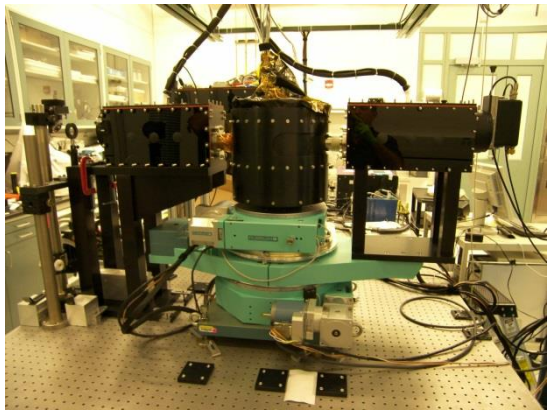
NIST IR Index Measurement Program - Update

John Burnett, Leonard Hannsen, and Simon Kaplan
National Institute of Standards and Technology
Physical Measurement Laboratory
john.burnett@nist.gov

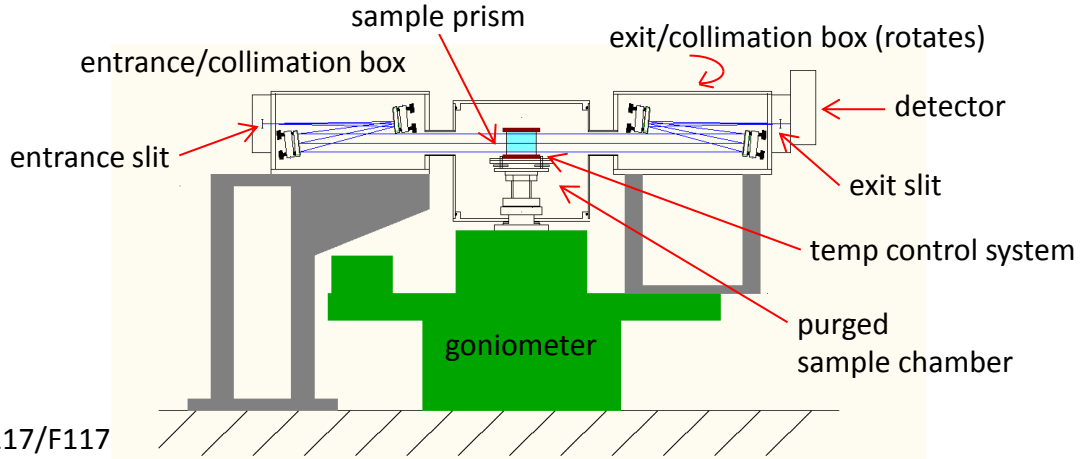
1. NIST high-accuracy refractometry program – UV/vis
2. IR measurement upgrade
3. Measurement plans/schedule

NIST High-Accuracy Refractometry - UV/vis

John Burnett, Eric Benck, Simon Kaplan, Leonard Hanssen



NIST Refractometry Facility located at NIST AML 217/F117



Operational Minimum-Deviation Refractometry System

- All reflective optics + purge housing + sources/detectors ⇒ operates VUV (120 mm) through near-IR.
- Temperature range - operates normally near room T (15 - 25 °C).
- Specs.:
  - FL=0.5 m, F/# = 10.
  - Goniometer - calibrated angle encoder scale: absolute angle uncertainty ≤ 0.2 arc-sec.
  - Feedback temperature control of sample to ≤ 5 mK, purge gas to to ≤ 10 mK.

  ⇒ Absolute index uncertainty ≤ 5×10^{-7} routinely attained in visible and UV.

  dn/dT in range T (15 - 25 °C).
- Delivering index results with above uncertainty in UV/vis to the semiconductor lithography industry.
  - 22 nm feature-size node requires wavefront phase control to sub-nanometer.

  ⇒ For lens design and lens material quality control, needs absolute sub-ppm index measurements.

