Spectroscopic diffuse-reflection imaging at 1.5 m stand-off, using a frequency-switchable terahertz quantum cascade laser

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Numerous potential applications exist for imaging at terahertz (THz) frequencies, within fields including medicine, security, manufacturing quality inspection and chemical sensing. Imaging diffuse reflections from rough or powdered objects offers several advantages over specular-reflection or transmission imaging configurations. Objects of arbitrary thickness may be used, and precise alignment of collection optics is not required, as diffuse reflections spread over a large solid-angle. Furthermore, commonly-used smooth packaging materials have little effect upon diffuse reflection images. Many substances exhibit strong, material-specific spectral responses to THz radiation and spectroscopic THz imaging has been demonstrated in transmission and specular-reflection geometries using both time-domain and frequency-domain techniques. However, spectroscopic imaging of the relatively-weak diffuse reflections is challenging, as a high-intensity multi-frequency THz radiation source is required, along with a sensitive THz detector.

In this work, we demonstrate four-frequency diffuse-reflection imaging using a frequency-switchable THz quantum cascade laser (QCL) as a radiation source. This QCL contains a heterogeneous active region, which may be switched between single-mode emissions at 3.05, 3.21, 3.28 and 3.35 THz by adjusting the bias voltage.