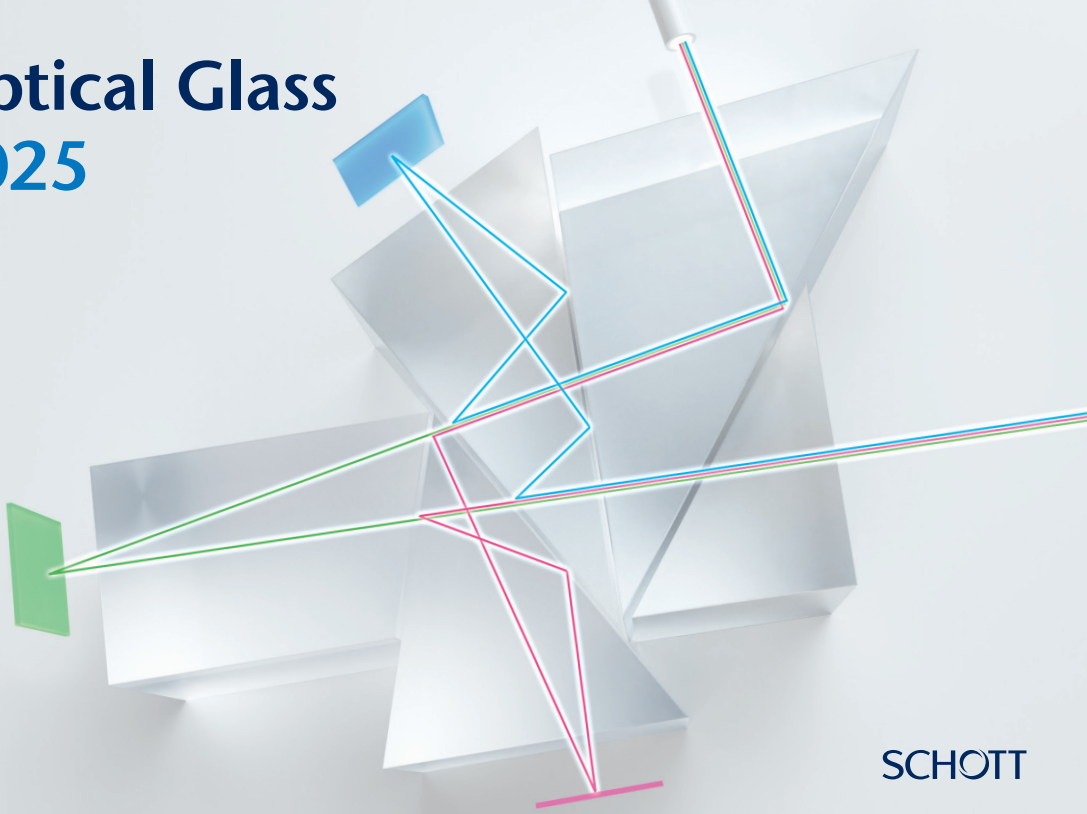
Optical Glass
2025



SCHOTT

Optical Glass 2025

Description of Properties

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Cover Picture
The cover shows a prism set for laser-based 3 DLP® projectors used in cinemas and at events. Our high-tech material N-BK7HTSultra improves the image quality.

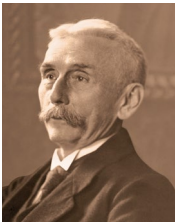
Foreword

SCHOTT Advanced Optics –
Your Partner for Excellence in Optics.

SCHOTT is an international technology group that is active in the areas of specialty glasses and glass-ceramics. The company has more than 140 years of outstanding development, materials and technology expertise and we offer a broad portfolio of high-quality products and intelligent solutions, thus contributing to our customers' success.

Today, SCHOTT's Advanced Optics unit offers optical materials, components and filters and has been a trailblazer for various applications. With a product portfolio of over 120 optical glasses, special materials (e.g. active laser glass, IR-Materials, sapphire), ceramic converters, high-precision optical components, wafers, and optical filter glasses, Advanced Optics develops customized solutions all over the world for applications in optics, lithography, astronomy, opto-electronics, life sciences, research, and more.

Advanced Optics masters the entire value chain: from customer-specific glass development and its production all the way to high-precision optical product finishing, processing and measurement.



Company founder:
Otto Schott (1851–1935)

For more information on Advanced Optics, please visit our website:
www.schott.com/advanced-optics

New

What's new?

