ePIC pfRICH Aerogel

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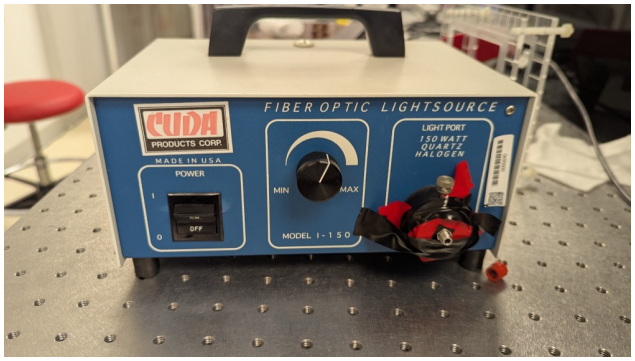
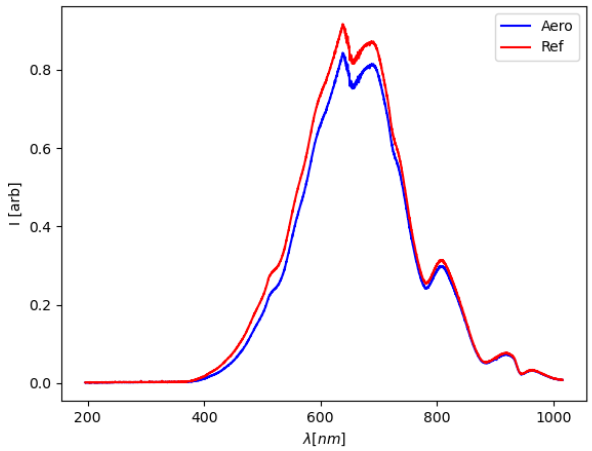
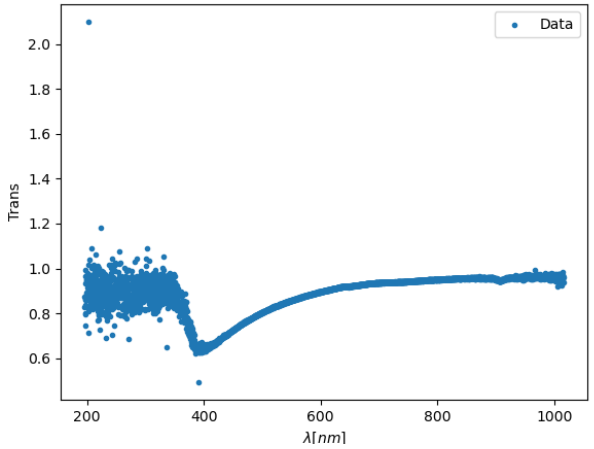
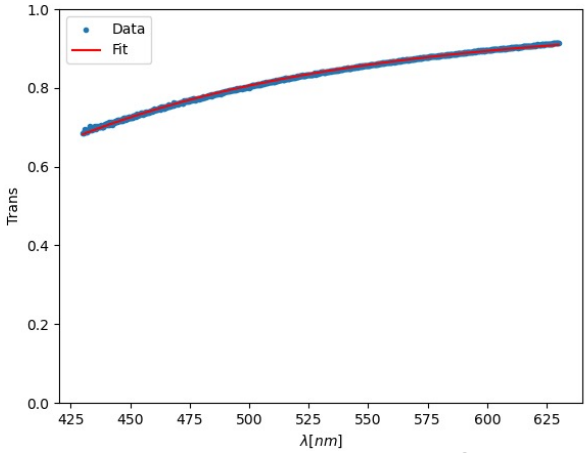
Transmittance Measurements: Halogen Lamp



- Replace fix frequency LEDs with halogen lamp for continuous coverage
  - Slightly shorter measurement time
  - Continuous spectra allows better fitting uncertainties
  - Minimum wavelength limited to about $450\ nm$

