OCCS

Optical Coating Characterization System Design and Qualification

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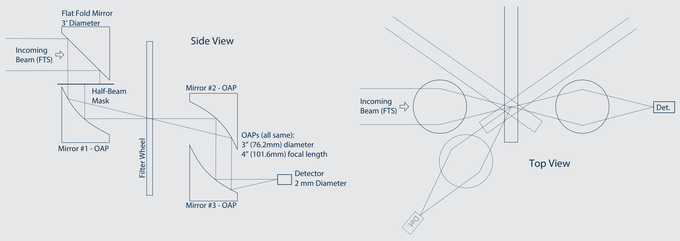
Abstract

The Space Dynamics Laboratory designed and built the optical coating characterization system (OCCS) cryogenic system for spectral (FTIR) measurement of optical transmittance and reflectance at temperatures of 90K and higher. The OCCS is designed to make cryogenic transmittance measurements from normal up to a 50 degree angle-of-incidence, and reflectance measurements between 40 and 50 degrees angle-of-incidence, in a converging optical beam of F/2 or greater. The system can measure up to 20, 1-inch diameter, optical components in a single cold cycle, or fewer larger components with flat surfaces up to 3 inches in diameter. This presentation will provide a brief overview of the OCCS design, followed by test results showing the performance achieved during qualification measurements.

OCCS Design Goals & Optical Schematic



- **Maximum functionality**
  - Transmittance and reflectance
  - Cryogenic measurements (LN_2)
  - Large number of samples
  - Removable filter wheel plate to simplify sample exchange
- **Maximum wavelength coverage**
  - All-reflective design
- **Minimize cost**
  - Commercial OTS optics

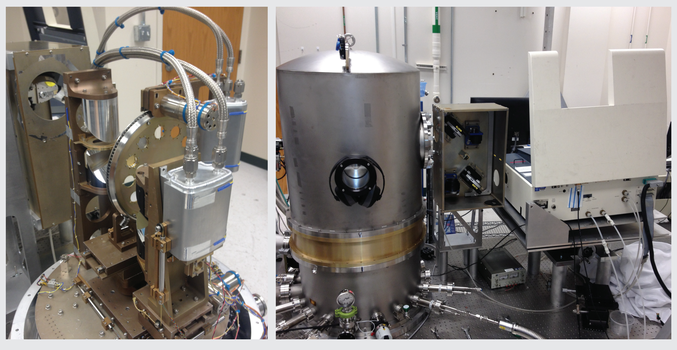
OCCS Motion Functions

7 Motion Axes:

Axis Name	Type	Range of Motion	Description
Filter Wheel Offset	Translation	± 1.5"	Filter horizontal position (moves filter test point, consistent with 3 inch sample size)
Filter Focus	Translation	± 0.5"	Filter location relative to focus point along optical axis
Detector Focus	Translation	± 0.5"	Detector and optics position along optical axis
Detector Offset	Translation	± 0.5"	Detector horizontal position relative to nominal optical axis
Detector Angle	Rotation	0° to 150°	Detector position relative to incoming optical axis
Filter Angle	Rotation	-15° to +55°	Filter angle relative to incident axis (sets test angle of incidence)
Filter Wheel Rotate	Rotation	± 180°	Filter test position (moves filter test point)

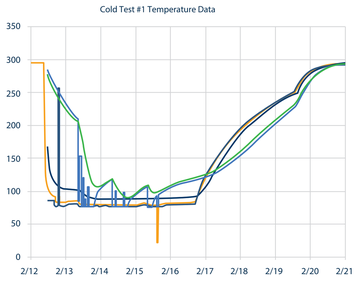
OCCS Photograph

- OCCS fits into existing SDL dewar
- OCCS dewar mounts to optical bench with FTS and interface optics to form complete system



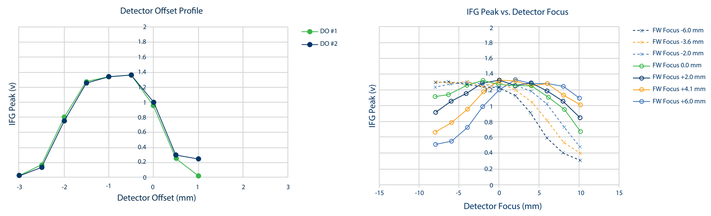
OCCS | Interface Optics Assembly | FTS 60A