SCHOTT Advanced Optics maintains top-tier quality standards and employs cutting-edge techniques in glass manufacturing. This dedication enables us to provide a diverse array of products for optical and industrial uses, adhering to the strictest tolerances and adapting to evolving market trends and customer demands. Our long-standing expertise in optical glass continues to be fundamental to our latest innovations. In the current market landscape, photonics and optical glasses are crucial for advancements in areas such as Industry 4.0, autonomous driving, digitalization, augmented reality, and the Internet of Things (IoT), among others. Ongoing developments ensure that we can meet the high expectations of our global clientele with our optical glass offerings.

The photonics market for digital projectors requires optical glass with highest resilience to solarization due to strong light intensities inside of the installed prisms. SCHOTT has successfully finished the development of a N-BK7HT variant which is unveiled in this catalogue under the name N-BK7HTSultra. This glass type is carefully engineered to exhibit low solarization when exposed to strong blue light.

Due to the improved solarization features, N-BK7HTSultra can also be used in manufacturing laser applications and other photonics markets. This catalogue is introducing a further new glass type under the name N-SSK20 which also features low solarization under blue light exposure. Additionally, it demonstrates excellent UV transmission along with a comparatively high refractive index. Combining these properties this glass type is ideally suited for applications such as endoscopy or manufacturing laser equipment.

The latest application note "Optical Materials for Industrial Lasers" in chapter 12.4 outlines the criteria for materials used in this industry and provides a list of various compatible SCHOTT materials.

We also included chapter 1.5.2, "Blue Laser Solarization Stabilized Glasses," which details the characteristics of these glass types.

We have removed table 1.6 which shows high homogeneity glass type product dimensions from the optical glass catalogue, please refer to TIE-26.

Table 2.3 for stress birefringence has been revised slightly to improve clarity.

Since the last catalogue from 2022, SCHOTT has launched two new glass types in its portfolio. (1) N-BK7HTSultra is a N-BK7HT variant with supreme solarization resistance with respect to blue light irradiation. (2) N-SSK20 is an optical glass with high transmission in the UV, high resistance to solarization under blue light exposure and a comparatively high refractive index.

Improving the quality and processing ability of our products on a regular basis is extremely important to us at SCHOTT. To achieve this, we have made a few changes to some of our glass properties.

All of the glass products covered in this catalog meet the requirements of the RoHS II Directive and the REACH Regulations. If you require additional information that is not included in this catalog, please contact a local member of our global sales team. We are happy to work with you and develop a custom solution that meets your specific requirements. SCHOTT will continue to expand its product portfolio in the future and reserves the right to change the information contained in this catalog without prior notice. We have assembled the latest edition with the greatest care. Nevertheless, SCHOTT accepts no liability in the unlikely event that it contains any incorrect information or printing errors. The current catalog 06/2025 replaces all previous editions.

The legally binding version of this catalog is available on our website: www.schott.com/products/optical-glass/downloads

Advanced Optics
SCHOTT AG
Mainz
June 2025



Lloyd's Register Quality Assurance:
All plants of SCHOTT Advanced Optics in Mainz, Yverdon, Penang, and Duryea are certified

Further Product Information

One of SCHOTT's main objectives is to provide professional support in addition to supplying current products. Extensive technical mentoring, detailed product information and application support before and after a product is purchased and joint developments of customized solutions highlight our uniqueness. We offer detailed data sheets, databases for use with optical design programs and survey diagrams for all materials listed in this catalog. Electronic versions of technical information or so-called TIEs are also available.

The stamp shown here is placed within this catalog and indicates the availability of relevant Technical Information (TIE). An overview is shown on page 76 of this catalog. Detailed technical information can be found online at: www.schott.com/products/optical-glass/downloads



Optical Glass Catalog

In this **catalog,** you will find an overview of our optical glasses and materials that cover the needs of a wide range of applications from consumer products to optical systems at the cutting edge of research.

We address the following categories:

- "N"-glasses as a lead- and arsenic-free alternative to conventional glass types
- Classic glass types with lead oxide as an essential component for outstanding optical properties
- Optical glasses with enhanced transmission values in the visible spectral range, especially in the blue-violet range: HT & HTultra glasses
- Optical glass with enhanced solarization protection for blue laser applications: HTSultra glass
- High homogeneity glasses available from stock
- "P"-glasses for the precision molding process (Low T_g glasses)
- i-line glasses for microlithography
- Radiation resistant glass types
- XLD glasses (eXtreme Low Dispersion)

While addressing these different categories, SCHOTT distinguishes between Preferred Glass Types, usually kept in stock for immediate delivery, and **Inquiry Glass Types**, which can be ordered, although SCHOTT cannot guarantee that they will be in stock. Details are listed in the Part II Optical Glass – Properties section of the catalog.