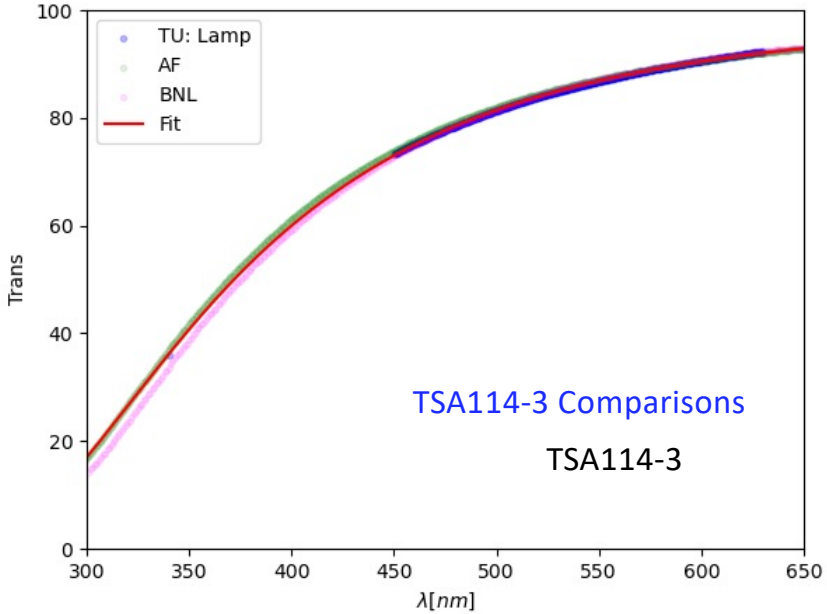






Transmittance Measurements: Halogen Lamp

- Compare transmittance measurements to halogen lamp results
  - Good agreement between other validation measurements
  - Fit of halogen data yields comparable fit results as other measurements with better fit uncertainties compared to TU LED measurements
  - Halogen data can be extended to $\lambda = 340$ nm LED data point



Transmittance Measurements: Halogen Lamp

- Better constraints provided by fits

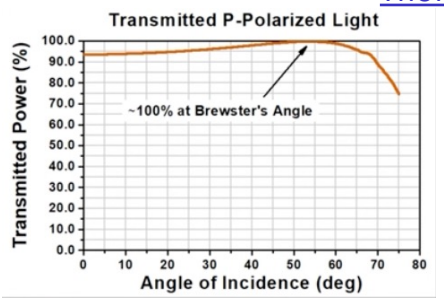
TSA114-3 fit result comparisons

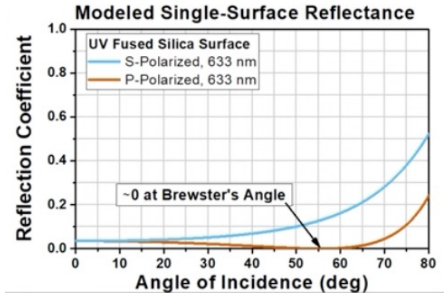
Source	A [%]	B [μm^8]	C [μm^4]	T [$\lambda = 400\ nm, \%$]
Aerogel Factory	$99.05 \pm 6\times10^{-2}$	$9.14\times10^{-6} \pm 2.51\times10^{-7}$	$4.56\times10^{-3} \pm 2.17\times10^{-5}$	61.2
BNL	$99.77 \pm 9\times10^{-2}$	$1.25\times10^{-5} \pm 4.26\times10^{-7}$	$4.82\times10^{-3} \pm 3.37\times10^{-5}$	59.25
TU (LED)	99.55 ± 1.60	$7.64\times10^{-6} \pm 7.07\times10^{-6}$	$4.87\times10^{-3} \pm 5.47\times10^{-4}$	59.99
TU (Lamp)	$99.87 \pm 8\times10^{-4}$	$1.41\times10^{-28} \pm 8.96\times10^{-11}$	$5.10\times10^{-3} \pm 7.66\times10^{-8}$	60.56
TU (LED + Lamp)	$99.61 \pm 2\times10^{-4}$	$6.36\times10^{-6} \pm 3.5\times10^{-12}$	$4.92\times10^{-3} \pm 6.71\times10^{-9}$	59.97

