November 2008

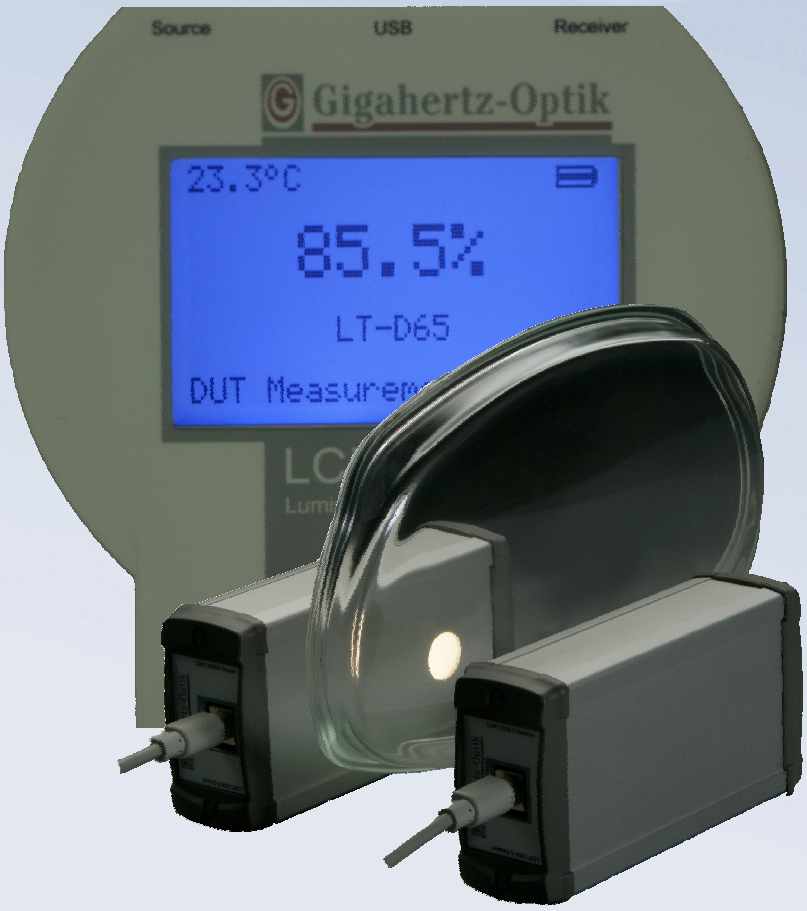
Gigahertz-Optik

Measurement of Light

Measurement with Light

LCRT-2005-S

Portable Spectrophotometer for Transmission Measurement

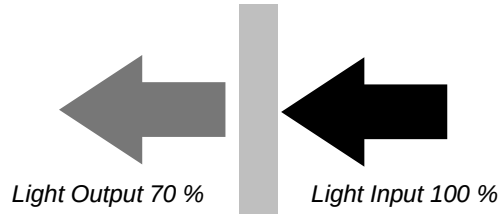


- Spectral Transmission in d/0 and 0/0 Measurement Geometries
- Transparency Measurement in “real in-line” Set-up
- Photometric Transmission in CIE D65 and Illuminant A Conditions
- Two-Sensor Design Simulating Double Beam Spectrophotometer
- Hand-held Portable Measurement
- Internal Camera Supported Optical Axis Alignment
- Ambient Light Compensation
- USB Interface for Recording Data & Reporting

Fully Portable Spectrophotometer for Transmission Measurement

The LCRT-2005-S is a portable spectrophotometer designed for *in situ* measurement of transmission in the visible wavelength range (luminous transmission). Its hand-held design and compact size allow measurement at the test sample. Profiling a test sample by multiple measurements across the sample is easily performed. The instrument can also be integrated into stationary measurement set-ups.
An internal camera targeting system supports the alignment of light source and receiver in manual operation. Two diode array spectrometers simultaneously measure the light illuminating the test sample (Device Under Test - DUT) and the light output of the DUT to create transmission measurements independent of light source fluctuation and re-reflected light. The test source light source is pulsed enabling measurement under ambient light conditions. Spectral transmission measurements can be performed covering the whole integrated spectral range from 425 to 705nm or monochromatically with selectable wavelengths between 425 to 705nm and selectable bandwidths down to 1nm. The spectral measurement method also enables photometric transmission measurements with either standard CIE illuminant A or D65 illumination simulations. The LCRT-2005-S is suitable for use in process control, incoming inspection as well as in research and development for measurement of the efficiency of anti-reflection coatings, influence of interference effects to transparency, legal conformity of window transmission or for any spectrophotometer application in the visible wavelength range where mobility or compact size is required. An optional B2S-75-RIT Bench is available to set-up the LCRT-2005-S for stationary use.

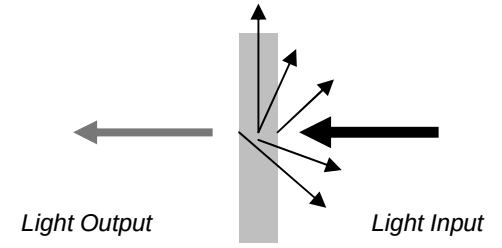
Light Transmission Measurement



70% Regular Transmission

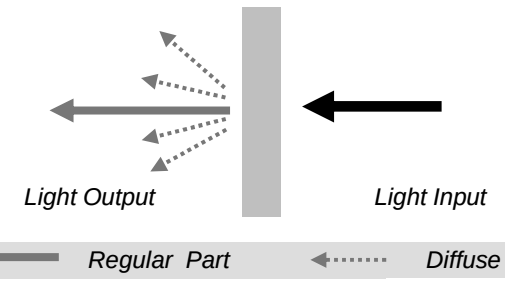
Transmission refers to the physical process of light passing through a sample. Transmittance refers to the mathematical quantity. Transmittance is measured in percent and is used to specify the light throughput of transparent materials.

Transmittance describes the ratio of the transmitted radiant or luminous flux to the incident flux under stated conditions.



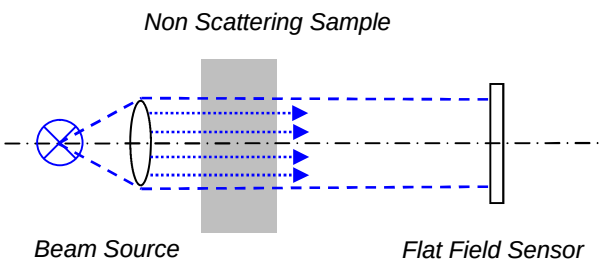
Reflection Loss

Light traveling through a test material can be reduced by re-reflection at the sample surfaces, by particle inclusions, rest porosity and absorption. **Transmission** without diffusion, specified as regular, direct or in-line transmission or with diffusion specified as diffuse transmission or mixed with partly regular and partly diffuse transmission.