Relevant definitions for the glasses listed in this catalog:

The optical data for the glasses listed in this catalog are meant for use in optical applications and therefore refer to air.

Supply Forms

SCHOTT offers **different supply forms** of the glasses available.
Detailed information is included in chapter 7.

Quality Management

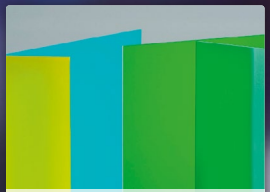
SCHOTT operates a globally centralized Management System. It integrates the requirements of ISO 9001 on Quality Management, ISO 14001 on Environmental Management, ISO 50001 on Energy Management and on the Policy and Standards of SCHOTT on Environmental, Health and Safety System in accordance with ISO 45001. This results in compliance with environmental regulations such as RoHS II and REACH (refer to chapter 3.6) and assures a high quality level (refer to chapter 6.1). In addition, SCHOTT implemented large parts of ISO12123:2018 "Optics and Photonics – Specification of Raw Optical Glass" and ISO 10110:2018. References are provided in the descriptions.

Welcome to our shop for optical materials

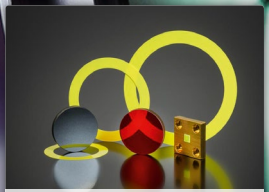
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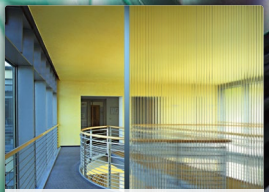
Optical Glass



Optical Filter Glass



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1 Optical Properties

1.1 Refractive Index, Abbe Number, Dispersions, Glass Designations

TIE-29 Refractive index and dispersion

The primary characteristics used to identify optical glass are the refractive index n_d in the middle range of the visible spectrum and the Abbe number $\nu_d = (n_d-1)/(n_F-n_C)$ as a measure for dispersion. The difference n_F-n_C is referred to as the principal dispersion.

Optical glass can also be identified by a numerical code, commonly referred to as the glass code. SCHOTT employs a nine-digit code for this purpose. The first six digits align with the international glass code, indicating the optical properties of the glass. The initial three digits represent the refractive index n_d, the next three digits denote the Abbe number ν_d, and the final three digits indicate the glass density.

Table 1.1: Examples of glass codes

Glass type	n_d	ν_d	Density	Glass code
N-SF6	1.80518	25.36	3.37	805254.337
SF6	1.80518	25.43	5.18	805254.518

When specifying optical systems, the values derived from the e-line n_e and $\nu_e = (n_e-1)/(n_{F'}-n_{C'})$ are other commonly established quantities.

Preferred optical glasses are categorized into families in the n_d/ν_d or n_e/ν_e diagram. These glass families are detailed in Part II Optical Glass – Properties section arranged by decreasing Abbe numbers.

1.2 Tolerances for Refractive Index and Abbe Number

The tolerances for the refractive index and Abbe number are listed in Table 1.2. The standard delivery quality for fine annealed glass is Step 3 for n_d and ν_d. We supply material in tighter steps upon request. Selected glass types can be delivered in Step 0.5 for refractive index and Abbe number. The available glass types are marked in the Part II Optical Glass – Properties section of the glass catalog. Step 0.5 is available for fine annealed optical glass as well as pressings.

Table 1.2: Tolerances for refractive index and Abbe number (grades according to ISO 12123:2018/ISO 10110-18:2018 in parentheses).

	n_d	ν_d
Step 0.5*	±0.0001 (NP010)	±0.1% (AN1)
Step 1	±0.0002 (NP020)	±0.2% (AN2)
Step 2	±0.0003 (NP030)	±0.3% (AN3)
Step 3	±0.0005 (NP050)	±0.5% (AN5)

* only for selected glass types

All deliveries of fine annealed optical glass are made in lots of single batches (see Fig. 1.1).

The batch can consist of a single block or multiple strips. Delivery lots are identified by a unique delivery lot number.