Refractive Index: Brewster's Angle Approach

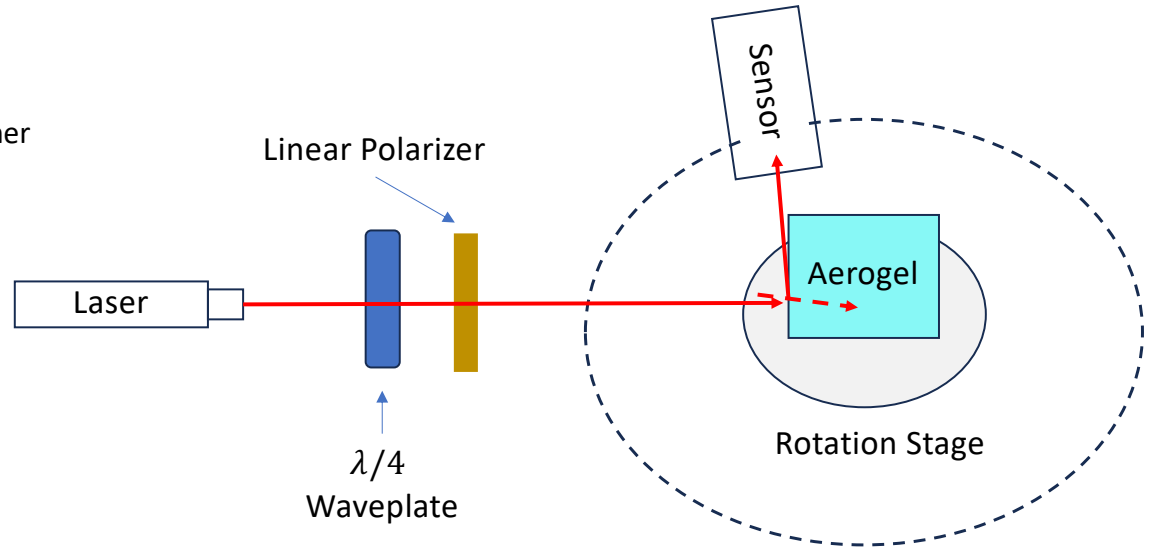
- Determine refractive index from Brewster's angle:
  - $n_{aero} = \mathrm{n_{air}} \tan(\theta_B)$
  - θ_B from minimum reflected P-wave polarization
- Reference beam via beam splitter could be added
- Can mimic setup used in reflectivity measurements at BNL
  - e.g. rotation stage / arms
- Funding would be needed to put system together

