scope of the DOTNAC project[1], the potential of THz imaging and analysis for the non-destructive investigation of composite materials from the aeronautics industry should be evaluated.

A special TDS system was designed for the project; it utilizes ECOPS for fast data acquisition and is fully fiber-integrated to enable in-the-field use and remote sensor heads with six meters position range from the operational base unit. Two reference systems were available to explore the THz detectability of various defects under optimal conditions and validate the results of the fiber-integrated device. Furthermore, data from established NDT tools such as X-ray, ultrasound, and infrared techniques were available for comparison.

II. Results

Over seventy samples have been fabricated and examined during the project (see Fig. 1b where XY and XZ images are provided). These include solid glass fiber laminates as well as GFRP A- and C-sandwiches, and additionally CFPR panels. Defects are foreign objects, debonds and delaminations, impact damage and water contamination for the GFRP samples and impact damage or coating misprocesses for the CFRP panels.

TDS imaging facilitates detection of most kinds of defects and enables a quasi-3D reconstruction of samples volumes through the depth information that the time-of-flight parameter in reflection measurements provides. The detectability of the defects critically depends on the evaluation methodology of the time-domain trace, such as delay, frequency or peak-to-peak amplitude, which has to be chosen for optimal contrast depending on the defect type. Additionally, the sample material strongly influences the probability of detection. For example, it turns out that a Rohacell sandwich core is much harder to penetrate for broadband THz radiation than a honeycomb structure. For coatings on CFRP panels, THz TDS in reflection provides a convenient way of identifying errors during the coating process since they commonly manifest themselves through variations of the optical thickness of the layer.

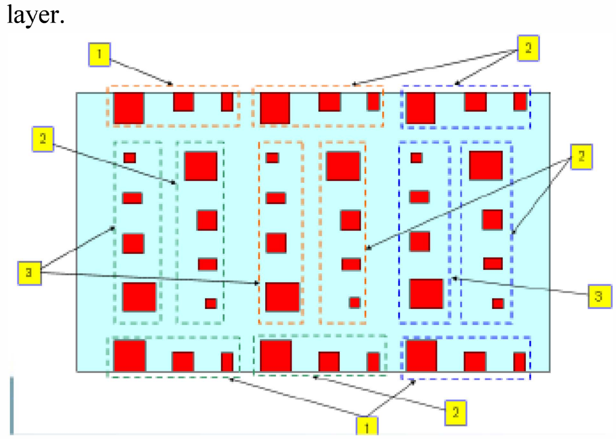

Figure 1a: Scheme of a calibration object to be tested with the THz NDT tool. In the above figure, the material can be fiberglass or quartz laminates, or sandwich structures. The red areas represent different types and sizes of inclusions.

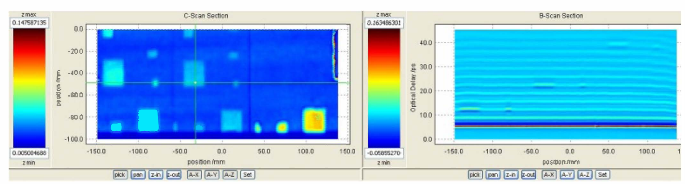

Figure 1b: Example of images obtained with time-of-flight parameter and extraction of thickness positioning by c-scan procedure.

III. Conclusion

Glass-fiber reinforced plastic (GFRP) laminate and sandwich samples and CFRP panels with defects of various types, sizes and depth position within the samples were tested and analyzed by THz imaging. The general detectability is demonstrated; however the choice of contrast parameters in the data evaluation is crucial to reveal defects.

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References

[1] http://www.dotnac-project.eu/

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