Terahertz frequency imaging for explosives and weapons detection

A. Valavanis, P. Dean, A. D. Burnett, S. Chowdhury, A. Marshall, A. G. Davies and E. H. Linfield

School of Electronic and Electrical Engineering, University of Leeds, Leeds LS2 9JT
email: a.valavanis@leeds.ac.uk

The terahertz (THz) region of the electromagnetic spectrum lies between microwave and infrared frequencies, and has many potential benefits for security imaging. In particular, terahertz radiation can provide spectral signatures of explosive compounds, illicit drugs and metallic objects, whilst passing through many common packaging and clothing materials with little attenuation. The relatively short wavelength also allows high-resolution imaging of features smaller than 100 μm. We have developed high power ($>$ 50 mW) and frequency-tunable sources operating in the 1–5 THz spectral range, and used these in two demonstrations of terahertz imaging:

Spectroscopic diffuse-reflectance imaging: We have shown that a common explosive (PETN) can be distinguished from a simple sugar (lactose monohydrate) at THz frequencies (Fig. 1(a)).[1] We are also able to detect signatures of powdered solids at a 1.5 m distance by measuring the back-scattered radiation (Fig. 1(b)). This technique offers several advantages over the state of the art. Firstly, thick and/or highly-absorbing samples can be probed, unlike the case of transmission imaging. Secondly, there is no need for precise detector alignment, unlike specular-reflection imaging. Furthermore, we have undertaken measurements through smooth containers, with no deterioration in signal.

Self-mixing imaging: We have removed the need for any external radiation detector by coupling reflected radiation from an object back into the laser cavity.[2] This interference-sensing technique has allowed us to demonstrate high-resolution imaging and sensing at distances in excess of 7 m, and to obtain height-sensing of concealed objects (Fig. 1(c)).

Our two demonstrations illustrate the potential of THz imaging technology as a potential 'fieldable' compact system, and we are now seeking industrial partners to develop our research into demonstrator systems for targeted applications.

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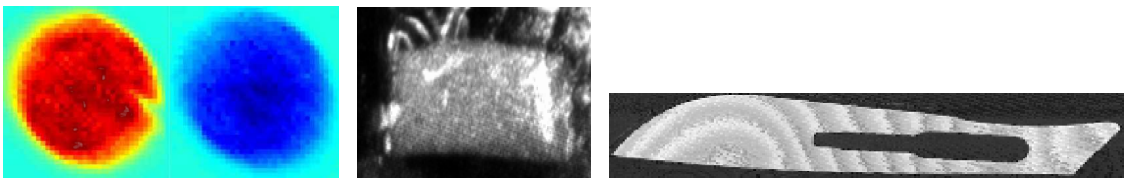
[1] P. Dean et al., *Opt. Exp.* **17**, 20631 (2009)

[2] P. Dean et al., *Opt. Lett.* **36**, 2587 (2011)



(a) (b) (c)

Figure 1: (a) Difference-frequency images at 3.05 and 3.24 THz illustrating contrast between PETN high-explosive and lactose monohydrate [left and right, respectively]. (b) Diffuse-reflectance image at 2.8 THz revealing a bag of powdered PTFE concealed within a visually-opaque envelope. (c) A 2.6 THz self-mixing image of a concealed scalpel blade. Contours in the image reveal the surface-height.