Materials used for **windows** in buildings, vehicles or as **cover glass** for instrumentation, displays and light sources are typically specified with very low diffuse transmission for maximum clarity and low stray light. This specification applies to reflection reducing coatings as well. In order to specify materials for these kinds of applications the regular transmission needs to be measured.

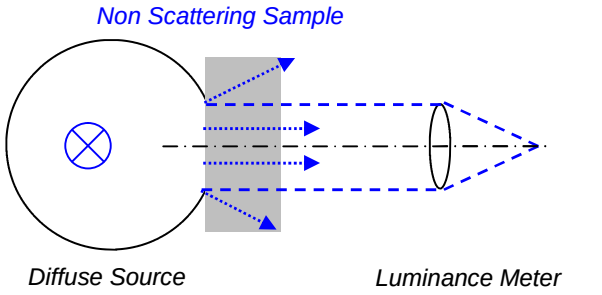
Light Transmission Measurement



0/0 Measurement Set-up for Regular Transmission or Transparency of Non Scattering Samples

Regular transmission or transparency of non-diffuse samples can be measured with parallel beam light source illumination with large detection area flat field sensor (0/0 set-up) or with diffuse light source sample illumination and narrow field of view luminance sensor (d/0 set-up).

Diffuse light sources employing integrating spheres (uniform light sources, Lambert's law light sources) offer a higher light intensity than collimated beam sources because of better efficiency in light collection as compared to a lens. 0/0 set-ups with integrating sphere based sources are therefore preferable for spectral transmission measurements of test samples with no diffuse component.

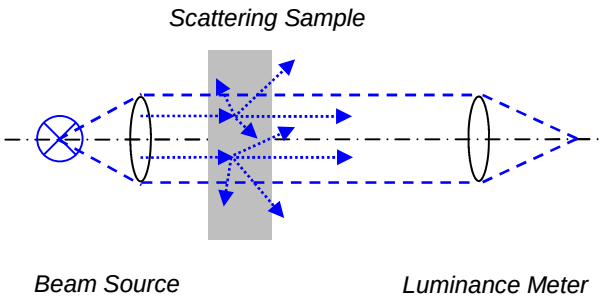


d/0 Measurement Set-up for Regular Transmission or Transparency of Non Scattering Samples

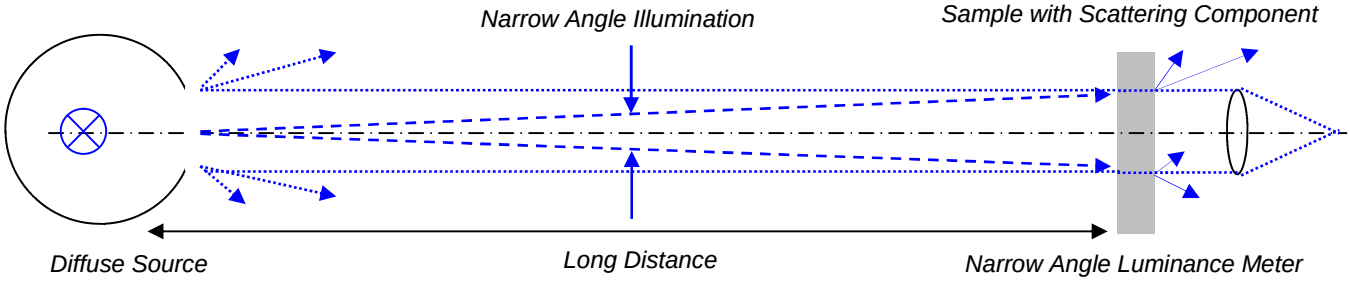
Regular transmission or transparency of samples with diffuse component can be measured with narrow angle beam sample illumination and narrow field of view luminance sensor. Only with a very narrow field of view the "real in-line Transmission" excluding scattered components is measured.

Measurements of regular transmission or transparency of samples with diffuse component using an integrating sphere light source can be measured with some distance between source and sample. The space creates a narrow beam illumination of the sample. The longer the distance the narrower the illumination angle.

The use of diffuse light sources employing integrating spheres (uniform light sources) offer a higher light intensity than collimated beam sources because of the integrating sphere's higher efficiency in collecting light than a lens.

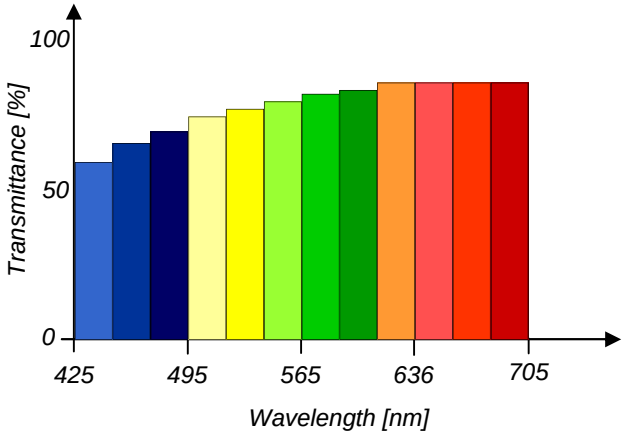


0/0 Measurement Set-up for In-Line Transmission or Transparency of Scattering Samples



d/0 Measurement Set-up for In-Line Transmission or Transparency of Scattering Samples

Spectral Transmission



Graph of Spectral Transmittance

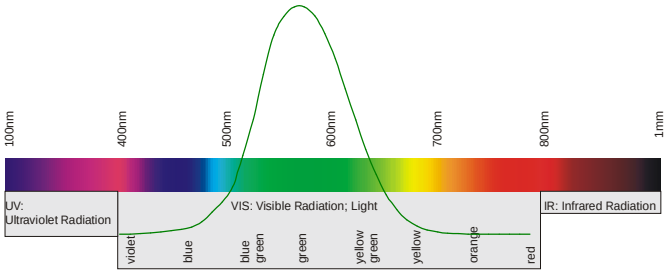
Spectral transmission is specified for monochromatic light conditions. The peak wavelength and the spectral bandwidth of the monochromatic light must be known together with the transmittance data.

Spectral transmission can be measured with monochromatic light sources such as halogen lamps with bandpass filters, LEDs or LASERs.

Using a spectrometer as the measuring device for spectral transmission (spectrophotometer) the spectral transmission or wavelength dependent transmission can be measured.