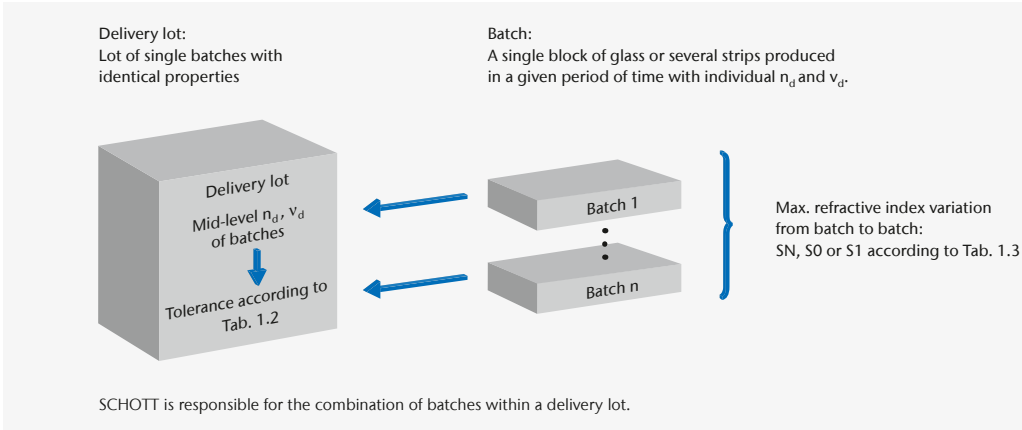
The delivery lots are organized according to the maximum permissible deviations in refractive index and Abbe number for individual batches from the nominal values specified in the data sheets (tolerances as per Table 1.2), as well as the refractive index variation from batch to batch as specified in Table 1.3.

Delivery lots of fine annealed glasses may consist of batches with varying annealing histories, rendering them unsuitable for repressing. All components of a delivery lot of fine-annealed optical glass, whether cut blanks or pressings, conform to the standard refractive index variation specified in Table 1.3. Upon request, parts can be provided in lots with tighter refractive index variations than those indicated in Table 1.3.

Table 1.3: Tolerance for refractive index variation within a lot of fine annealed glass and within a lot of pressings (grades according to ISO 12123:2018/ ISO 10110-18:2018 in parentheses).

Fine annealed glass, cut blanks		Pressings	
Designation	**Refractive index variation**	**Designation**	**Refractive index variation**
SN	$\pm 10 \cdot 10^{-5}$ (NV10)	LN	$\pm 20 \cdot 10^{-5}$ (NV20)
S0	$\pm 05 \cdot 10^{-5}$ (NV05)	LH1	$\pm 10 \cdot 10^{-5}$ (NV10)
S1	$\pm 02 \cdot 10^{-5}$ (NV02)	LH2	$\pm 5 \cdot 10^{-5}$ (NV05)

Fig. 1.1: Delivery lot compilation of glass for hot processing and fine annealed glass



1.3 Test Reports for Refractive Indices and Dispersions

1.3.1 Standard test reports

We provide standard test reports according to ISO 10474 for all deliveries of fine annealed optical glass. The information they contain is based on sampling tests and refers to the mid-level position of the optical values of a delivery lot. The value of the individual part may deviate from the reported mid-level value in terms of the tolerance of the refractive index variation.

Measurements are carried out with the v-block refractometer method with an accuracy of $\pm 3 \cdot 10^{-5}$ for refractive index and $\pm 2 \cdot 10^{-5}$ for dispersion. Numerical data is listed down to five decimal places.

Table 1.4: Refractive index and dispersion information in standard test reports

Optical position	n_d, ν_d, n_e, ν_e
Refractive index	n_g, $n_{F'}$, n_F, n_e, n_d, $n_{632.8}$, $n_{C'}$, n_C, n_r, n_s, n_t
Dispersions	$n_F - n_C$, $n_d - n_C$, $n_F - n_d$, $n_F - n_e$, $n_g - n_F$, $n_{F'} - n_{C'}$, $n_{F'} - n_e$

Test certificates that are even more accurate can be provided for individual glass parts upon request ($\pm 2 \cdot 10^{-5}$ for refractive index and $\pm 1 \cdot 10^{-5}$ for dispersion). These certificates also list the constants of the Sellmeier dispersion formula for the applicable spectral range evaluated from a complete measurement series.

1.3.2 Precision test certificates UV-VIS-IR

Precision test certificates are issued upon request and always refer to individual glass parts.

Within the visible spectral range, these certificates contain the same quantities as the test reports for standard accuracy, however the dispersion data is reported down to six decimal places. Upon request,

refractive index data can be provided for an expanded spectral range of 185 nm to 2325 nm and the constants of the Sellmeier dispersion formula can be listed for the applicable spectral range.

