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LOW OPTICAL ABSORPTION MEASUREMENT REPORT

SAMPLE: PAN8948 (PO10693) C5

Request from		Testing institute	
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Contact person	Audrius Valavičius	Tester	Edvinas Zacharovas
Inquiry date	2025-05-26	Sale order	SO05921
Purchase order	PO11970	Test ID	EJOP97
		Test date	2025-05-30

Specimen

Name	PAN8948 (PO10693) C5
Front surface (S1)	AR Coating (AR<0.1% @ 1055-1080 nm + R<5% @ 630-650 nm, AOI 0-26 deg)
Rear surface (S2)	AR Coating (AR<0.1% @ 1055-1080 nm + R<5% @ 630-650 nm, AOI 0-26 deg)
Dimensions	Ø25.4 x 6.4 mm
Packaging	Plastic box
Storage before test	Normal laboratory conditions
Dust blow-off	Canned air
Cleaning	None

Measurement

Method	Photothermal common-path interferometry (PCI)
Regime	Transmission
Protocols	Longitudinal scan (L-scan), Time scan, Transverse scan (T-scan).

SUMMARY OF MEASUREMENT RESULTS

Wavelength	AOI	Polarization	Location	Sample absorption *
1070.0 nm	(2.0 ± 1.0) Deg	Linear P	Front surface (S1)	$0.90^{+0.17}_{-0.19}$ ppm
			Estimated S1	$0.49^{+0.36}_{-0.19}$ ppm **

* Sample absorption is evaluated from Transverse scan protocol.
** Read more in Technical note 1.

TEST EQUIPMENT

Definitions and test description

Photothermal common-path interferometry (PCI) for low absorption measurements is based on spatially resolved pump-probe techinque: low power probe beam senses the heating effect of an absorbed pump beam [1]. Several different scanning protocols are performed to measure the absorption of the sample.

Irradiation sources	Pump laser	Probe laser
Manufacturer	IPG Photonics	Lumentum
Model	YLR-10-LP	1122P
Type	Continuous wave Ytterbium fiber	Continuous wave HeNe
Central wavelength	1070 nm	632.8 nm
Angle of incidence	(2.0 ± 1.0) Deg	(9.0 ± 1.0) Deg
Polarization state	Linear P	Linear S
Spatial beam profile in target plane	TEM00	TEM00
Beam diameter in target plane (1/e2)	(58.1 ± 5) µm	(210 ± 5) µm
Average power	(3.9778 ± 0.0040) W	(2.00 ± 0.05) mW

Measurement setup calibration	Surface
Calibration sample	UVFS Reference Surface Sample
Absorption	23.6 %
Correction factor	1.0
Responsivity	$73.95^{+0.54}_{-0.58}$ 1/W

Power meter	
Manufacturer	Ophir
Model	12A-P
Calibration due date	2026-03-19

Test environment	
Environment	Air
Cleanroom class (ISO 14644-1)	ISO7
Pressure	1 bar
Temperature	24 C
Humidity	37 %

[1] A. Alexandrovski, M. Fejer, A. Markosian, and Roger Route "Photothermal common-path interferometry (PCI): new developments", Proc. SPIE 7193, Solid State Lasers XVIII: Technology and Devices, 71930D (28 February 2009)

LONGITUDINAL SCAN (L-SCAN) RESULTS

FRONT SURFACE (S1)

Scan parameters

Scanning axis	Longitudinal (from S1 to S2)
Scanning distance	6.0 mm
Scanning step	20 µm
Pump laser power	(3.9749 ± 0.0040) W
Number of scans	1

