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National Nuclear Security Administration

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Sandia National Laboratories

Imaging Spectropolarimetry for Solids Detection

Project # SL13-PETRO/PRISM-PD07

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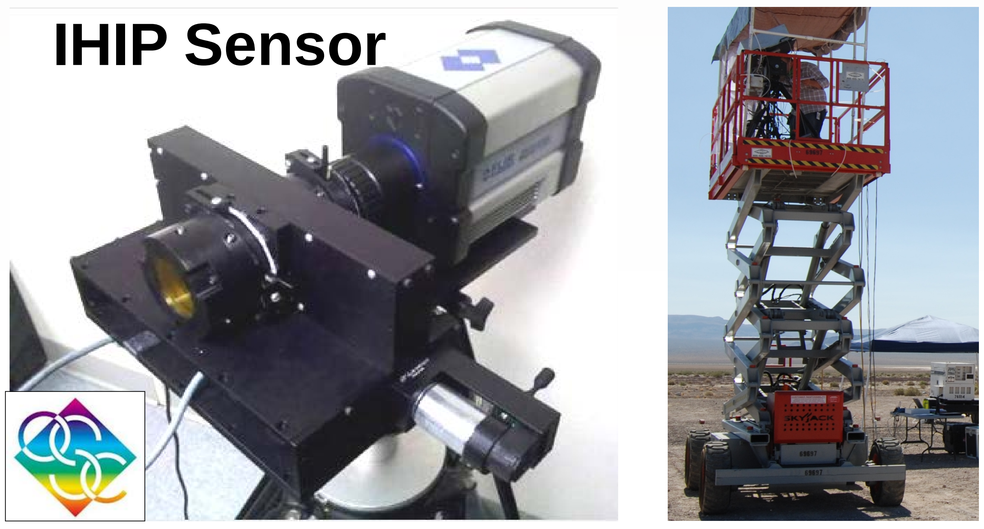
Introduction - Polarimetric data provides information on surface roughness, shape and structure and can be exploited for material characterization and detection.

Objectives

- Assess the value-added utility of infrared imaging spectropolarimetry for solid material characterization and detection.
- Assess the utility of polarized spectra for isolating intrinsic material features.

Method – Polarimetric field measurements

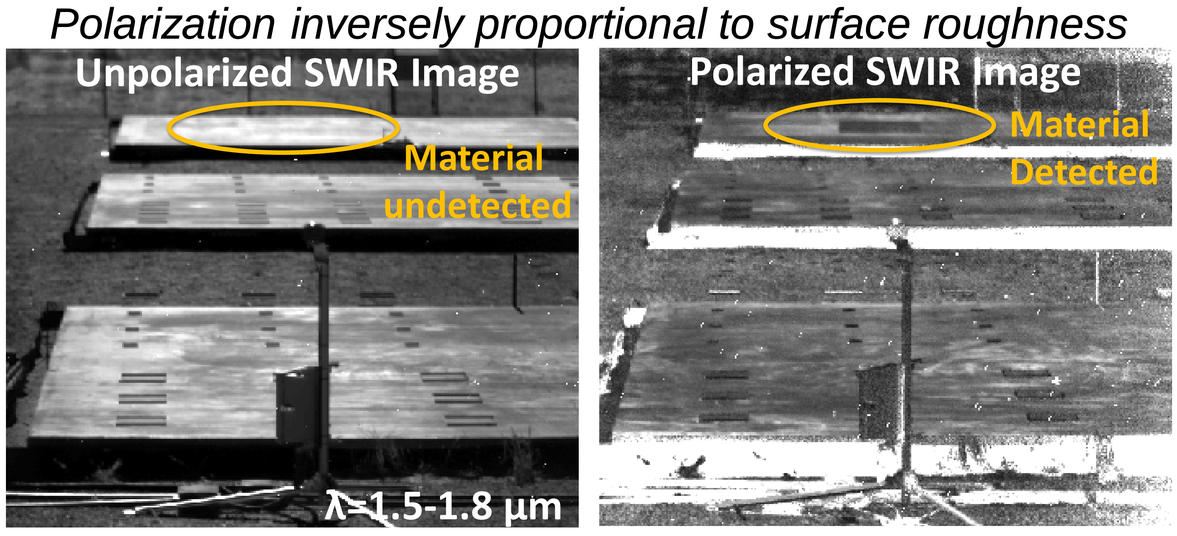
- SWIR/MWIR imaging spectropolarimeter (IHIP) deployed in a June 2012 field test at NNSS.
- Measurements on controlled materials (known particle morphology and size) and materials with varied particle sizes and morphologies.



