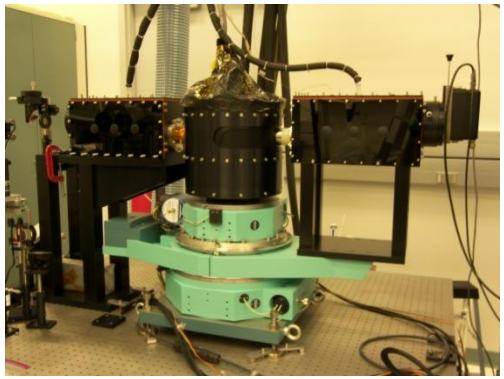
Review

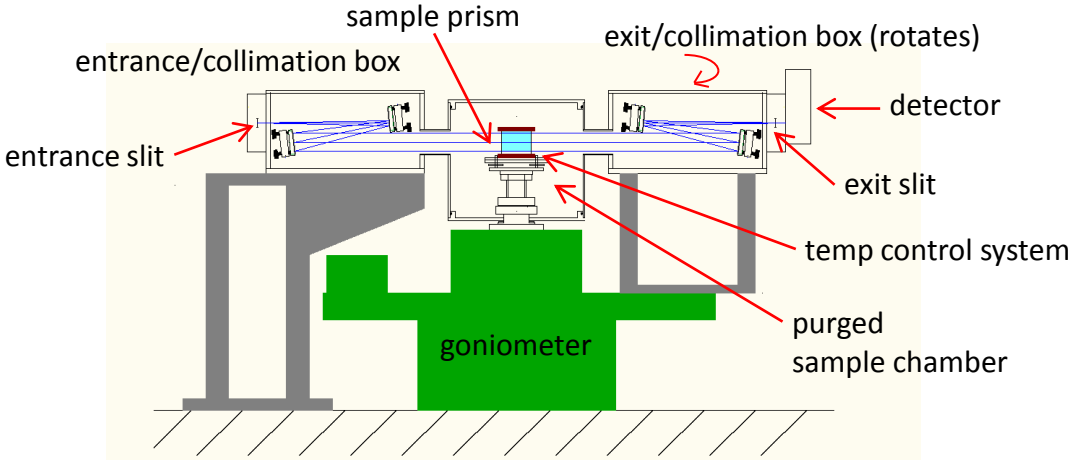
- Existing NIST refractometer instrument “easily” upgradeable to infrared
- At DSS, indicated interest and willingness to respond to community needs
- Received accuracy requirements via SPIE; can exceed them (see next slide)
- SPIE letter to NIST Director likely received; awaiting internal response at Division level
- Next steps – determine best approach to contribute; investigate approach(es) to funding

NIST Precision Refractometry

John Burnett, Eric Benck, Simon Kaplan



Refractometry Facility located
at NIST AML 217/F117



Minimum Deviation Refractometry System – Custom NIST Design

- All reflective optics + purge housing ⇒ operates from vacuum UV (120 mm) into mid-IR.
- Operates normally near room T (20 - 24 °C). Upgradable for cryogenic and other T's.
- Index accuracy for optical materials and fluids:
  - FL=0.5 m, F/# = 10
  - Goniometer angle encoder: absolute angle accuracy ≤ 0.2 arc-sec
  - Feedback temperature control to ≤ 5 mK

  ⇒ Absolute index accuracy

$0.12\ \mu m \le \lambda \le 0.5\ \mu m$	$\sigma \le 1 \times 10^{-6}$
$0.5\ \mu m < \lambda \le 1.5\ \mu m$	$\sigma \le 2 \times 10^{-6}$
$1.5\ \mu m < \lambda \le 5\ \mu m$	$\sigma \le 7 \times 10^{-6}$
$5\ \mu m < \lambda \le 15\ \mu m$	$\sigma \le 20 \times 10^{-6}$

- Thermo-Optic Coefficient of optical materials and fluids:
  - d*n*/d*T* near room T (20 - 24 °C) – accuracy from above.