The transmittance data can be calculated and displayed for monochromatic light or for the spectral transmission distribution within the specified wavelength range. In this case the average transmission in that range is displayed.

Photometric Transmission



CIE Human Eye Sensitivity
Wavelength range 380 to 780 nm

Light specifies the wavelength range from 380 to 780 nm of the electromagnetic spectrum which is visible to the human eye. The spectral sensitivity of the human eye is specified in CIE, DIN and EN standards. **Photometry** is the measurement of quantities referring to radiation as evaluated according to the spectral luminous efficiency function of the human eye.

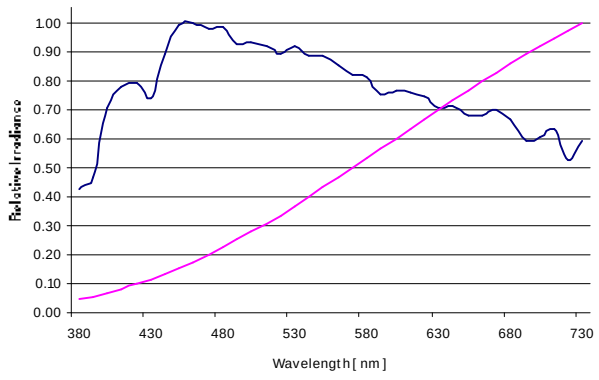
Materials used for **windows or glazing** are specified by their photometric or light transmission. Light transmittance is therefore an important parameter in the evaluation of windows in many industries including automotive, aviation, building construction and other applications where a minimum visibility for objects is specified. For a clear view window material should not adversely effect transmitted light in anyway. Therefore only the regular transmitted part is specified as luminous transmission.

Photometric transmission is specified with the type of light source emission spectrum used for test sample illumination. Typically standard CIE* illuminant A and D65 are used.

CIE Standard Illuminant A is an artificial light source with black body emission spectrum at 2856 K.

CIE Standard Illuminant D65 simulates day light at 6500 K.

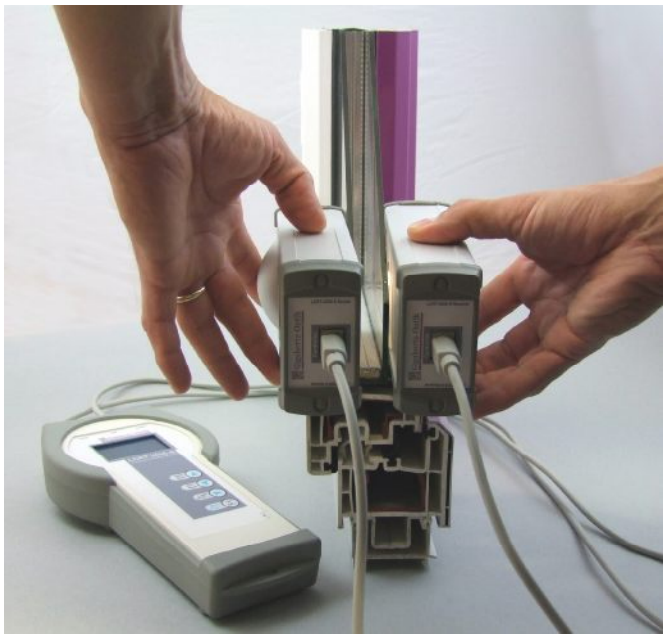
**CIE is the International Commission on Illumination*



Standard Illuminant A and D65

Application Note: Spectral Transmission of Refined Flat Glass

LCRT-2005-S Measuring Flat Glass Sample



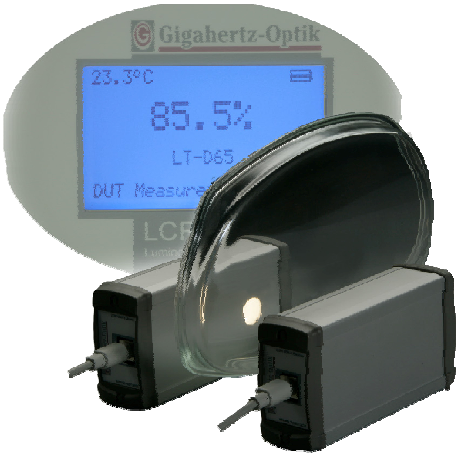
LCRT-2005-S Measuring Duplex Glass Sample

The spectral transmission of optical flat glass plates widely used as common window glass in buildings and transportation industries is typically specified and process controlled by the glass manufacturer not by the end-user. Besides the glass manufacturer a wide range of industries exist offering refining processes for glass plates to reduce reflection, minimize dirt accumulation and increase scratch resistance. Other common glass processes involve the application of conductive coatings for heating (windshield), transmission control or generation of electricity (Thin-layer solar cells). All of these are based on applying single layer or multilayer thin film coatings on the glass substrate. Beside the transmission at one measurement point the uniformity tolerances of thin film coating processes are important to control since the uniformity can be affected by many of the process parameters.

The typical way in doing process control of thin film coatings is to use smaller size reference plates running through the same process as the end product itself. The test plates are qualified by measurement of the spectral transmission using laboratory type spectrophotometers. The limitation of this qualification procedure is that the qualification is not actually done with the end product itself and does not include the surface area non-uniformity. This indirect method of process control increases the risk of rejected product in the coating process.

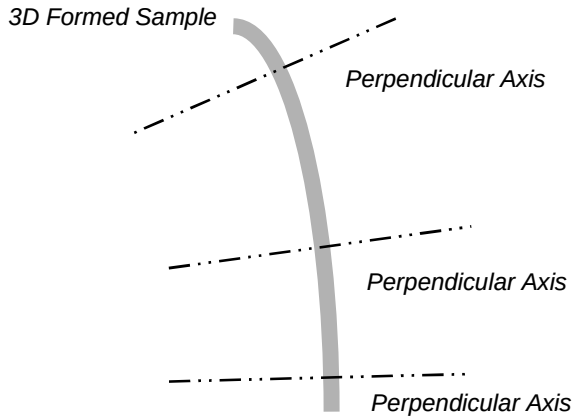
The LCRT-2005-S light transmission spectrophotometer enables the glass pane refining industry to do spectral transmission measurements *in situ* directly on the final product. This can be accomplished using hand-held method or the instrument can be fixture for stationary use. For on-line uniformity process control the LCRT-2005-S can be installed on a scanning system or in a measurement matrix using several LCRT-2005-S.