The IHIP sensor was deployed in June 2012 to collect experimental spectropolarimetric data products on solid materials at NNSS.

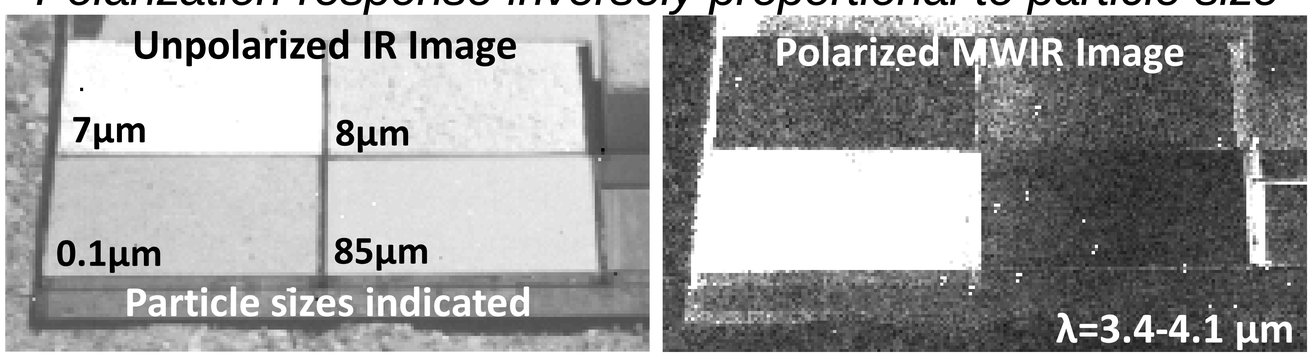
Results - Contamination Detection

Polarization inversely proportional to surface roughness



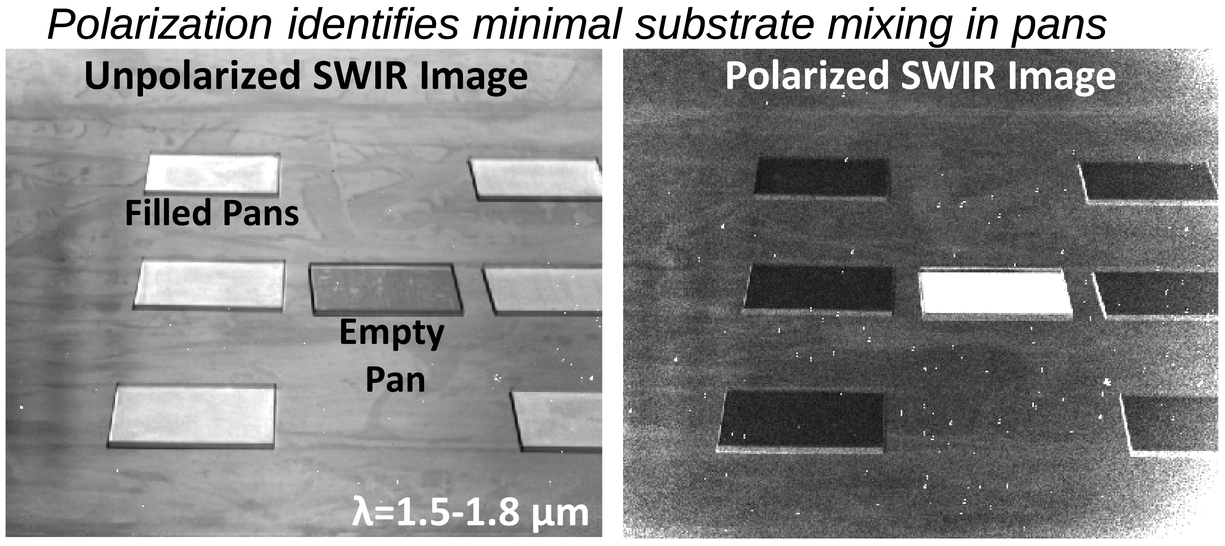
Results - Particle Size Evaluation

Polarization response inversely proportional to particle size



Results – Substrate and Mixing Effects

Polarization identifies minimal substrate mixing in pans



Conclusions

- Preliminary analysis of FY12 field-collected data indicates that polarimetric sensing may assist in solids detection.