NIST
National Institute of Standards and Technology

Infrared Reflectance, Transmittance and Emittance Capabilities Overview

Leonard Hanssen,, Simon Kaplan, Jinan Zeng, Sergey Mekhontsev

Measured Quantity	*Reflectance and Transmittance*		*Emittance (ε)*	*All (future – CBS3)*	
Measurement Technique	*Relative Flux Ratio*		*Radiance Comparisons*	*Both*	
	Integrating Sphere	Goniometer & Cryostat	Comparison w/ Blackbody Reference Sources	Vacuum Chamber Environment	
Temperature Range, K (°C)	295 to 475 (20 to 200)	10 to 575 (-265 to 300)	425 to 1175 (150 to 900)	200 to 505 (-75 to 230)	
Spectral Range (μm)	1 to 14	1 to 20	3 to 20	3 to 100	
Temperature Measurement Technique	Contact		Non-contact	Both	
Sample Type	All	Specular	Opaque	Opaque	
Special Features	Custom Absolute Methods for both Specular & Diffuse	Simple Absolute Method	Use Sphere-based Reflectometry	Controlled Cooled Background	Vacuum / Purge
Incidence / Viewing Angle	8°	0° to 80°	0° to 70°	0° to 70°	
Relative Expanded Uncertainty, % (k = 2)	Diffuse 1.5 – 3.0 Specular 0.3	0.3 – 1.0	0.5 – 1.5 for $\varepsilon \geq 0.1$	Goal ≤ 2.0	

IR Refractive Index Support Alternatives

- Standard Reference Materials
- Calibration Service
- Measurement Assurance Program
- Standard Reference Data
- Conducting Round Robins / Intercomparisons
- Organize Workshop(s) as Appropriate

Standard Reference Materials (SRMs)

- What: calibrated samples for purchase
- Effort (cost and time): low - medium level
- Funding source: potential NIST reference materials development support; later SRM sales
- Tasks:
  - Extend Refractometry System into the IR
  - Determine most important materials
  - Acquire high quality groups of samples from major suppliers
  - Characterize materials in batch mode
  - Make calibrated SRMs available for purchase
  - Monitor stability of materials over time

Standard Reference Data (SRD)

- What: calibrated values for select materials
  - From major material suppliers
- Effort (cost and time): medium level
- Funding source: external (Consortium?)
- Tasks:
  - Extend Refractometry System into the IR
  - Determine most important materials
  - Acquire high quality samples from major suppliers
  - Characterize materials
  - Make data available on NIST SRD website

Calibration Services

- What: calibrations of customer samples
- Effort (cost and time): medium - high level
- Funding source:
  - Potential NIST internal to develop service
  - Service income necessary for continued support
- Tasks:
  - Extend Refractometry System into the IR
  - Establish quality system & review process
  - Calibrate customer samples

Measurement Assurance Program (MAP)

- What: loan calibrated samples to customer
- Effort (cost and time): low - medium level
- Funding source:
  - Potential NIST internal to develop service
  - Service income necessary for continued support
- Tasks:
  - Extend Refractometry System into the IR
  - Establish quality system & review process
  - Provide calibrated samples to customer
  - Repeat sample measurement upon return
  - Provide analyzed results to customer

Round-Robins/Intercomparisons

- What: organize and conduct intercomparison between major measurement facilities
- Effort (cost and time): higher level
- Funding source:
  - External Consortium
  - Internal possible
- Tasks:
  - Extend Refractometry System into the IR
  - Recruit/select participants; design intercomparison process;
  - Obtain high quality samples, characterize and distribute
  - Compile, analyze, communicate and publish results

Process

- NIST willing to participate / contribute to effort
- NIST likely to begin instrument upgrade process in near term
- Need to determine best way to contribute
- Need to obtain funding internal/ external (Consortium?)