Cold Testing



- **System cool-down in approximately 2 days**
- **System warm up in approximately 4 days with ambient heating**
  - Internal heating possible for accelerated warm-up
- **Cryogen hold time**
  - Main tank: >24 h
  - Filter tank: ~6 h
  - Detector: ~8 h

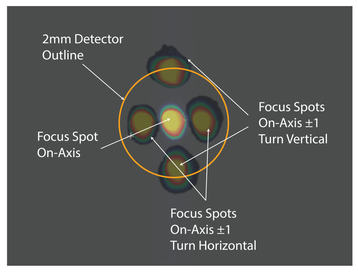
Alignment & Focus



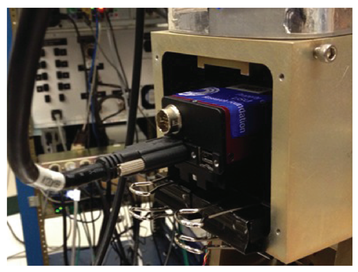
- **Detector offset demonstrates detector centration on optical axis**
- **Detector focus demonstrates depth of focus (detector underfilled)**
  - Predicted depth of focus: 6.2 mm
  - Measured depth of focus: ~6 mm
- **Measurements indicate excellent margin for alignment and focus**

Warm Testing with Si Camera FPA (1)

Investigate tolerance to FTS position alignment error



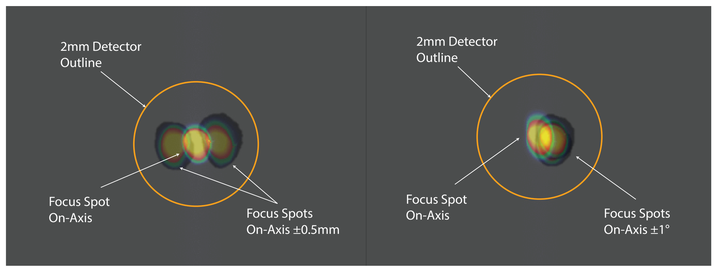
vs. FTS Table Angle



Si FPA on OCCS

Warm Testing with Si Camera FPA (2)

Investigate tolerance to detector alignment error

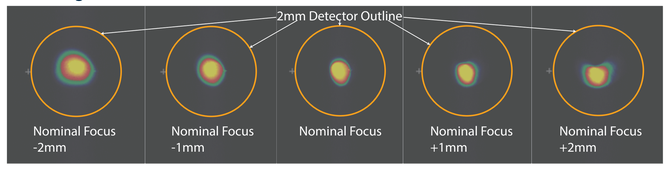


vs. Detector Offset

vs. Detector Angle

Warm Testing with Si Camera FPA (3)

Investigate tolerance to detector focus error

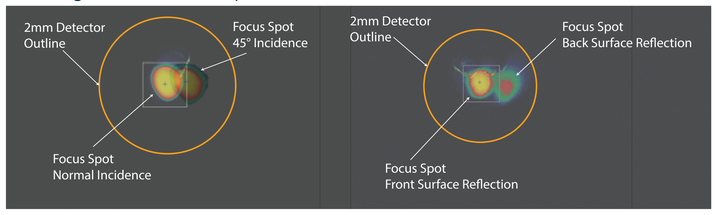


vs. Detector Focus

- **Camera images indicate excellent optical performance margin**
  - Apparent spot size on FPA confirms predicted focus spot (0.7 mm)
  - Small spot size on detector provides good resolution to find detector edges for alignment
  - Detector remains underfilled over more than the adjustment range needed for alignment

Warm Testing with Si Camera FPA (4)

Investigate detector focus performance in reflection



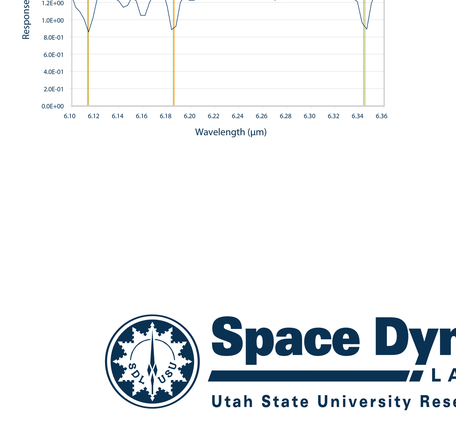
vs. Angle of Incidence

Front Surface vs. Back Surface (45° AOI)

