Report to ASC-OP TF6

Leonard Hanssen / NIST

San Francisco, February 3, 2014

1. Status update on NIST support for IR materials standards.
2. Document standards.
   - *dn/dT* (John Burnett).
   - *T* (Leonard Hanssen).

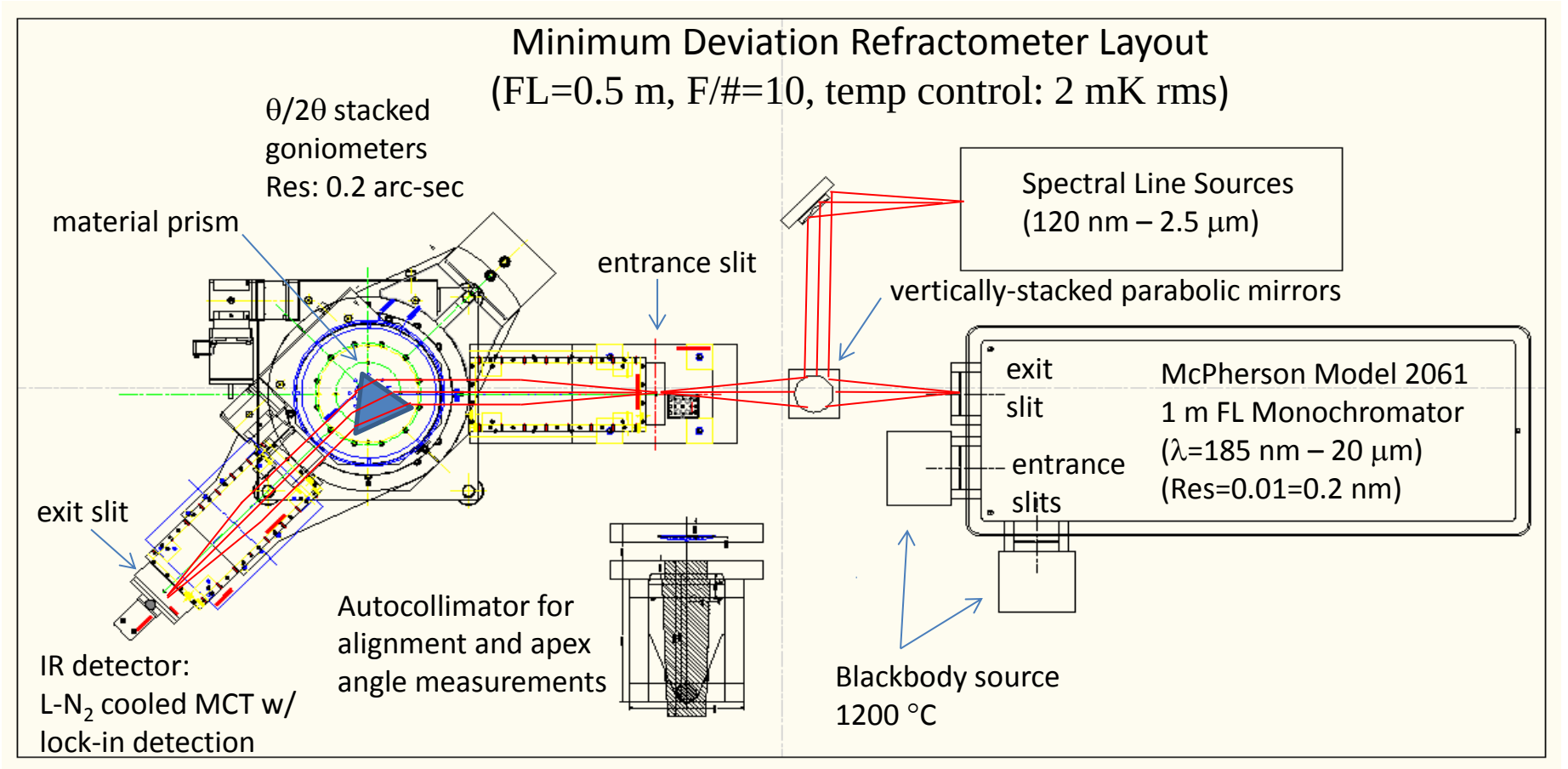
Status Update on NIST Support for IR Materials Standards

- NIST Director response of support to SPIE CEO request.
  - Extend index capability into infrared.
  - Participate in SPIE, ASC-OP and ISO working groups to develop documentary standards.
- NIST provided internal funding in FY13 to develop IR index capabilities:
  - $50 K, Calibration Service Development – 1/6 staff-years.
  - ~$75 K Division base funds covering remaining labor, equipment.
  - Upgraded refractometry system/procedures.
    - Index measurements to mid-IR (~14 μm) (room temp).
  - Progress sufficient to establish index measurement within a Calibration Service.
- Requested (end January) continued internal funding for FY14.
  - To complete room temp. development & to begin temp. range extension effort.

NIST Precision Refractometry- IR Upgrade

- Extended λ range into the IR; now covers – λ: 0.12-14 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.
- Blackbody source (1200 °C), 1 m FL monochromator - Resolution at λ =5 μm ~ 0.1 nm.
- IR detector (Liquid N_2 cooled MCT), lock-in detection.
- Index uncertainty ~1×10^{-5} for λ = 1 - 14 μm – now being verified (dep. on material, prism specs.).



NIST Precision IR Refractometry 1

Immediate Effort

- Facility operational: λ=0.12-14 μm (T=15-25 °C).
- System/procedures being tested to verify expected uncertainty levels with CaF_2 sample.
- Worked w/ Gary Weise – IR community polled to establish material interests/priorities.