Application Note: Spectral Transmission 3D Formed Glass



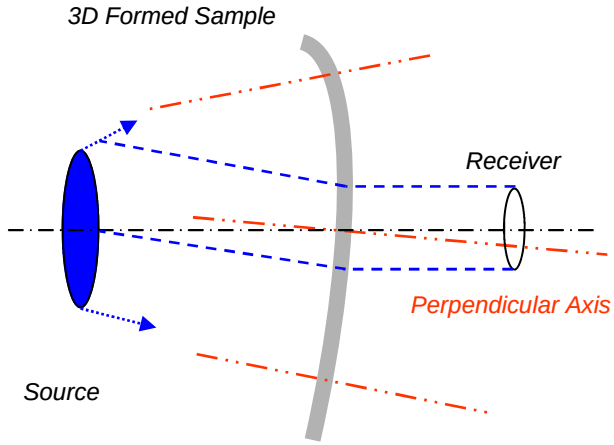
LCRT-2005-S Measuring 3D Formed Glass Sample

For improved transmission, scratch and contamination protection hard antireflection and protection coatings in nanotechnology can be applied on three dimensional formed glass. For process control and to ensure adherence to regulatory specifications the spectral transmission needs to be measured.



Perpendicular Alignment

The transmission measurement of 3D formed glass with no diffuse component requires precise perpendicular alignment of the transmission measurement path to the test sample surface. Due to the three dimensional form of the glass this alignment has to be done at each dimensional measurement position.

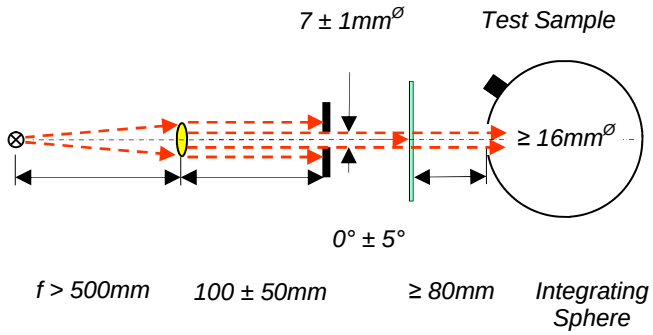


Alignment Support by Targeting Camera

The LCRT-2005-S receiver employs an internal targeting camera for alignment support. For transmission measurements on 3D formed glass the LCRT-2005-S source and receiver need to be operated in a fixed set-up. A three dimensionally formed test sample placed between source and receiver effect a beam deviation which can be used for the perpendicular alignment supported by the camera. The targeting camera offers a settable resolution using a zoom function for measurement distances between 0 and 100mm between source and receiver.

Application Note: Photometric Transmission of Car Windows

Built-in Windscreen



ECE-R43 Laboratory Measurement Set-up

Photometric transmission is the measured luminous transmission weighted to the human eye visual response. Photometric transmission is most commonly used for the specification and qualification of automotive window glass. In several countries the ECE-R43 standard has been adopted as a means of regulating window tint based on transmission levels.

Basic ECE-R43 Standard Information:

While driving, 90% of all incoming information is perceived by the eye for processing. So good *vision* is obviously necessary for safety. Light transmittance is therefore important in evaluation of windscreens and side windows and therefore specified in the ECE-R43 standard. *Brightness* is another important factor for good vision. Tinting of vehicle glass reduces light transmittance and therefore perceptibility. If automotive glass is laminated or tinted original light transmittance levels will be reduced requiring a re-qualification of the light transmittance specification. For a clear view, windshields should not effect transmitted light in anyway. So only regular transmitted light is specified as luminous transmission.

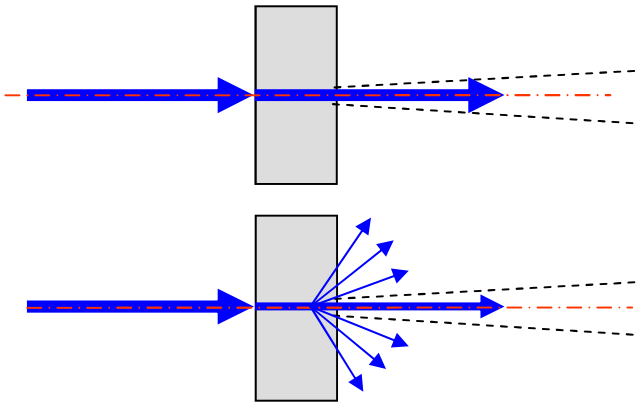
ECE-R43 Laboratory Set-up Description:

The ECE-R43 standard describes a measurement set-up limited to use in a **dark room laboratory** and useful only for the measurement of small size test samples. The measurement set-up is that of a collimated light beam with flat field detector. Particular emphasis is placed on low diffuse transmitted light sensitivity. **The light source** follows the Koehler design collimator with standard illuminant A spectrum of 2856 Kelvin. Aperture plates limit the beam diameter. The use of a tungsten lamp requires long burn-in phase for stabilization. **The receiver** is designed with an integrating sphere and photometric detector. The sphere offers the large diameter sensing area required. **The test sample** is positioned between the source and detector. The specified distance between the test sample and detector aperture limits the sensitivity for diffuse transmitted light. The limitation of this measurement set-up is it's size and operating procedure that prohibits use in mobile applications, for system integration and measurement of windshields. Also using an integral photometric detector makes the measurement set-up insensitive to test samples with variable spectral transmission.

LCRT-2005-S Light Transmission Meter:
Gigahertz-Optik's LCRT-2005-S spectrophotometer is designed for applications requiring a mobile instrument, like transmission measurement of auto windshields already installed in the vehicle. It is also suitable for system integration. It features a unique two-sensor design including light source and receiver spectrometers working in coordination with integral sensors and targeting camera for optical alignment for precise, ambient light independent and rapid measurement of luminous transmission.

