Detection of concealed weapons and characterisation of crystalline powders using terahertz quantum cascade lasers

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Terahertz (THz)-frequency radiation (located between the microwave and infrared parts of the electromagnetic spectrum) offers many potential benefits for security sensing. In particular, it propagates through many common packaging materials, and excites material-specific resonances in crystalline compounds.[1] However, THz sources are typically too large, expensive or low-powered for many applications. We present two imaging techniques that exploit THz quantum cascade lasers (QCLs)—compact semiconductor sources of intense coherent 1–5 THz radiation.

Self-mixing-interferometry imaging of concealed objects: When THz radiation is partially reflected from objects back into a QCL, intra-cavity interference (self-mixing) causes measurable changes in terminal voltage, depending on the amplitude and phase of the reflections.[2] This removes the need for an external detector and allows imaging of metallic objects (Fig. 1a) at up to 21 m round-trip distances. The 3D surface-profile may then be inferred from the phase of the interference.

Spectroscopic diffuse-reflectance imaging: We measure backscattered radiation from powders illuminated by a tuneable 3–3.4 THz QCL. Unlike transmittance imaging, this technique does not require precise detector alignment, and arbitrarily-thick samples may be scanned.[3] Diffuse reflectance measurements reproduce THz spectral features accurately and we show that material-specific resonances may be obtained for a range of materials (Fig. 1b).

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(a) (b)

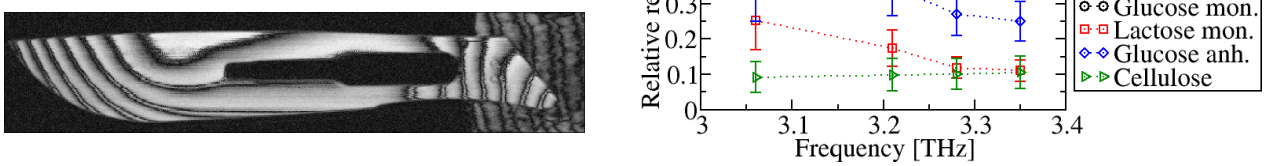

Fig. 1 (a) 2.6 THz self-mixing interferometry image of a scalpel blade at 10.5 m scanning-range. (b) Diffuse-reflectance spectra of a range of powders, at 3–3.4 THz.