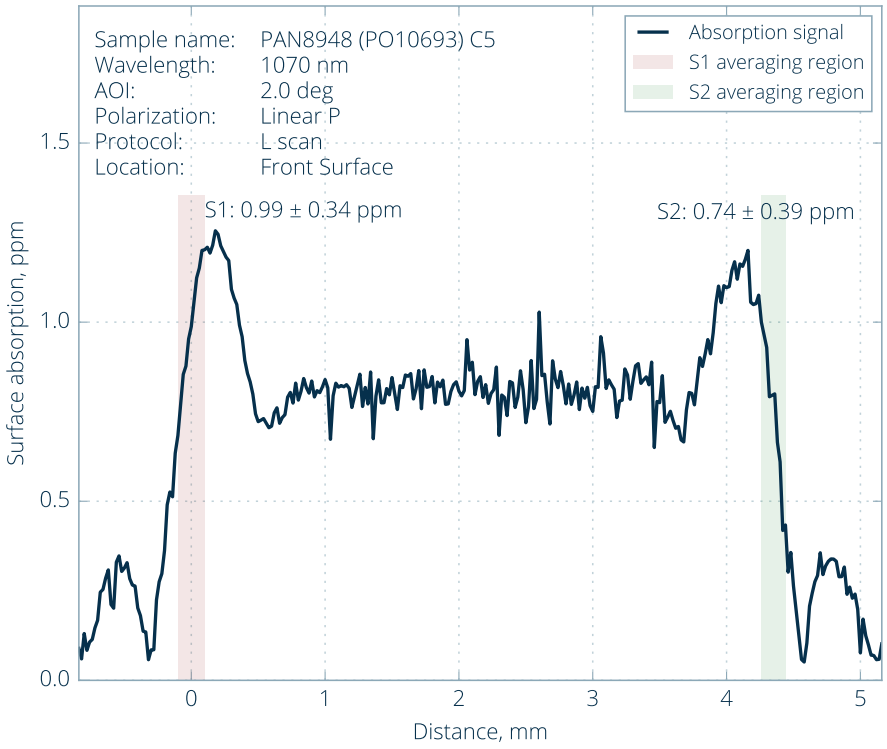


Figure 1. Longitudinal scan.

The central peaks, found at S1 and/or S2 positions, indicate the points where the pump and probe beams traverse the entrance (S1) and exit (S2) surfaces. The peak value of the signal corresponds to the surface absorptance, however, the secondary peaks (sidelobes) surrounding central peak should be regarded as part of the surface response function and lack any physical significance.

It's important to emphasize that the recorded scan distance between S1 and S2 is affected by refraction index of optical medium and therefore deviating from the actual physical thickness of the sample. The reported values are calibrated using a surface etalon sample. In cases where optical elements exhibit substantial bulk absorption, the longitudinal scan signal includes a central baseline that should be subtracted when estimating surface absorptance. The bulk absorptance portion of the signal necessitates a separate calibration process and should be interpreted separately.

Absorption values in L-scan figure are displayed only for comparison purpose, because absorption might change during the L-scan procedure. Temporal absorption changes can be seen in Time-scan results.

TIME SCAN RESULTS

FRONT SURFACE (S1)

Scan parameters

Scanning axis	Time
Scanning duration	685 s
Scanning step	1 s
Pump laser power	(3.9753 ± 0.0040) W
Number of scans	1

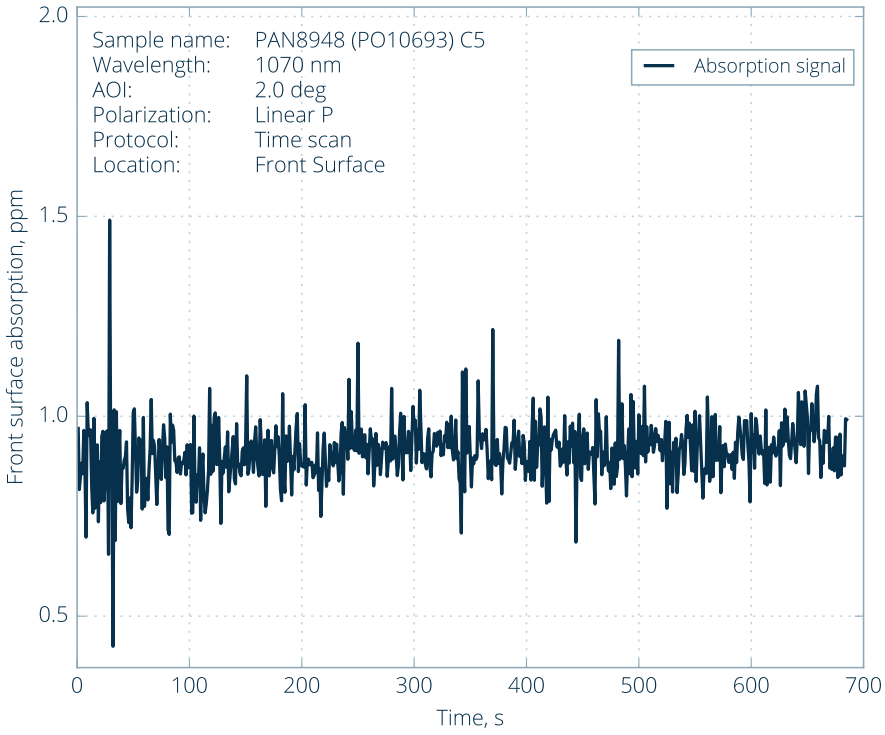


Figure 2. Time scan on front surface (S1) .