Application Note: Real In-Line Transparency of Scattering Samples

Plexiglas Window with Scratches

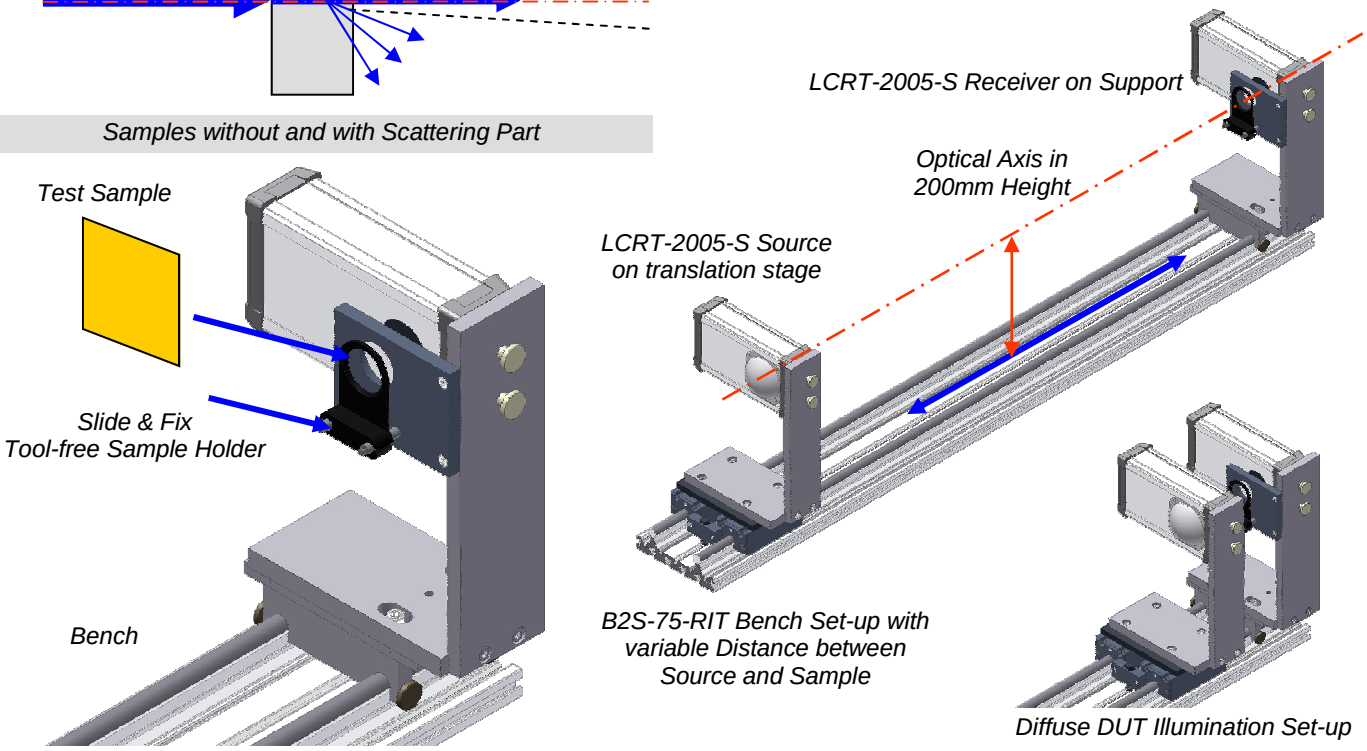


Samples without and with Scattering Part

The term **fully transparent** should only be used to describe materials that exhibit clear images. Scratches on windows or the internal structure of transparent material (e.g. transparent ceramics) reduce clear images by scattered light. The measurement of transparency requires a spectrophotometer with **very narrow illumination and measurement aperture** since only non scattered in-line transmitted light contributes to clear images.

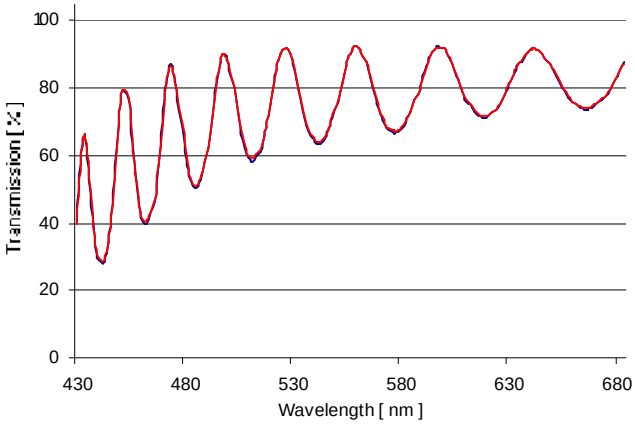
Spectrophotometers with a 3 to 5° aperture are quite common. But for reliable characterization of the real in-line transmission it is important to measure the inline intensity with as small an aperture as possible to exclude any scattered light. Since a zero degree aperture is impractical a very small aperture (e.g. 0.5°) has to be used.

At 0.4°, the full angle measurement aperture of the LCRT-2005-S is narrower than most commercially available spectrophotometers enabling real in-line transmission measurement. To achieve a narrow beam sample illumination a long distance of about 1m is necessary between source and sample. The long distance measurement mode of the LCRT-2005-S supports the alignment of source and receiver. It is best to use a stable bench set-up such as the B2S-75-RIT for simple use and reproducible measurements. The translation stage of the B2S-75-RIT bench set-up enables simulation of different illumination angles of the device under test.



B2S-75-RIT Bench Set-up for 0/0 and "Real In-Line" Measurement of Transmission and Transparency of Samples with Scattering Components with Spectrophotometer LCRT-2005-S

Application Note: Measurement of Optical Interference Effects



Spectral Transmission of Transparent Interference Filter measured with 1nm resolution in diffuse and parallel illumination conditions

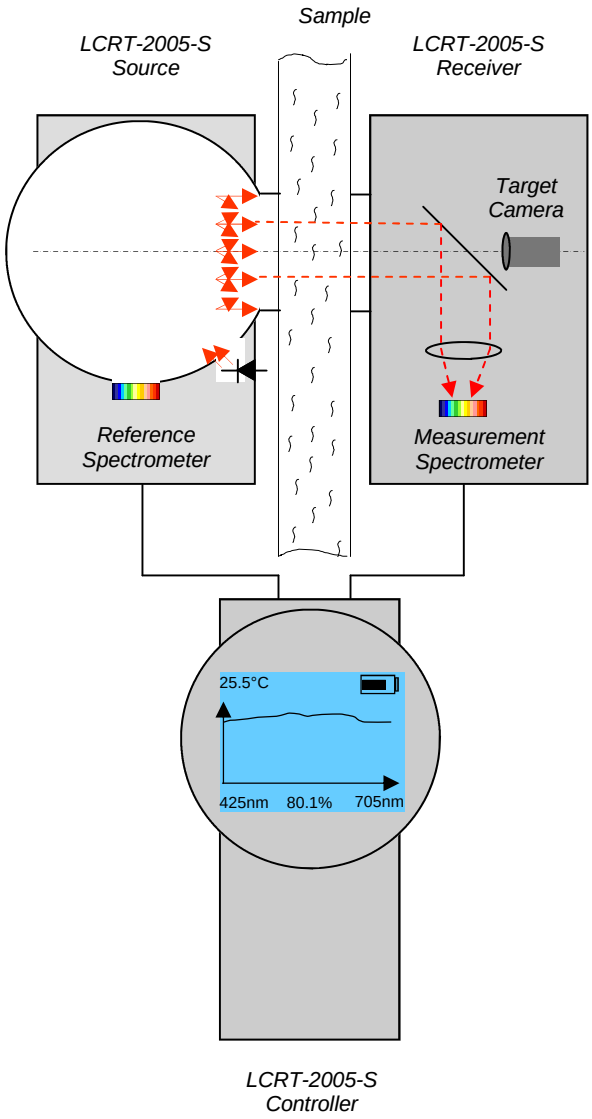
The measurement of spectral transmission of interference filters is one of the common applications of standard spectrophotometers in the optics and lighting industries. Beside the desired effect of tailoring spectral transmission, interference coatings are used for antireflection purposes in displays, windows and other materials. However, interference effects can also be produce by the thin layers of sandwich constructed windows, protection coatings on plastic windows and others.