Measurements are carried out using a prism spectrometer. The accuracy is $\pm 1 \cdot 10^{-5}$ for refractive index and $\pm 3 \cdot 10^{-6}$ for dispersion. Accuracy of up to $\pm 4 \cdot 10^{-6}$ for the refractive index and $\pm 2 \cdot 10^{-6}$ for the dispersion measurement, independent of the glass type and measurement wavelength, can be provided upon request.

The measurement temperature is 22 °C. The measurement temperature can be changed to a constant value between 18 °C and 28 °C upon request. The standard measurement atmosphere is air at a pressure of about 1013.3 hPa. The actual measurement temperature and pressure are indicated on the individual test certificates. Measurements in a nitrogen atmosphere are possible upon special request.

1.4 Refractive Index Homogeneity

TIE-26 Homogeneity of optical glass

The refractive index homogeneity is a measure for designating deviations in the refractive index in individual pieces of glass. Pieces of glass with a high homogeneity of refractive index can be obtained by undertaking special efforts in the area of melting and fine annealing. The refractive index homogeneity that can be achieved depends on the type of glass, the volume and the shape of the individual glass piece.

The required optical homogeneity should be specified with respect to the application and the final dimensions of the optical component. This generally corresponds with the maximum refractive index variation within the desired testing aperture (e.g. 95 % of the physical dimension). The

refractive index variation is calculated from the interferometrically measured wavefront deformation. In many cases certain aberration terms with negligible impact on the application can be subtracted. For example, focal aberrations (expressed by the focal term) can often be corrected by adapting the geometry of the final part. This should be specified in advance. The gradient of the homogeneity distribution can be evaluated in terms of refractive index variation per cm aperture upon request. This too should be specified in advance. Increased requirements for refractive index homogeneity comprise five classes in accordance with the standard ISO 10110-18:2018 and ISO12123:2018 (see Table 1.5). The maximum deviation of refractive index is expressed in peak to valley values. Depending on the volume of the optical element and other factors, such as the type of glass and the size of the blank used, the measurement of the wavefront deformation is carried out on a single piece. Glass parts of up to 500 mm in diameter can be tested with the existing Fizeau-interferometer. Glass parts with diameters up to 1500 mm are measured in sub-apertures of up to 500 mm in diameter. Subsequently, the individual measurements are combined using a stitching software. Individual interferograms can be made available for each piece of glass.

Table 1.5: Homogeneity of optical glass (grades according to ISO 12123:2018/ ISO 10110-18:2018 in parentheses).

Homogeneity class	Maximum variation of refractive index	Applicability, deliverability
H1	$40 \cdot 10^{-6}$ (NH040)	For individual cut blanks
H2	$10 \cdot 10^{-6}$ (NH010)	For individual cut blanks
H3	$4 \cdot 10^{-6}$ (NH004)	For individual cut blanks, not in all dimensions
H4	$2 \cdot 10^{-6}$ (NH002)	For individual cut blanks, not in all dimensions, not for all glass types
H5	$1 \cdot 10^{-6}$ (NH001)	For individual cut blanks, not in all dimensions, not for all glass types

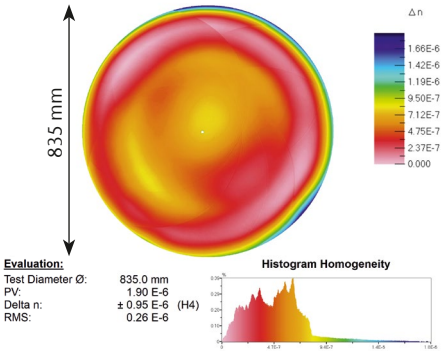


Fig. 1.2: H4 quality on 835 mm aperture after focus subtraction (stitching of individual measurements).

The refractive index homogeneity of pressings can not be measured directly. The evaluation is done by measurement of reference samples instead.

A special raw material selection and processing allows SCHOTT to produce pressings with homogeneities up to class H3 homogeneity for diameters below 65 mm.

1.4.1 High Homogeneity Glass available from stock

TIE-26 Homogeneity of optical glass

SCHOTT offers a selection of optical glasses as fine annealed cut blanks in high homogeneities from stock.

TIE-26 provides an overview of available glass types, maximum possible dimensions, and homogeneity levels. For smaller diameters, higher homogeneities are also available on request.

1.5 Internal Transmittance, Color Code



According to general dispersion theory, internal transmittance, i.e. the light transmittance excluding reflection losses, is closely related to the optical position of the glass type. Using the purest raw materials and sophisticated melting technology, it is possible to approach the dispersion limits for internal transmittance in the short wave spectral range.

