Material Scanner in the Lower THz

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***Abstract*—The aim of the project is the development of an imaging system for material characterizations. Measurements with real aperture have been conducted at the frequency range between 75 GHz – 220 GHz in amplitude and phase and from 75 GHz – 260 GHz in amplitude. To increase the measurement time a synthetic aperture (SAR) method will be tested. The following paper presents the actually project results.**

I. Introduction And Background

Sensor concepts in the lower THz range can offer an alternative to common systems like x-ray or optical sensors. On the one hand, examinations with x-ray are common, but due to the safety regulations the implementation in the food industry is very difficult or not allowed. On the other hand optical sensors are cheap but offers only limited information about the internal structure of the device under test (DUT). The frequency range of interest covers the region between the classic radar band and communication bands (under 40 GHz) and the Infrared band (over 1THz). It offers better transmission measurement capabilities than the IR or optical frequency range, and cause of the wavelength and the better antenna focusing advantages about classical radar systems [1].

II. Measurement System

The first goal of the project was the development of a measurement system from 75 GHz up to 500 GHz. The range between 75 GHz and 260 GHz has been realized. It is possible to measure the frequencies between 75 GHz and 260 GHz in amplitude and from 75 GHz to 220 GHz in amplitude and phase. A linear motor concept was developed to scan a 2D area with a third axes to move the antenna in z-direction. The scan region is about 320 mm by 320 mm in x-y direction and 290 mm in z direction [2].

The second goal of the project is to build an imaging system for transmission and reflection measurements to analyse materials e.g. the contamination of food inside packaged products. In the future the implementation of this system in a production line is placed. Due to the high band velocities it is necessary to increase the scan time. A synthetic aperture algorithm is under development to release a faster image acquisition and better image quality.

The antennas mounted in the system are dielectric waveguide tips. The advantage of this kind is the flexibility. So it is possible to change very fast between the transmission and reflection configuration. Another advantage is the low loss at higher frequencies compared to standard rigid waveguides. This is possible thus the electromagnetic wave is guided mostly around the dielectric waveguide [3].

III. Measurements

The first sample is a jelly cookie measured in amplitude and phase at 77 GHz (Fig.1). The cookie in the middle and the right one was contaminated with a 2 mm by 2 mm piece of glass and plastic. Thru the inhomogeneity of the jelly inside the cookies we observe strong fluctuation in the amplitude. Cause due these fluctuation we can not detect the impurities in the amplitude picture. The measurement of the phase allows us to visualize the delay between different materials and so we can easily detect the two impurities.

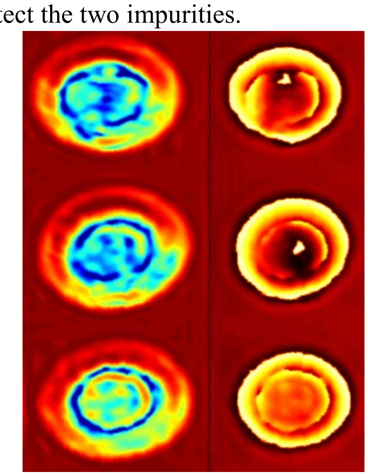

Fig.1 Jelly cookie left: measured in amplitude;
rightt: measured in phase at 77 GHz with impurities.

The next picture shows the reconstruction of a test structure in the near field with a SAR algorithm in one dimension. The green line represents the raw dataset and the red line the result

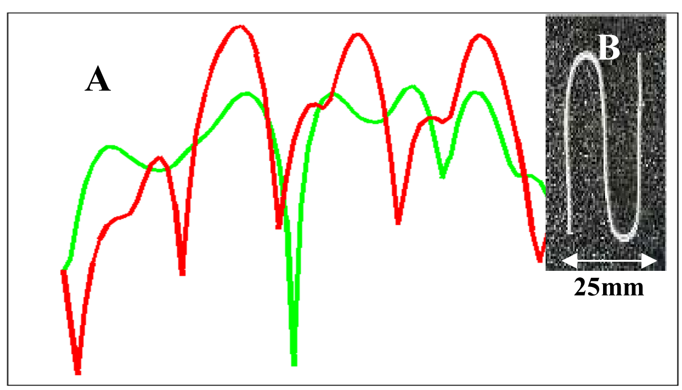

Fig.2 A: SAR reconstruction; B: Test structure

of the reconstruction. It becomes clear that the three wires in Fig 2-B represent the three peaks in the reconstructed profile. In the next step we measured a Dataset of an aluminum plate,