Future Work

- Combine modeling with experimental spectropolarimetric data products from the lab and the field.
- Next-Gen spectropolarimeter design.

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U.S. DEPARTMENT OF ENERGY

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Polarimetry for Solids Detection

- Goal is to determine if polarized spectra provide a means to isolate intrinsic spectral absorption features from signatures tied to morphological effects.
  - Specular signatures, which are tied to the complex index of refraction of the material(s), are often polarized.
  - Diffuse signatures, which are affected by bulk material properties, are typically unpolarized.
- Work by others has shown success in using this technique for isolating absorption features for liquids.
  - Can this technique be extended to solids?
- Field demonstration will be essential for validation.

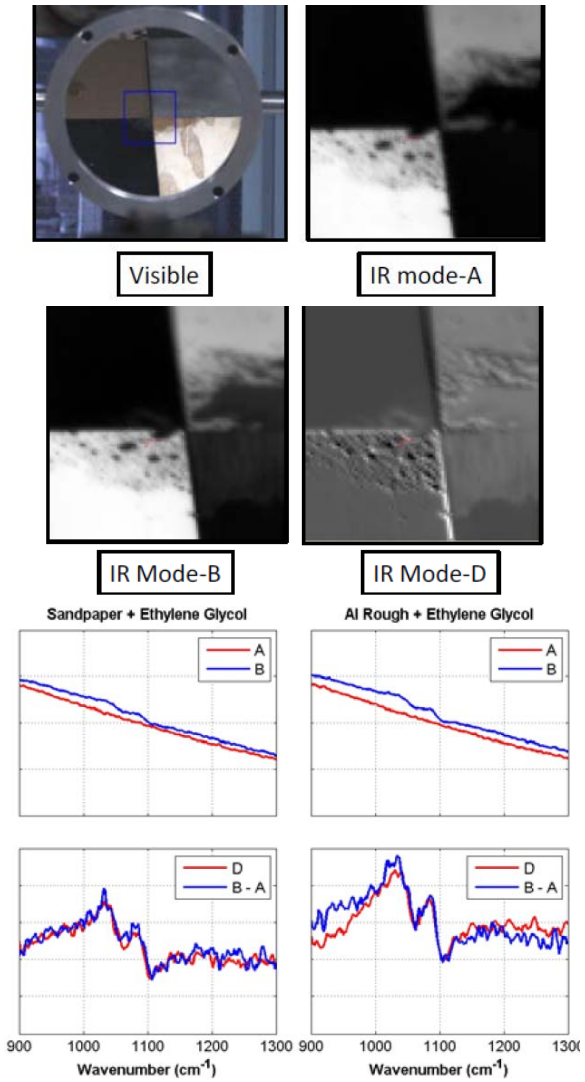
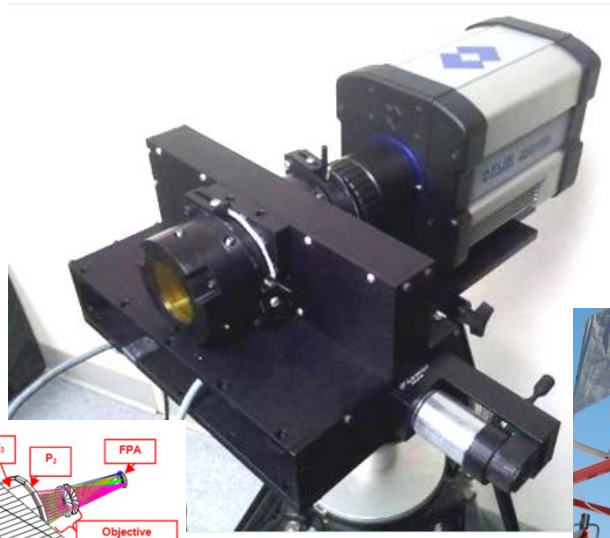
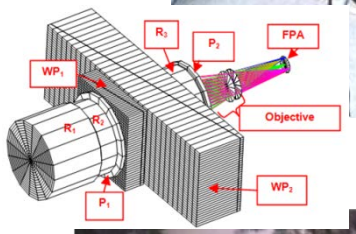