Uncontrolled interference effects can cause limitations in clear imaging or color drifts under the influence of quasi monochromatic light sources. For process control and incoming inspection in the visible spectrum the LCRT-2005-S is a inexpensive alternative to other commercially available spectrophotometers. Plus LCRT-2005-S has no maximum sample size limitation enabling uniformity testing on large size samples.

Combined with the B2S-75-RIT bench spectral transmission can be measured with diffuse or parallel sample illumination. The spectral plot graphic shows the spectral transmission of an interference filter with diffuse and parallel illumination. Because of the filter transparency, as expected, there is no difference between the two different measurement conditions.

Device Description

LCRT-2005-S Receiver - Source - Controller



LCRT-2005-S Principal Device Set-up

The **LCRT-2005-S manufactured by Gigahertz-Optik** is designed for precise luminous transmission measurements in mobile and stationary applications.

The LCRT-2005-S is a portable instrument for the measurement of the regular (In-Line) transmission of windows, glazing, instrumentation cover glass and others with and without reflection reducing coatings in the laboratory or on site.

The measurement set-up is identical to the luminance set-up in CIE 130 and DIN 5036. Both detectors for light source reference and transmittance are compact BTS256 diode array sensors manufactured by Gigahertz-Optik.

Device Description

Uniform light source with compact *integrating sphere* offers a uniform sample illumination with large diameter luminance area. The rugged ODM98 sphere coating and the semiconductor white LED light source ensure long life. The LED pulse modulation suppresses ambient light effects and extends battery operation time.
A BTS256 reference detector provides light source spectral data making the transmission measurement independent of emission spectrum changes due to substitution effects from the test sample and the source emission spectrum. The reference detector spectral measurement data is used to calculate standard illuminant A or D65 or monochromatic transmission at specified wavelength.

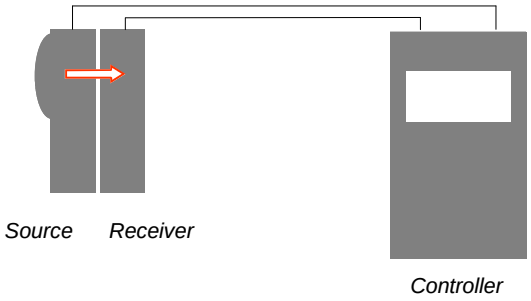
Receiver designed as a luminance meter offers an achromatic corrected narrow viewing angle of 0.4°. This very narrow angle accepts only 'real' regular or in-line transmitted light. A BTS256 sensor measures the spectral data of the light source for the 100%reference value and of the transmitted light. The photometric transmission is calculated by the spectral measurement data.
A compact CCD camera viewing in the measure-ment axis of the receiver supports the alignment of the receiver to the light source.

Controller supports the measurement set-up, the measurement itself and documentation employing simple four button operation. It's compact size housing with silicon edge 'bumper' protection holds four AA type batteries to provide long operation time without need for AC power. A backlit monochromatic display features large digit size for easy reading and also supports receiver to light source alignment. The controller is supplied with a USB interface for remote control operation of the LCRT-2005-S.The IR printer interface can be used to printout results.

Optional B2S-75-RIT Bench to set-up the LCRT-2005-S for stationary use. The translation stage of the B2S-75-RIT bench set-up enables simulation of different illumination angles of the device under test.

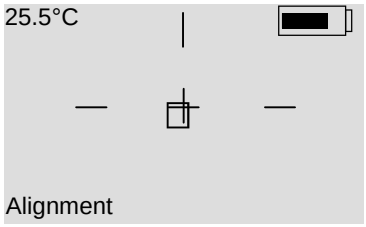
Three Step Measurement Procedure in Mobile Use

I. 100% Adjustment

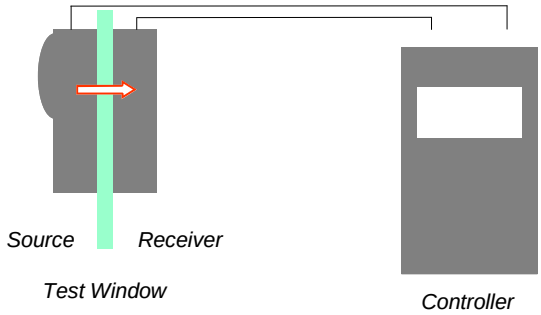


- A set 100% adjustment of the instrument is required before measurement
- For the 100% adjustment the source and receiver must be paced together and aligned
- 100% adjustment is initialized at the controller

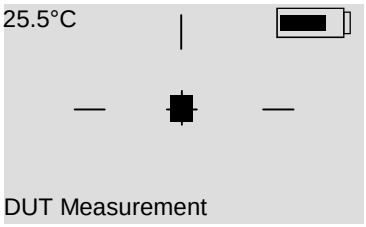
II. DUT Alignment

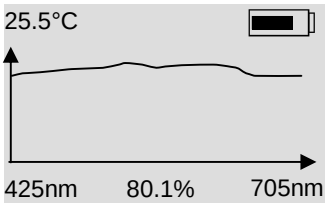


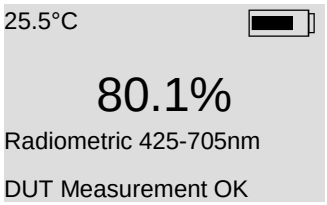
Before the DUT (device under test) measurement the light source and receiver are attached to the DUT and aligned