SCHOTT seeks to achieve the best possible internal transmittance within economically reasonable limits.

The internal transmittance and color code listed in the Part II Optical Glass – Properties section represent median values from several melts of one glass type. Minimum values for internal transmittance can also be maintained for all glass types upon special request. Prior clarification of the delivery situation is necessary. The internal transmittance at 400 nm for a sample thickness of 10 mm is listed in the Part II Optical Glass – Properties section.

Some glasses are available with improved transmittance in the visible spectrum, especially in the blue-violet range. These products are marked with the suffix HT (High Transmittance) or HTultra (ultra High Transmittance) and will be shown separately in Part II Optical Glass – Properties section (like N-SF6HT or SF57HTultra). For HT and HTultra grade, the internal transmittance in the visible spectrum includes guaranteed minimum values. For HTSultra glass types such as N-BK7HTSultra small variations from the internal transmittance values are allowed.

The limit of the transmittance ranges of optical glasses towards the UV area is of particular interest in high index glasses because it moves closer to the visible spectral range with increases in the refractive index. A simple description of the position and slope of the UV absorption curve is shown by the color code.

The color code lists the wavelengths λ_{80} and λ_5 at which the transmittance (including reflection losses) is 0.80 and 0.05 at a thickness of 10 mm. The values are rounded off to 10 nm and denoted by eliminating the first digit. For example, color code 33/30 means λ_{80} = 330 nm and λ_5 = 300 nm.

For high index glass types with $n_d > 1.83$, the data of the color codes (marked by *) refers to the transmittance values 0.70 and 0.05 (λ_{70} and λ_5) because of the high reflection loss of this glass. The tolerance of the color code is ± 10 nm.

1.5.1 i-Line glasses

i-Line glasses are optical glass types, which offer both high UV-transmittance at 365 nm and high refractive index homogeneity. These glass types, such as FK5HTi, LF5HTi, N-SK5HTi, F2HTi, LLF1HTi and N-BK7HTi, are available in customized shapes and as final components.

i-Line glasses offer:
- High UV-transmittance at 365 nm
- High refractive index homogeneity (see Table 1.7)
- Excellent internal quality
- Negligible stress birefringence due to a well-defined annealing process
- Maximum refractive index variation per lot of less than $\pm 30 \cdot 10^{-6}$
- Extremely low solarization levels

Table 1.6: Refractive index homogeneity of i-line glasses relative to their dimensions

Dimension	Maximum variation of refractive index
Ø 150 mm	$0.5 \cdot 10^{-6}$
Ø 200 mm	$1.0 \cdot 10^{-6}$ (H5)
Ø 250 mm	$2.0 \cdot 10^{-6}$ (H4)

Table 1.7: Optical position, transmittance and solarization of i-Line glasses

Glass type				Solarization measurement according to JOGIS	
	n_d	ν_d	τ_i (10/365)	Rating	Achievable level
FK5HTi	1.48748	70.47	0.998	very good	< 7.5
N-BK7HTi	1.51680	64.17	0.994	very good	< 6
N-SK5HTi	1.58913	61.27	0.991	good	< 12
LLF1HTi	1.54815	45.9	0.997	excellent	< 2
LF5HTi	1.58144	40.89	0.996	excellent	< 1.5
F2HTi	1.62004	36.37	0.985	excellent	< 1.5

1.5.2 Blue laser solarization stabilized glasses

In recent years blue laser based solutions (wavelengths around 450 nm) became more and more present in industrial and commercial applications. Optical glasses are widely used in optical systems of blue light laser applications. These glasses must meet the stability requirements challenged by the steadily increasing power of blue lasers. High power blue laser irradiation can lead to a broad band transmittance reduction in the glass (induced extinction). Therefore, understanding and mitigating of this solarization phenomena is a prime challenge.

The blue laser solarization is characterized by using a light guide irradiation setup with a polished sample of 4 x 4 mm^2 cross section and 100 mm length. The sample is irradiated with a blue laser at 455 nm under standard test conditions of about 305 ± 5 W/cm^2 for three days. The induced extinction is characterized in units of 1/m sample length per wavelength.

