Immersion in refractive index matching liquid for 2D and 3D terahertz imaging

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Abstract : We investigate the possibility to limit refraction effect at interfaces between a sample and a liquid medium to improve resolution in 2D and 3D terahertz imaging. Indeed, an important part of the terahertz beam is reflected, diffracted and refracted at each interfaces because of refractive index mismatch. We propose to adapt the refractive index of medium around the sample replacing surrounding air by medium with an optimized refractive index and low absorption coefficient. This approach will be developed to recover good dimension for metrology and to improve reconstruction by tomography algorithm.

I. INTRODUCTION

Terahertz imaging as contact-less method can be used to reconstruct complex geometry objects [1, 2]. Among these techniques, some have been specially developed to visualize a complex three-dimensional (3D) shape object. For instance, if the object is composed with a multi-layered structure, THz pulsed imaging is a powerful technique to reveal internal structures of the object by using the time of flight of the reflected THz pulses.

However, for complex pattern like cylinder, different effects appear in terahertz imaging at different angular position of the projection. Lens effect at the center of the projection of a cylinder could be observed whereas a strong diffraction effect is observed fort radial positions. The first effect induces higher pixel values at the center of cylinder. The second effect makes the cylinder larger. These effects induce artifacts in the volume reconstruction and make the cylinder size larger than expected when the tomography algorithm is performed. At interfaces, the refractive index mismatch creates severe refraction effects[3]. Besides, the amplitude value of the measured terahertz radiation by receiver depends on the beam deviation induced by refractive index mismatch, coupled with the absorption properties of the sample. Generally, the media around the sample is air with refractive index of around 1 which is always quite different with the sample refractive index. To limit these effects, we propose the sample to be inserted in a liquid medium with an optimum refractive index.

II. . RESULTS

Terahertz measurements were obtained from time domain spectro imaging apparatus, a TPS 3000 from Teraview, working in transmission mode. The frequency used is 0.2-4 THz. The scanner uses emitter, receiver, lenses and mirrors to focus terahertz beam on one point of the sample.

Then, a Fast Fourier Transform leads to extract the absorbance spectra. We will then compare and extract the shape of sample with and without immersion liquid.

We select liquid paraffin, also known as paraffinum liquidum, which is a very highly refined mineral oil used in cosmetics and for medical purposes. The spectroscopic analysis show a constant value of the refraction index about 1.51 associated with a very low extinction coefficient for all the bandwidth under investigation. For the test sample, we used a small polymer cone with a thickness about 1mm. and refraction index equal to 1.52

In *Figure 1*, we show the comparison between false color imaging and a picture of our cone. We cropped and superposed images in order to evaluate the difference in dimension between visible and THz images. Moreover, we compared two images, one of a sample in the air and one with the same sample immerged in liquid paraffin. The value of each pixel is corresponding to the absorbance at 1.8THz. On the left, we show sample within few ml of paraffin liquid and 1.8 THz absorbance in the air, on the top, and in paraffin in the bottom right. On the right, the comparison between in air and in paraffin imaging shows that the apparent thickness is clearly reduced when the sample in immerged in paraffin. A significant thickness difference has been found at 1THz (FWHM 1.3mm in air and 0.9 mm within paraffin).

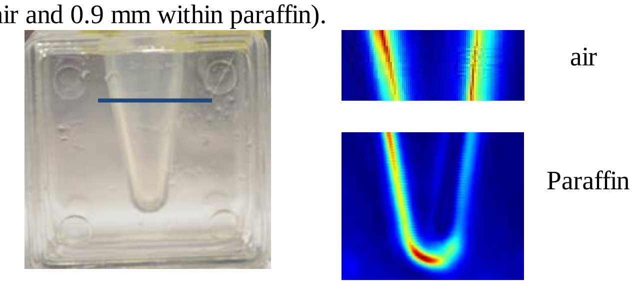

Figure 1 *:* Comparison between photo and 1THz picture of a half cone in air (on the left) and in paraffin on the right,

III. SUMMARY

In this work, we will present the advantage of using index matching medium to extract exact dimensions for metrology purposes. We will also quantify this improvement as a function of the frequency to select the optimal parameters. Tomography reconstruction will also been addressed.

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