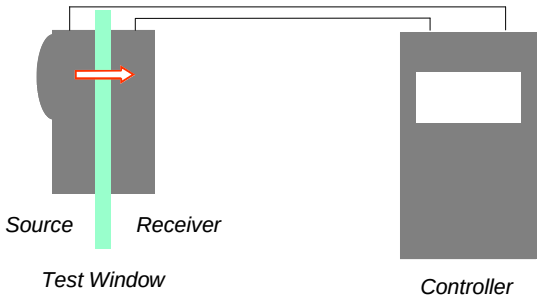


III. DUT Measurement



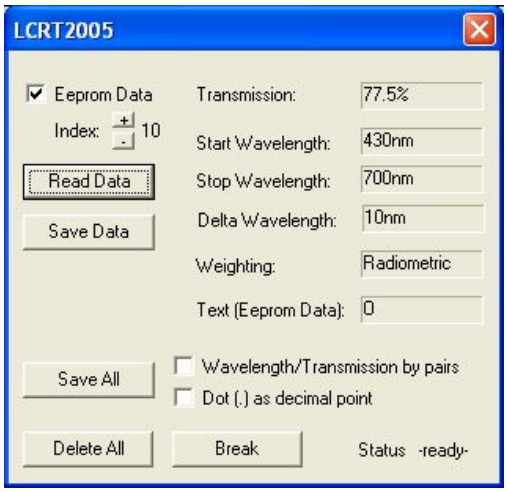


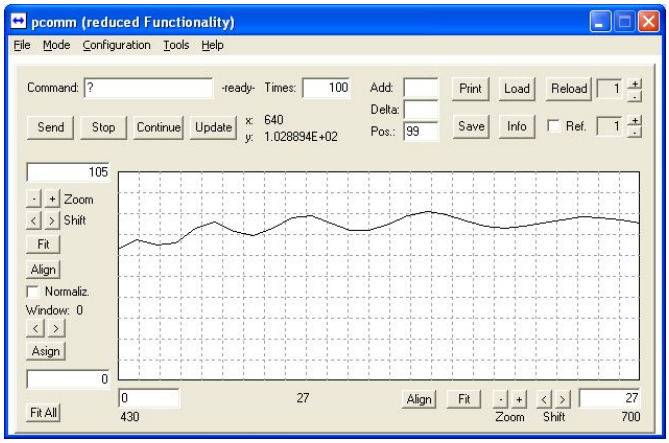


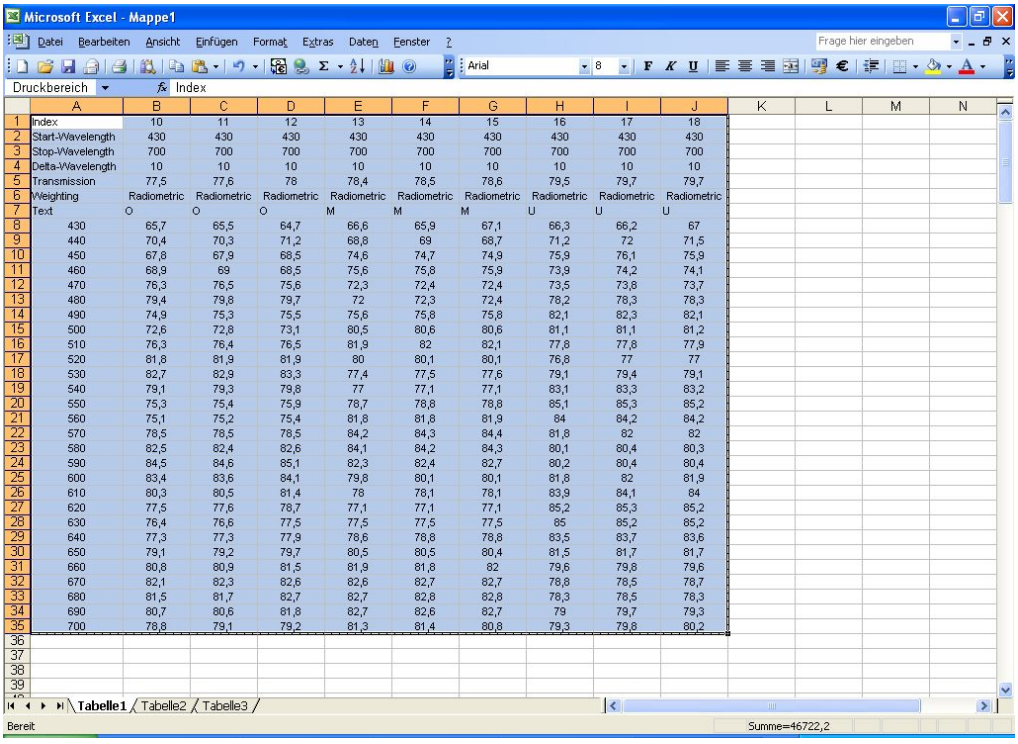


- After alignment measurement is started automatically. Alignment position is monitored by the instrument.
- The spectral transmittance measured can be displayed in numbers or graphic
- Several successive measurements can be performed using the set 100% as reference value

