Millimetre-wave and Terahertz Imaging Systems with Medical Applications

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ABSTRACT

The properties of terahertz (THz) radiation make it ideal for medical imaging but the difficulty of producing laboratory sources and detectors has meant that it is the last unexplored part of the electromagnetic spectrum. In this paper we report on near-field reflection and absorption measurements of biological and non-biological samples at 0.1THz with a view to developing THz and millimetre-wave imaging schemes. In particular we have investigated the effects of standing waves on such systems and the sensitivity to water content of the sample as a means to extract medically useful information.

I. INTRODUCTION

The measurements reported were taken using an automated scanning system with a waveguide mounted detector fed by either a horn antenna or a bare waveguide. Active near field transmission and reflection images were recorded to obtain structural information on various biological samples as useful models for potential medical applications.

II. NEAR FIELD IMAGING

Shown in Fig. 1 is an image of a slice of bacon obtained by illuminating a thin sample (3-4 millimetres) from the front and scanning with the detector (fed by a bare waveguide) behind the sample. A distinct difference between the larger amounts of terahertz (THz) radiation transmitted through the fatty tissue compared to the lean tissue is seen. This sample was partially dried to reduce its water content. At higher levels of hydration transmission was totally dominated by THz absorption by the water [1] and only a silhouette of the sample was recovered.

Imaging of biological samples using transmission is restricted to thin samples a few millimetres thick because of water absorption. On the other hand, reflection imaging holds more scope for examining surface layers in thicker biological samples.

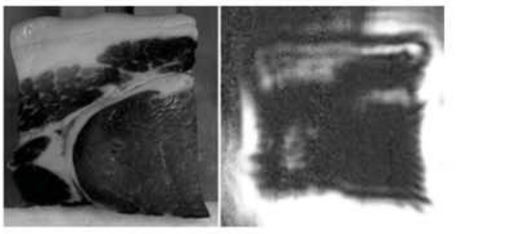

Figure 1: Bacon slice shown in visible, right, and THz Transmission, left.

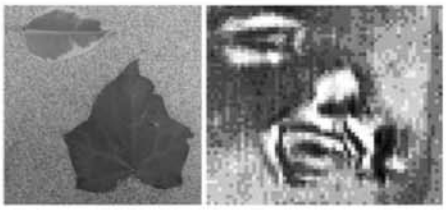

Figure 2: Two leaves shown in visible, right, and THz Reflection, left.

In near field reflection imaging, the sample is scanned behind a small aperture in an absorbing screen illuminated by the source and a horn antenna fed detector records the power reflected. The size of the aperture determines resolution. In Fig. 2 a reflection image of two leaves is shown. In addition to the outline of the samples, some of the internal structure can be seen as the THz radiation penetrates to different layers before reflection back to the detector. However, standing waves do cause fringes to appear on the image.

III. STANDING WAVE EFFECTS

The reflection image of two coins in Fig. 3 shows clear standing wave effects. The coins differ in thickness by $\lambda/4$, resulting in a phase shift in the standing wave pattern, causing one coin to appear bright while the other appears dark. Research conducted in parallel has shown the importance of standing wave effects in THz systems. A detailed electromagnetic description of these effects is being researched with a view to enhance the quality of information obtained using THz reflection [2].

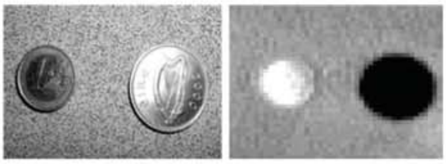

Figure 3: The effect of standing waves are shown clearly here in the reflected image of 2 different coins placed side by side

REFERENCES

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[2] Trappe N., J.A. Murphy, S. Withington, and W. Jellama, 'Gaussian Beam Mode Analysis of standing Waves Between Two Coupled Corrugated Horns',in *IEEE Transactions on Antennas and Propagation*, 53, pp. 1755-1761, (2005)