  - As_2Se_3, BaF_2, CaF_2, GaAs, GASIR1, Ge, BD-2 ($Ge_{28}Sb_{12}Se_{60}$), Si, Spinel, ZnSe, ZnS.

  - Developed optimal prism specifications for each material (to achieve lowest uncertainty).

NIST Precision IR Refractometry 2

Estimated Uncertainty

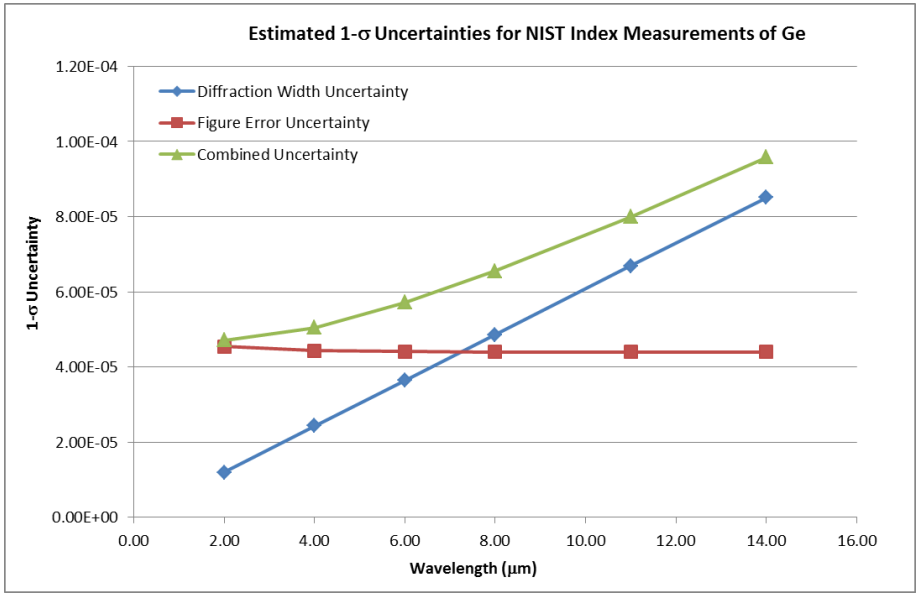
- For each material, investigated estimated uncertainty vs. sample specs.

  - prism geometry (apex angle), surface figure (Zernike coefficients).

- For example, as λ increases.

  - uncertainty due to diffraction width increases.

  - uncertainty due to figure error decreases.



- Developed optimal specifications for each material.

NIST Precision IR Refractometry 3

Measurements

- Prism samples of several materials being prepared by various suppliers.
- NIST has committed internal funds to support index measurements of samples above.

  - Will begin index measurements for λ = 0.6-14 μm (22 °C) when samples arrive (expect Feb/Mar ‘14).

- Expect results will start to be disseminated to community starting April/May ’14.

NIST Precision IR Refractometry 4

Longer-Range Plans

Use NIST IR Calibration Service to measure index IR materials as requested

- This will require some external support.

- Explore dependence of index on sample location in growth structure.
- Measure other IR materials as requested.

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

- Developing designs to incorporate temperature-controlled cryostat housing in minimum-deviation refractometry system with adjustable angle windows in range T (4 to > 450 K).
- Requested NIST internal support to build required modifications FY14 -15.

dn/dT Document Standard

John Burnett / NIST

- Began to consider some of the issues for a ISO *dn/dT* standard, along the lines of the IR index standard.
- NIST system is complex in order to achieve high-accuracy temperature determination and control that we desire, which is higher than is generally needed.
- For this reason NIST approach is probably not appropriate for an ISO standard.
- Instrument features also depend on the temperature region involved.
- Several alternative designs work equally well, so it is not clear which choices should be the standard.
- Will study the issues further; provide recommendations at later date.

T & R Document Standard

- Existing ISO Standard 15368: "*Optics and optical instruments - Measurement of reflectance of plane surfaces and transmittance of plane parallel elements*".
- References:
  - IEC 60050-845:9187, *International Electrotechnical Vocabulary – Chapter 845: Lighting*
  - ISO 31-6, *Quantities and Units – Part 6: Light and related electromagnetic radiations*
  - ISO 9211-1, *Optics and optical instruments – Optical coatings – Part 1: Definitions*
  - ISO 9211-1, *Optics and optical instruments – Optical coatings – Part 2: Optical properties*
  - ISO 10110-8, *Optics and optical instruments – Preparation of drawings for optical elements and systems – Part 8: Surface texture*
- Contents
  - Definitions, measurement system descriptions, method descriptions, sources of error.

ISO Standard 15368

Contents

T & R Document Standard

- Review ISO 15368.
  - Covers basic details.
  - Needs updating: additions to instrumentation, methods, error sources, etc.
- Potential additional references:
  - CIE 130 1998 Technical Report, *Practical Methods for the Measurement of Reflectance and Transmittance.*
  - ASTM C-1649, others (?).
- Plans
  - Pursue modification of ISO 15368 through TC172-SC1-WG1.
    - Produce set of proposed changes, corrections, etc.
    - Distribute to members of TF6 & SPIE ISMWG for further comments.
    - Propose updating ISO 15368 at the next meeting of SC1-WG1 in September 22-24 at DIN in Berlin.
    - Coordinate modification process within SC1-WG1 as project leader.
  - Request ASC-OP to adopt revised ISO 15368 as T & R standard.