Detection of illicit substances is promising due to strong spectral signatures observed for pure samples of many explosives and drugs.

Opacity of these substances requires reflection or scattering geometry for practical screening applications.

Spectral signatures are modified by scattering physics:
- rough surface scattering
- scattering from granular particles in the media

Approach: combined experimental and theoretical investigation of robust reflection/scattering imaging techniques

(1) Sheet of simulated explosive (MMW image from Kemp [2006], Proc. SPIE 6402)
(2) http://picometrix.com/pico_products/terahertz_app_exam.asp
NEAR-Lab Scattering Models

Volume Scattering (Analytic)
Quasi-Crystalline Approximation

Surface Scattering (Analytic)
Kirchhoff Approximation
Small Perturbation Method

Layered Media
Radiative Transfer

Volume & Surface Scattering (Numeric)
Finite Difference Time Domain (FDTD)
NEAR-Lab Measurement Capability

Pulsed THz Spectrometer

- CW Swept Frequency
- Angle & polarization diversity

Two port s-parameter measurements
0.045 – 0.780 THz

Pulsed THz Imaging System

- 8” x 8” 2D scanning

Funded by NSF MRI, Murdock Foundation, & ONR
Rough Surface Samples

Gold-coated sandpaper samples
P40 grit
P80 grit

80% Lactose (20% PTFE\(^1\)) samples
P40 grit
Smooth

Commercially produced sandpaper used for controlled surface roughness

- Gold-coated samples (perfect conductor)
- Explosive simulants (lactose, L-tartaric acid, sucrose) pellets with surface impressions\(^2\)
- Grit size inversely related to roughness; Gaussian rms height \(h\) and correlation length \(L_c\)

<table>
<thead>
<tr>
<th>Sandpaper(^3)</th>
<th>(h) ((\mu)m)</th>
<th>(L_c) ((\mu)m)</th>
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<tr>
<td>36</td>
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<td>161</td>
</tr>
</tbody>
</table>

(1) PTFE (DuPont Teflon® 7C) powder was used as an inert pressed binder matrix
(2) Simulant samples prepared courtesy of John Wilkinson, as part of NATO SET-124 Research Task Group
(3) Pederson et al., Measurement of Rough Surface Spectroscopy, IEEE Ultrasonics Symposium, 1997
Scattering complicates signature
- Introduces roughness-dependent frequency dependence
- May introduce spurious peaks (without sufficient averaging)

Material peaks present in both spectral and diffuse signatures – provided sufficient SNR exists