Thor Labs



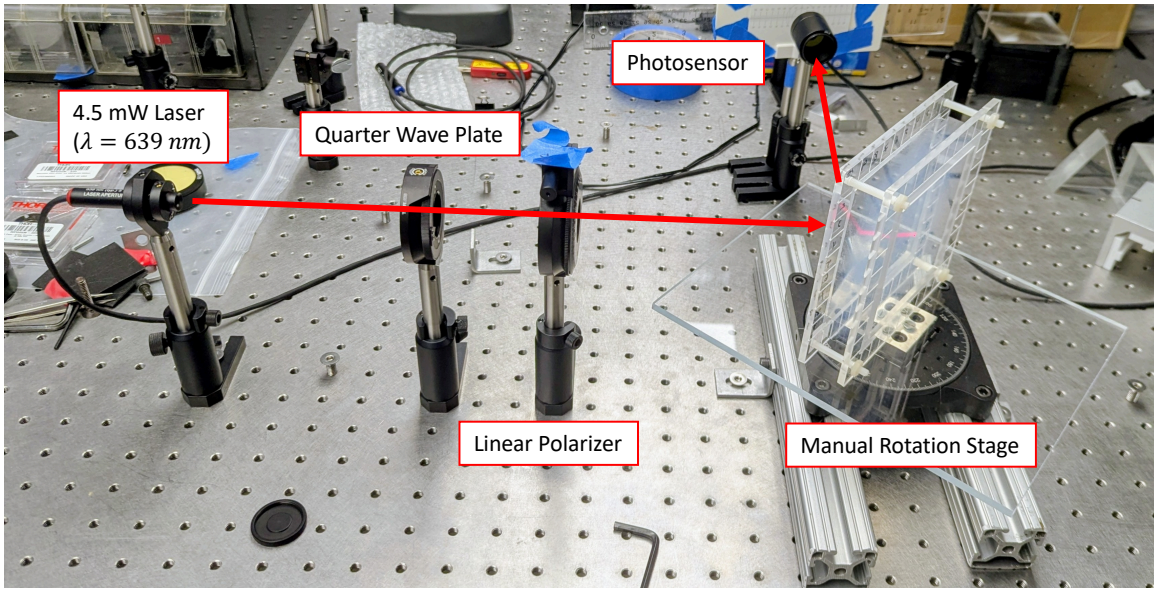


n_{aero}	$\theta_B\ [deg.]$
1.040	46.12
1.041	46.15

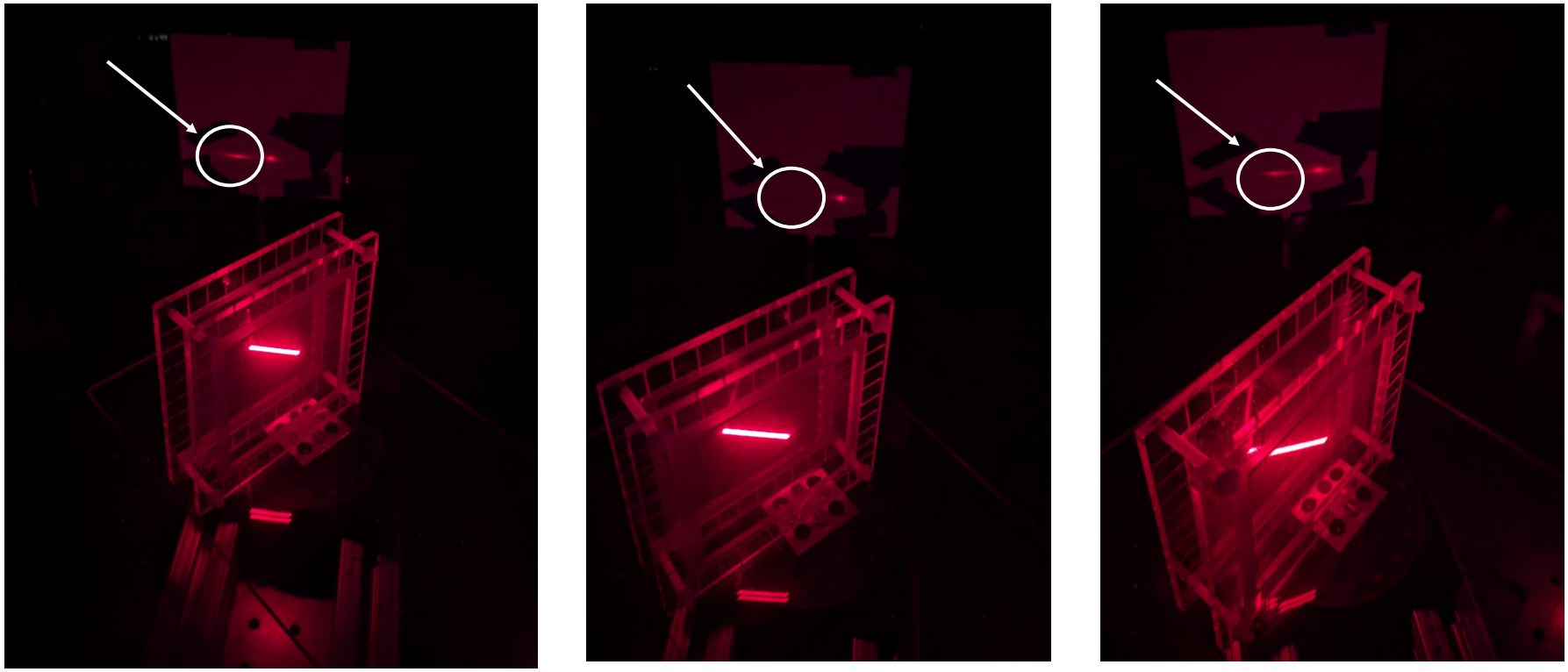


Brewster's Angle: Setup

- Laser
  - 4.0-5.0 mW (4.5 mW typ.)
  - Power Stability: 2%
  - Beam Diam: 3mm
  - Beam Divergence: -6 mrad
- Photosensor
  - 50nW – 50mW (200nm-450nm)
  - Resolution 1nW
  - Linearity: $\pm 0.5\%$
  - Measurement Uncertainty:
    - 200nm-270nm: $\pm 7\%$
    - 280nm-439nm: $\pm 5\%$
    - 440nm-980nm: $\pm 3\%$
    - 981nm-1100nm: $\pm 7\%$



Brewster's Angle: Aerogel TSA 114-3



Disappearance of spot reflected from aerogel front surface when angle of incidence is at Brewster's angle

Refractive Index: Aerogel TSA 114-3

- Refractive Index Measurements (via deflection through corner)
  - Aerogel Factory: 1.0377 @ $\lambda = 405\ nm$
  - TU: 1.0358 – 1.0409 @ $\lambda = 403\ nm$

The refractive index for a given Brewster's angle

n	$\theta_B\ [deg.]$
1.0000	45.0
1.0176	45.5
1.0355	46.0
1.0538	46.5

TSA 114-3 aerogel tile @ $\boldsymbol{\lambda = 639\ nm}$

Incident Angle [deg.]	Reflected Power [μW]
40	0.170
41	0.108
42	0.077
43	0.055
44	0.035
45	0.01 (spot not visible)
46	0.01 (spot not visible)
47	0.025
48	0.053
49	0.096
50	0.142

Brewster's Angle: Improvement

- More precision is needed on measuring Brewster's angle if approach is to be used in QA
  - Angle of incidence precision needed: $\Delta n = 0.001 \Rightarrow 0.52\ \text{mrad} \approx 0.03^{o}$
    - Replace manual rotation stage with 1^{o} tick marks with high precision automated rotational stage
  - More careful alignment of polarization axes