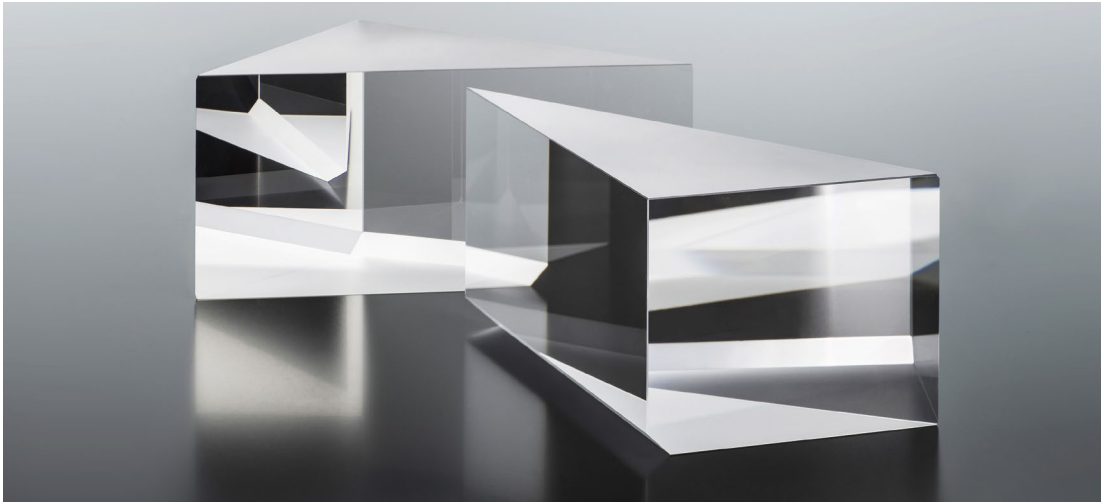
SCHOTT has improved the solarization of N-BK7HT and offers N-BK7HTSultra with a high degree of stabilization against blue laser solarization. The new glass type N-SSK20 features a high degree of solarization resistance against blue laser light as well. N-BK7HTSultra and N-SSK20 are only available as optical components, optimized for the application requirements.

Limit values for the induced extinction can be guaranteed at wavelengths 436 nm, 546 nm and 644 nm. Spectral extinction curves are available on request.

1.6 Measurement Capabilities for Optical Properties

Table 1.8 provides an overview of the measurement accuracy for methods used to characterize optical properties in the quality assurance of optical glass.

Property		Accuracy		Method	Spectral range	Sample	
		refr. index	dispersion			Shape	Format
Refractive index	standard	$\pm 3 \cdot 10^{-5}$	$\pm 2 \cdot 10^{-5}$	V-block refractometer	g, F′, F, e, d, C′, C (ν_d, ν_e)	cube	$20 \cdot 20 \cdot 5$ mm³
	increased	$\pm 2 \cdot 10^{-5}$	$\pm 1 \cdot 10^{-5}$		i, h, g, F′, F, e, d, C′, C, r, s, t (ν_d, ν_e)	cube	
	precision	$\pm 0.4 \cdot 10^{-5}$	$\pm 0.2 \cdot 10^{-5}$	Prism spectrometer (ISO21395-1:2020)	185 – 2325 nm	prism	side: 30 mm height: 22 mm
Internal transmittance		±0.5 % T ±0.3 % T		Spectro photometer	250 – 2500 nm 400 – 700 nm	cube	$30 \cdot 30 \cdot$ thickness in mm³
Refractive index homogeneity		~ 10 nm wavefront pv		Fizeau-Interferometer	633 nm	rectangular circular	up to ~ 1500 mm diameter
Temperature coefficients of refraction		$\pm 5 \cdot 10^{-7} \cdot K^{-1}$		Prism spectrometer	i, h, g, F′, e, d, C′, t –100 °C bis +140 °C	prism single side coated	side: 30 mm height: 22 mm
Precision measurement of stress birefringence		1 nm absolute (1 mm spatial resolution)		Imaging polarimeter	587 nm	arbitrary shape	up to 300 mm diameter



2 Internal Quality

2.1 Striae



Short range deviations of the refractive index in glass are called striae. They resemble layers of typical widths between tenths of a mm to the mm range.

The standard ISO 10110-18:2018 contains two methods for specifying striae. The first method specifies the density of striae. Since it refers to finished optical components, it is only applicable to optical glass in its original form of supply to a limited extent. It assigns the striae density to classes 1–4 based on the areal percentage of the test region that they obscure. Thus, it only considers striae that deform a plane wave front by more than 30 nm.

The fifth class specifies glass that is extremely free of striae. It also includes striae below 30 nm wave front distortion and advises the user to make arrangements with the glass manufacturer.

The production formats of all optical glasses by SCHOTT meet the requirements of density classes 1–4 of ISO 10110-18:2018. The tested glass thickness is usually much thicker than that of the finished optical components. Therefore, the effective striae quality in the optical system is much better.