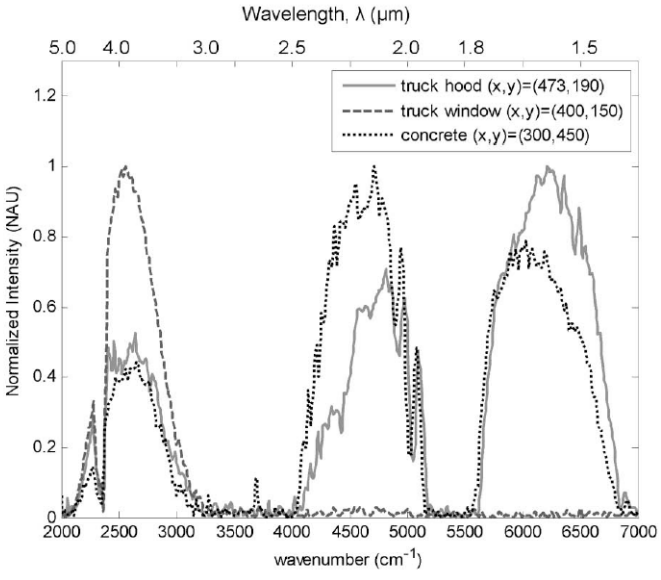
Figure from: J. Theriault et al., "A new imaging FTS for LWIR polarization sensing: principle and application," Imaging and Applied Optics Technical Digest, 2011.

Field Deployable Instrumentation

- Infrared Hyperspectral Imaging Polarimeter (IHIP)
  - λ=1.5-5.0 μm
  - $\Delta\sigma=46 cm^{-1}$ in S_0
  - 10 deg FFOV (512x640 pixels)
  - FTIR-based sensor
  - Measures linear and circular polarization states.



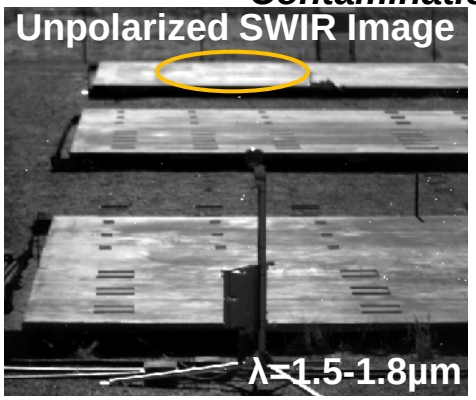


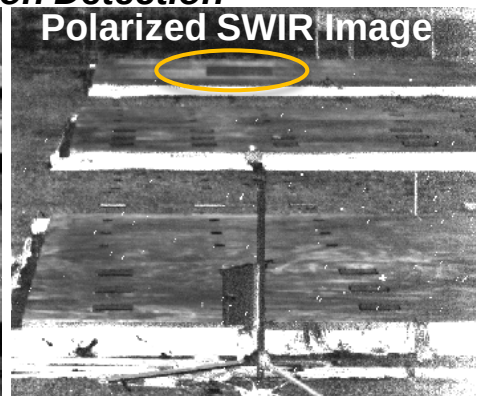


Field Test Results

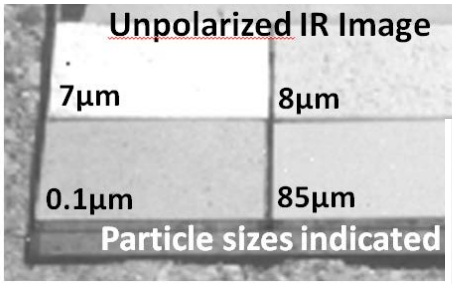
- The IHIP sensor was deployed in June of 2012 at NNSS to collect experimental spectropolarimetric data products on:
  - Materials of controlled particle size and morphology.
  - Materials of variable particle sizes and morphologies.
- Preliminary analysis of the field collected data indicates that polarimetric sensing may assist in solids detection.
- Future work: combine modeling with experimental data products from the lab and the field to provide a comprehensive model of the impact of morphology on polarized spectra.

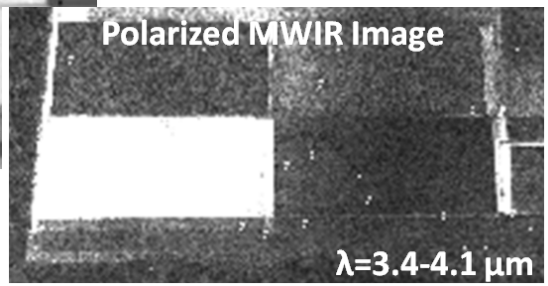
Contamination Detection





Particle Size Evaluation





Spill Characterization