    - Currently using back and front face of linear polarizer to align polarization axis perpendicular to the table and cross calibrate to find horizontal axis.
  - Automate sensor positioning to measure reflected light.
    - Currently manually position at appropriate location. How to automate?
      - Beam spot moves by about 7 mm/deg

Precision Rotational Stage

Thor Labs HDR50

- $3,340

Thor Lab Controller BSC201

- $1,754

Stage Specifications	
Translation and Motion Parameters	
Travel	360° Continuous Rotation
Speed[a,b]	50 °/sec (Max)
Acceleration[b]	80 °/sec^2 (Max)
On-Axis Load Capacity	50 kg (110 lbs)
Drive Mechanism	Worm Drive
Gear Ratio	66:1
Homing Sensor	Hall Effect, Non-Contact
Stage Bidirectional Repeatability	±350 µrad
Stage Bidirectional Accuracy	±820 µrad
Minimum Incremental Motion	0.8 µrad
Homing Bidirectional Repeatability	±203 µrad
Axis Wobble	65 µrad
Torque	6 N•m (Max)
Physical Specifications	
Platform Size	Ø3.86" (Ø98.0 mm)
Central Aperture	SM2 (2.035"-40) Threaded
Platform Mounting Holes	Four 8-32 (M4)
Dimensions	7.46" x 4.55" x 1.73" (189.4 mm x 115.5 mm x 44.0 mm)
Weight	3.34 lbs (1.52 kg)
Attached Cable Length	0.5 m
Included Extension Cable	PAA613, 3 m Long
Operating Temperature Range	5 °C to 40 °C
Humidity	80% RH at 31 °C (Max)

a. The max speed is only achievable as long as the max torque is not exceeded.
b. Measured Using a BSC201 Controller

Motor Specifications	
Motor Type	2-Phase Stepper
Step Angle	1.8° (200 Major Steps per Revolution)
Micro-Stepping	2048 Micro-Steps per Major Step (Total of 409,600 Micro-Steps per Revolution)
Rated Phase Current	0.85 A
Resistance / Phase	3.6 Ω
Inductance / Phase	4.6 mH