TRANSVERSE SCAN (T-SCAN) RESULTS

FRONT SURFACE (S1)

Definitions and protocol description

Sample absorption is defined as median absorption value of T-scan measurement. Uncertainty is evaluated as minimum and maximum absorption values of T-scan measurement without outliers, i.e. within range [Q1 - 1.5 · IQR, Q3 + 1.5 · IQR], where Q1 - first quartile, Q3 - third quartile, IQR - interquartile range.

Scan parameters

Scanning axis	Transverse (vertical)
Scanning distance	3.0 mm
Scanning step	34 µm
Pump laser power	(3.9778 ± 0.0040) W
Number of scans	1

Scan results

Sample absorption	$0.90^{+0.17}_{-0.19}$ ppm
Estimated S1 absorption	$0.49^{+0.36}_{-0.19}$ ppm *

* Read more in Technical note 1.

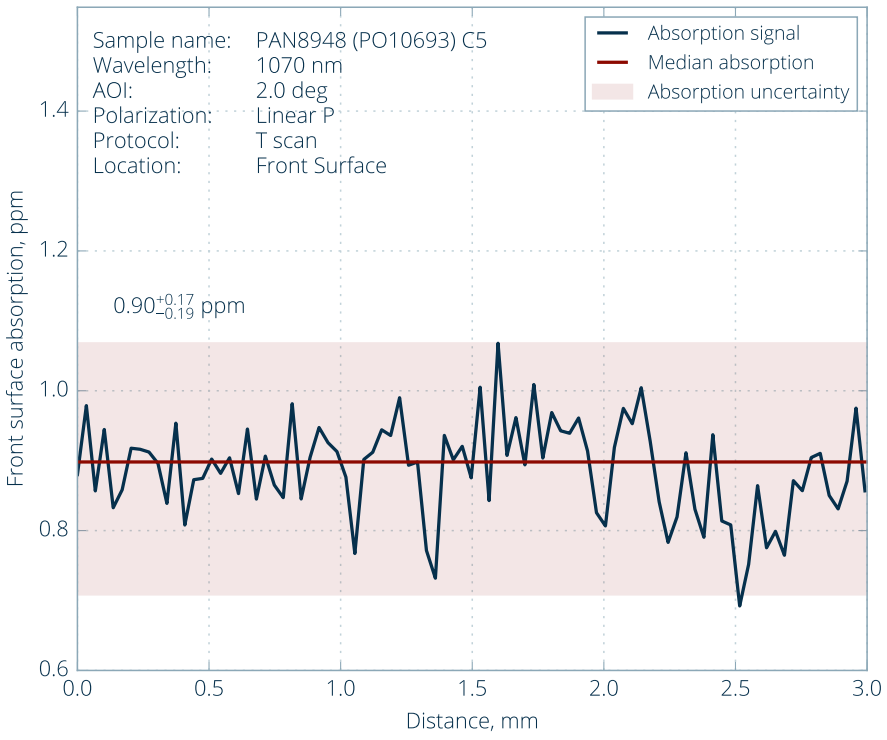


Figure 3. Transverse scan on front surface (S1) .

TESTING LOCATION

FRONT SURFACE (S1)