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shown in Fig 3. We measured in monostatic configuration an

Fig.3: Aluminum plate (20 x 18) mm

area about 50 mm times 50 mm. The antenna distance to the device under test (DUT) was about 20 mm. The center frequency was 90 GHz with a bandwidth of 20 GHz and a frequency step size of 200 MHz. Figure 4 shows the raw data and figures 5 the same dataset after the processing.

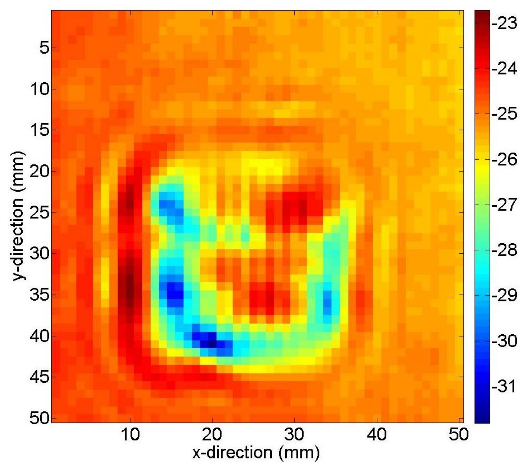

Fig.4 : Raw data obtained at 80 GHz. Scale in dB

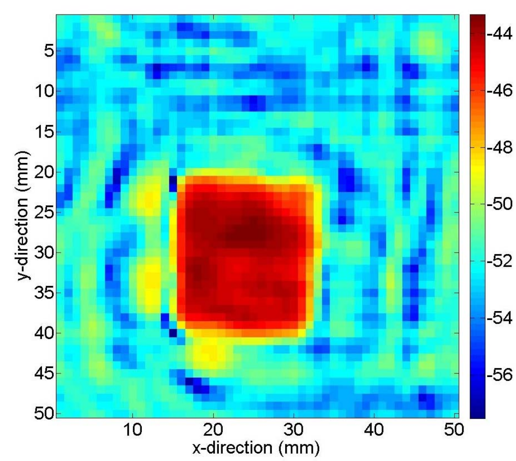

Fig.5 : Result of the processed image. Scale in dB

The basic idea of the reconstruction process is the concept of matched filtering often used in most radar applications [4]. We define a replica function that represents the system transfer function. For the first experiments the antenna characteristic is assumed as a Gaussian function with a predefined sigma value. After the match filtering we performed a fourier transform to suppress unwanted signal components.

In Figure 5 the time-gated reconstructed image is shown. The axes are scaled in millimeters and so we can compare the measured result with the geometry of the real object. The measured geometry fits well the real dimensions.

IV. Summary and Outlook

The configuration of a scanner, which operates in the millimetre range, has been shown. Recapitulating, a vector measurement system can be accomplished up to 220 GHz while the measurement of the amplitude alone can be done up to 260 GHz. In this frequency region the phase of the signal is vital for the detection of several pollutions (especially non – metallic pollutions) inside food probes. The synthetic aperture techniques known in air- or spaceborne radar applications can be used for the inspection in industry production lines. Our implementation of a 1D and 2D reconstruction algorithm based on matched filtering represents the possibilities of such a system.

In the next steps we will examine the real antenna characteristic to improve the results of the presented algorithm. Furthermore we expand the frequency range of our system up to 600 GHz. To decrease our measurement time a new scan configuration based on prism design will be tested till 2009.

V. Acknowledgement

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