LCRT-2005-S Data Read-out Software







	A	B	C	D	E	F	G	H	I	J
1	Index	10	11	12	13	14	15	16	17	18
2	Start-Wavelength	430	430	430	430	430	430	430	430	430
3	Stop-Wavelength	700	700	700	700	700	700	700	700	700
4	Delta-Wavelength	10	10	10	10	10	10	10	10	10
5	Transmission	77,5	77,6	78	78,4	78,5	78,6	79,5	79,7	79,7
6	Weighting	Radiometric	Radiometric	Radiometric	Radiometric	Radiometric	Radiometric	Radiometric	Radiometric	Radiometric
7	Text	O	O	O	M	M	M	U	U	U
8	430	65,7	65,5	64,7	66,6	65,9	67,1	66,3	66,2	67
9	440	70,4	70,3	71,2	68,8	69	68,7	71,2	72	71,5
10	450	67,8	67,9	68,5	74,6	74,7	74,9	75,9	76,1	75,9
11	460	68,9	69	68,5	75,6	75,8	75,9	73,9	74,2	74,1
12	470	76,3	76,5	75,6	72,3	72,4	72,4	73,5	73,8	73,7
13	480	79,4	79,8	79,7	72	72,3	72,4	78,2	78,3	78,3
14	490	74,9	75,3	75,5	75,6	75,8	75,8	82,1	82,3	82,1
15	500	72,6	72,8	73,1	80,5	80,6	80,6	81,1	81,1	81,2
16	510	76,3	76,4	76,5	81,9	82	82,1	77,8	77,8	77,9
17	520	81,8	81,9	81,9	80	80,1	80,1	76,8	77	77
18	530	82,7	82,9	83,3	77,4	77,5	77,6	79,1	79,4	79,1
19	540	79,1	79,3	79,8	77	77,1	77,1	83,1	83,3	83,2
20	550	75,3	75,4	75,9	78,7	78,8	78,8	85,1	85,3	85,2
21	560	75,1	75,2	75,4	81,8	81,8	81,9	84	84,2	84,2
22	570	78,5	78,5	78,5	84,2	84,3	84,4	81,8	82	82
23	580	82,5	82,4	82,6	84,1	84,2	84,3	80,1	80,4	80,3
24	590	84,5	84,6	85,1	82,3	82,4	82,7	80,2	80,4	80,4
25	600	83,4	83,6	84,1	79,8	80,1	80,1	81,8	82	81,9
26	610	80,3	80,5	81,4	78	78,1	78,1	83,9	84,1	84
27	620	77,5	77,6	78,7	77,1	77,1	77,1	85,2	85,3	85,2
28	630	76,4	76,6	77,5	77,5	77,5	77,5	85	85,2	85,2
29	640	77,3	77,3	77,9	78,6	78,8	78,8	83,5	83,7	83,6
30	650	79,1	79,2	79,7	80,5	80,5	80,4	81,5	81,7	81,7
31	660	80,8	80,9	81,5	81,9	81,8	82	79,6	79,8	79,6
32	670	82,1	82,3	82,6	82,6	82,7	82,7	78,8	78,5	78,7
33	680	81,5	81,7	82,7	82,7	82,8	82,8	78,3	78,5	78,3
34	690	80,7	80,6	81,8	82,7	82,6	82,7	79	79,7	79,3
35	700	78,8	79,1	79,2	81,3	81,4	80,8	79,3	79,8	80,2

Measurement data can be exported into spreadsheet type programs such as Excel for further manipulation.

The LCRT-2005-S provides internal memory for data storage of up to 100 measurement values. The stored data can be download into a computer for reporting and documentation or data back-up purposes using software supplied with the instrument.

The supplied software contains a control and display window to facilitate the download of real time displayed data or data stored in the LCRT-2005-S Eeprom memory. Single readings can be downloaded using the measurement index number. Readings as well as the measurement parameters for the selected index are displayed for easy selection. Plus all data in a group of measurements can be downloaded.

Spectral transmission measurement data for the selected measurement index is displayed in the graphics window.

Specifications

LCRT-2005-S	
Measurement Set-up	CIE 130 & DIN 5036 luminance ratio method with diffuse light source (Inverse ECE R43 set-up); BTS256 Diode array detectors for reference and measurement signal
Measurement Conditions	0.38° field of view; Incident angle on test sample 0°; 6.6 mm beam diameter at zero measurement distance. 12.6mm beam diameter at 1000mm measurement distance
Light Source	Integrating sphere with white light source; Diode array reference detector
Detector	Radiance sensor with diode array spectrometer and achromatic corrected optic; Simulation of Illuminant A, D65 sample illumination by spectral measurement data
Transmittance Measurement Range	5 to 100 % at color neutral attenuation
Transmittance Uncertainty	± 1 % absolute
Transmittance Resolution	0.1 %
Calibration	Transmission measurement without sample for 100% adjustment
	Transmission measurement with calibrated transmittance standard filter
Operation Temperature, Humidity	+ 10 to + 40 deg C (above dew-point); <85% at the instrument

LCRT-2005-S Source	
Light Source	LEDs in pulse mode; Useful emission spectrum from 425nm to 705nm; Pulse synchronization to receiver via controller
	Lambert source with ODM98 integrating sphere; 20 mm diameter light output port; Protective front window
	BTS-256P reference detector; Shutter for On-line offset
Controller Connection	1.5m length flexible cable with connectors; RS232 protocol with 115.2 kbaud
Dimensions	160 x 45 (60) x 85 mm
Weight	450 g

LCRT-2005-S Receiver	
Detector	BTS-256P detector with achromatic corrected front lens; Pulse synchronized to light source via controller
Measurement Aperture	0.38° field of view; Incident angle on test sample 0°; 6.6mm beam diameter at zero measurement distance. 12.60mm beam diameter at 1000mm distance
Controller Connection	1.5m length flexible cable with connectors; RS232 protocol with 115.2 kbaud
Dimensions	160 x 45 x 85 mm
Weight	400 g

LCRT-2005-S Controller	
Source and Receiver Input	Two sockets
Display	Back lit monochromatic display with on/off function
Parameter Settings	Menu controlled parameter set-up. Retention of last settings in continuous memory. Four function buttons.
Remote Interface	USB
Printer Interface	IR LED
Operating Temperature	10 to 40° C
Dimension	230 x 72 (115) x 35 (50) mm
Weight	400 g
Battery	4 x AA Type; Alternative 4 x re-chargeable AA Type Batteries

Ordering Information	
LCRT-2005-S	Light Transmission Meter, Light Source, Receiver, Controller, Software, Hard Case, Manual
B2S-75-RIT	1m long Bench with translation stage and sample holder for short and long distance measurements with LCRT-2005-S; Requires dark-room conditions

Gigahertz-Optik

Product Overview

Light Analyzer
- Photometer, Radiometer
- Colorimeter, Luminous Color Meter, Source Color Meter
- Spectral Data
- LIV source tester
- Lamp, LED, Display

Optometers
- Mobile, Stationary
- Single & multi channel
- UV-VIS-NIR detectors
- Photometric detectors
- Color detectors

Light Detectors
- Photometric
- UV-NIR Radiometric
- Luminous Color
- Photobiology
- Plant Physiology

Reflectance Material
- White & grey PTFE
- Raw Material
- Machined Parts
- ODP97 BaSO4 paint
- Painting Services

Integrating Spheres
- Flux Photometer
- Power Radiometer
- Uniform Source
- Radiant Standard
- Material Properties

Material Properties
- Light Reflectance
- Light Transmittance
- Light Absorbance
- DIN5036, ECExxx
- ECE R43

Calibration Standards
- Light Sources
- Uniform Sources
- Radiance Standards
- Light Detectors
- Reflection Standards

Calibration Service
- UV-VIS-IR Radiation
- Spectral Sensitivity
- Reflectance
- Transmittance
- Traceability

Contract Measurement
- Radiation Evaluation
- Light Hazard
- Expert Assessment & Report

Accessories for
- Lightmeters
- Light Detectors
- Integrating Spheres

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