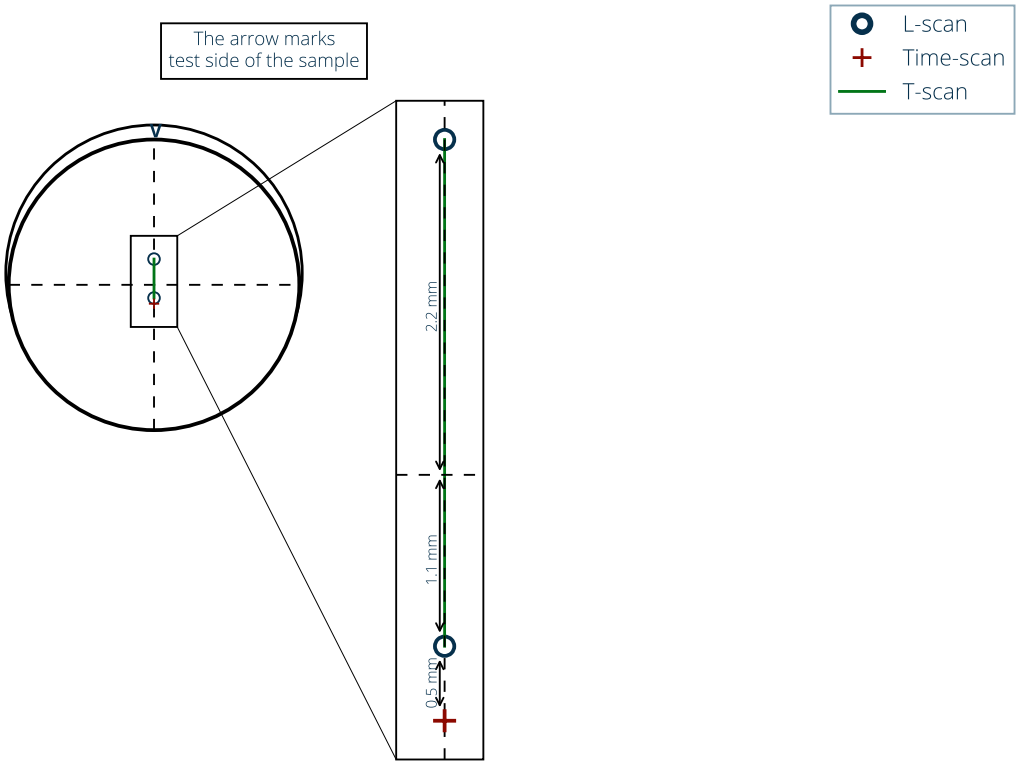


Figure 4. Measured sites on the sample.

TECHNICAL NOTES

TECHNICAL NOTE 1: Estimation of Surface Absorption (S1 or S2) in the Presence of Significant Bulk Absorption

Surface and bulk absorption have different thermal responses due to the thermal lensing geometry of the PCI technique. Surface absorption involves localized thermal lensing, while bulk absorption follows the pump beam geometry. When bulk absorption is comparable to or greater than surface absorption, the absorptance peak shifts, making it unreliable for determining surface absorption and position. This note outlines a method to estimate surface absorption values (S1 and S2) when bulk absorption complicates direct evaluation, as seen in PCI (including L-scan) tests.

We use a theoretical approach to estimate the optical thickness of the sample and the distance between the theoretical S1 and S2 positions, based on pump and probe geometry [Figure 5]. These positions are shown as dashed lines in the figure below.

We assume the L-scan signal at the surface is the sum of the surface absorptance peak and half of the bulk absorption signal. To estimate surface absorption, we calculate the bulk absorption signal and subtract half of the bulk median value from the measured signal at position S1.

For error estimation, we increase the upper margin for S1 absorption to account for the highest absorption detected in the L-scan, covering potential errors in the S1 position assumption.

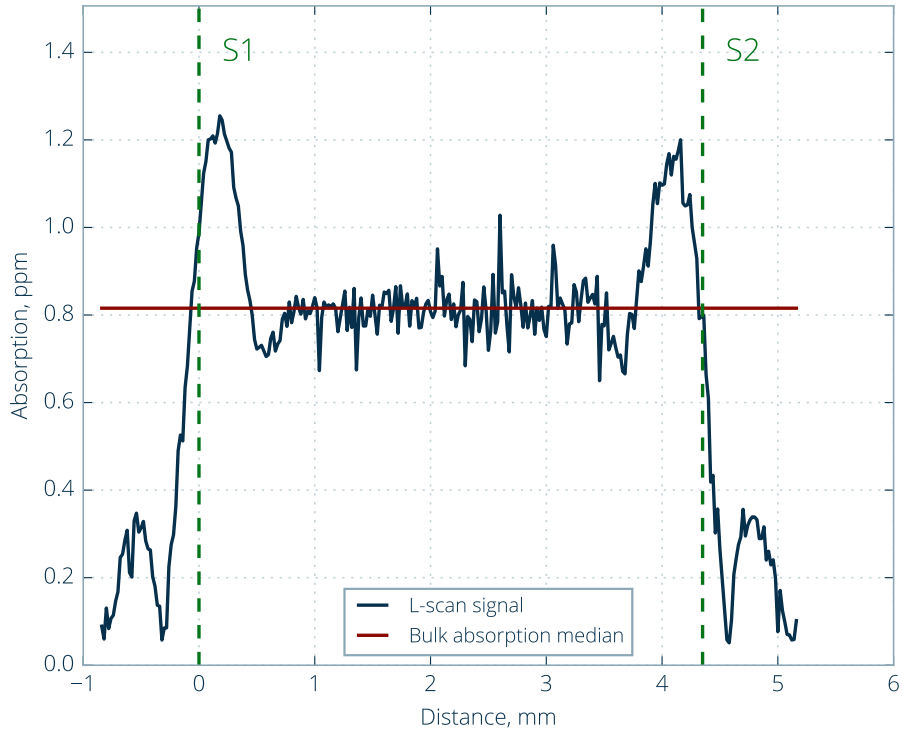


Figure 5. Bulk absorption evaluation from L-scan data. Dashed green lines mark theoretical S1 and S2 positions.