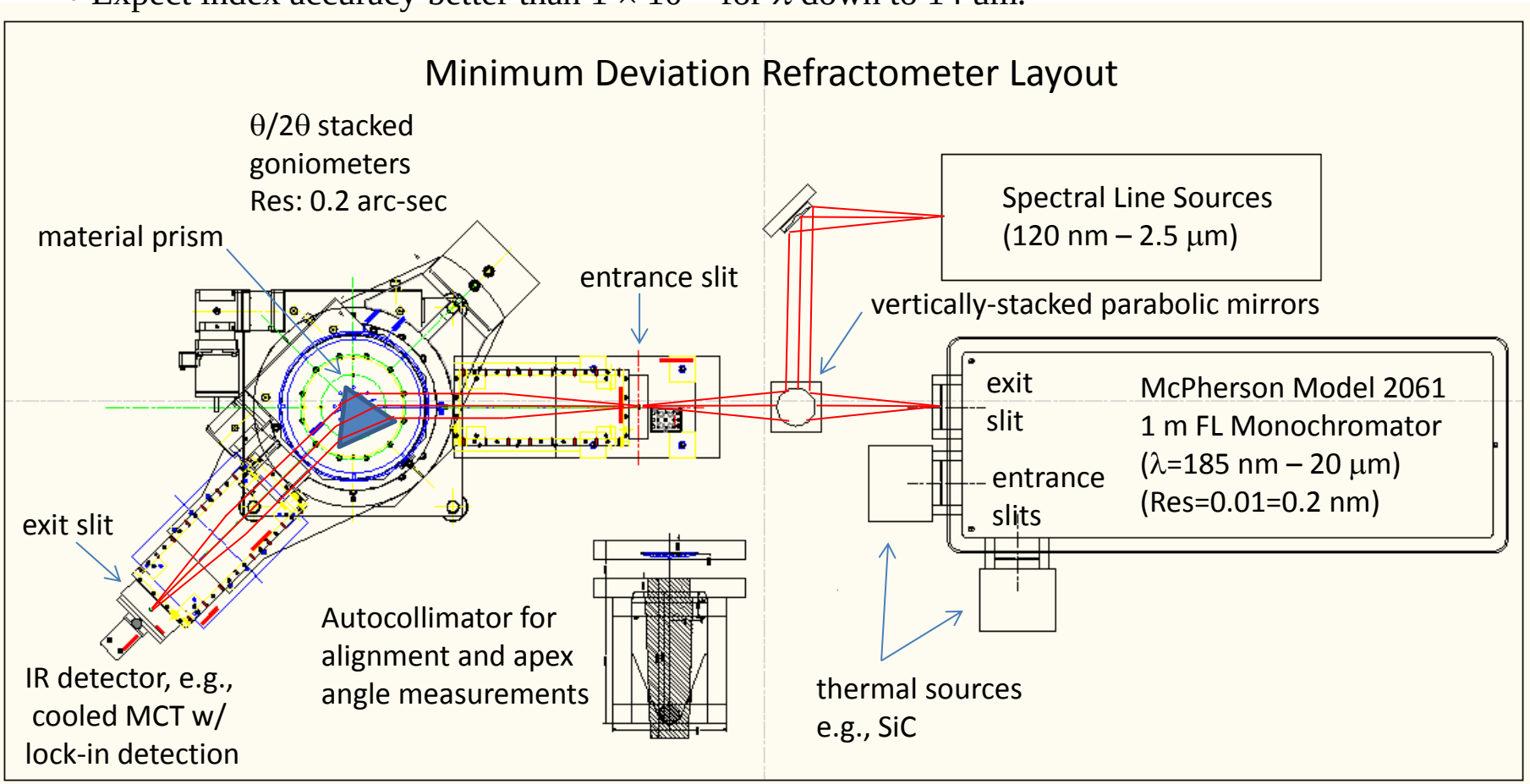
NIST focus: 1) Highest-accuracy index in vis/UV.

2) Developing index data base: CF_2, SrF_2, BaF_2, MgF_2, LiF, Al_20_3, spinels, garnets @ sub-0.2-1.2 μm.

NIST Precision Refractometry- IR Upgrade

Extension of λ range to IR – target λ=1-14 μm (T=15-25 °C)
(Consistent w/ ISO/TC 172/SC 3 N223 Test Method for IR Index)

- All reflective optics from source to detector.
- Thermal Sources (SiC), 1 m FL monochromator - Resolution at λ =5 μm ~ 0.1 nm.
- IR detector (cooled MCT), lock-in detection.
- Expect index accuracy better than 1×10^{-5} for λ down to 14 um.



NIST IR Refractometry – Plans/Schedule

Schedule:

- Expect to be fully operational for λ=1-14 μm (T=15-25 °C) by end of 2013.
- Plan to begin index measurements of key IR optical materials as identified by community.

  - Establish NIST IR *n* and d*n*/d*T* database.
- Expect absolute index accuracy better than 1×10^{-5} for λ down to 14 um.

  d*n*/d*T* in range T=15-25 °C.

  Accuracy depends on prism test sample characteristics:

  - material uniformity
  - sample stress
  - sample prism size and geometry
  - prism surface figure

  Will distribute sample requirements.
- Can explore material index sample variability, if warranted.

Longer-Range Plans:

Extension of Temp Range for *n* and d*n*/d*T* - Target λ = 0.2 - 14 μm (*T* = 4 - 450 K).

- Incorporate temperature-controlled cryostat housing in minimum-deviation refractometry system with adjustable angle windows in range *T* (4 to > 450 K).
- Design underway. Development depends on further support from NIST and/or outside.