- Reflectance measurements require careful attention to capture reflections from sample front and back surfaces

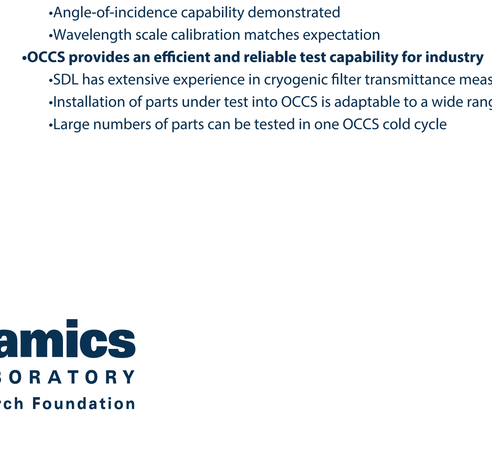
Sapphire Spectra

Sapphire transmittance and reflectance measurements with Si camera FPA show good agreement with prediction



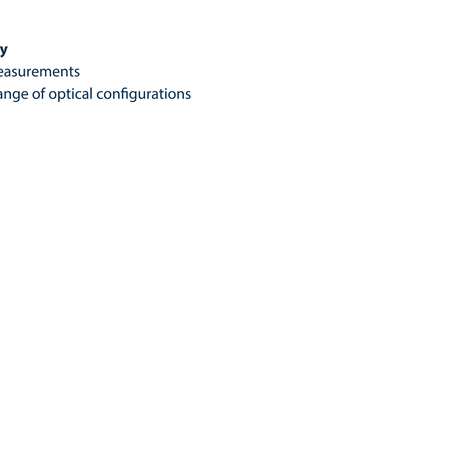
Sapphire Spectra

Sapphire transmittance from Pyroelectric detector



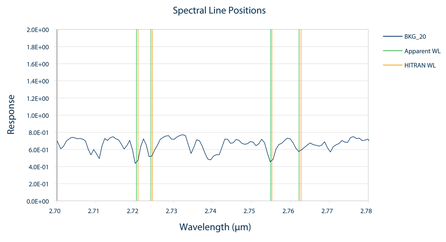
CaF_2 Spectra

Calcium Fluoride transmittance from Pyroelectric detector



OCCS Wavelength Calibration

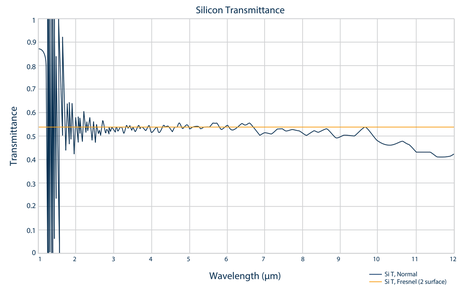
- OCCS measured atmospheric spectral lines match prediction
  - Mean wavelength error: -0.017%



- Mean uncertainty: 0.006%

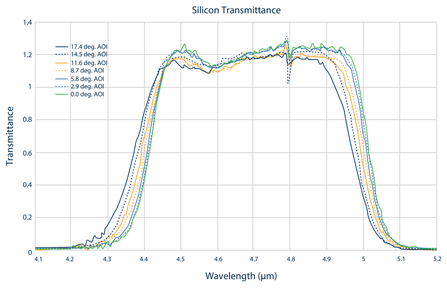
Silicon Spectra

Silicon transmittance from Pyroelectric detector



Transmittance vs Angle of Incidence

Bandpass filter transmittance versus angle of incidence



Summary

- **OCCS capability and performance has been demonstrated**
  - Measured transmittances match prediction
  - Angle-of-incidence capability demonstrated
  - Wavelength scale calibration matches expectation
- **OCCS provides an efficient and reliable test capability for industry**
  - SDL has extensive experience in cryogenic filter transmittance measurements
  - Installation of parts under test into OCCS is adaptable to a wide range of optical configurations
  - Large numbers of parts can be tested in one OCCS cold cycle

Space Dynamics Laboratory
Utah State University Research Foundation