Striae in optical raw glasses are defined in terms of wavefront deviations for 50 mm path length according ISO 12123:2018 and ISO 10110-18:2018. Striae are detected by means of the shadowgraph method using comparison standards with known wavefront deviations. The tolerance limits are shown in Table 2.1.

Table 2.1: Tolerance limits for striae (grades according to ISO 12123:2018/ISO 10110-18:2018 in parentheses).

Striae class	Striae wavefront deviation tolerance limit per 50 mm path length [nm]	Generally applicable for
Standard	≤ 30 (SW30)	Raw glass
B	≤ 15 (SW15)	Partial volume of raw glass
A	≤ 10 (SW10)	Partial volume of raw glass
VS1-3	not visible with shadow method	Cut blanks

Quality step VS specifies optical glass with increased striae selection. For optical glass in this quality category, no striae have been detected by the sensitive shadow method. For prism applications, SCHOTT offers quality step VS for 2 or 3 test directions perpendicular to one another.

2.2 Bubbles and Inclusions

TIE-28 Bubbles and inclusions in optical glass

Optical glass is remarkably free of bubbles. However, due to the glass composition and the need for an economical manufacturing process, bubbles cannot be completely avoided in glass.

The bubble content is expressed by the total cross section in mm^2 in a glass volume of 100 cm^3, calculated from the sum of the detected cross section of bubbles. Inclusions in glass, such as stones or crystals, are treated as bubbles that have the same cross section. The evaluation considers all bubbles and inclusions ≥ 0.03 mm.

The maximum allowable total cross sections and maximum allowable quantity of bubbles and inclusions are listed in Table 2.2. In the increased quality steps VB (increased bubble selection) and EVB (extra increased bubble selection), the glasses can only be supplied as fabricated pieces of glass.

In accordance with ISO 12123:2018, bubbles may be distributed. Instead of a bubble with a given dimension, a larger quantity of bubbles of smaller dimensions is allowed.

Table 2.2: Limit values for bubbles and inclusions in optical glasses (grades according to ISO 12123:2018 in parentheses).

Quality of bubbles	Standard (IC03/IN010)	VB	EVB
Total cross section in mm^2 per 100 cm^3	0.03	0.02	0.006
Maximum allowed quantity per 100 cm^3	10	4	2

Special applications, such as high energy lasers, beam splitter prisms or streak imaging cameras and high pitch gratings, only tolerate glasses that have a small number of tiny bubbles/inclusions. We can offer glass that meets these requirements upon request.

2.3 Stress Birefringence



The size and distribution of permanent inherent stress in glass depends on the annealing conditions, the glass type, and the dimensions. The extent to which stress causes birefringence depends on the glass type.

Stress birefringence is measured as a path difference using the de Sénarmont and Friedel method and is listed in nm/cm based on the test thickness. Its accuracy is 3 – 5 nm for simple geometric test sample forms. Measurements are carried out on round discs at a distance of 5 % of the diameter from the edge. For rectangular plates, the measurement is taken at the center of the longer side at a distance of 5 % of the plate width. A detailed description of this method can be found in ISO 11455.

The manual de Sénarmont and Friedel method is insufficient for measurements of low stress birefringence and low thickness. In these cases, we have systems for measuring with an accuracy of ± 1 nm.

With our annealing methods, we are able to achieve both high optical homogeneity and very low stress birefringence. The pieces of glass that are delivered generally have symmetrical stress distribution. The glass surface is usually under compression. Stress birefringence can be reduced significantly by cutting block or strip glass. If the optical elements are much smaller than the raw glass format they are made of, then the remaining stress birefringence will be even lower than the limiting values shown in Table 2.3.

The limit values for stress birefringence in parts larger than 600 mm are available upon request.

Higher stresses are allowed in glass used for reheat pressing. This has no effect on mechanical processing.

Table 2.3: Limit values of stress birefringence in cut blanks for various dimensions (diameter (diam.)/diagonal (diag.) and thickness (t)) (grades according ISO 12123:2018)

Dimensions		max. stress birefringence [nm/cm]		
Diam./diag. [mm]	t [mm]	Standard/ Fine annealing (STD)	Special annealing (SK)	Precision annealing (SSK)
≤ 300	≤ 50	10	6 (SB06)	4 (SB04)
> 300 and ≤ 600	≤ 100	12 (SB12)	8	6 (SB06)
> 300 and ≤ 600	> 100 and < 200	20 (SB20)	on request	
larger dimensions/thicknesses		on request		

3 Chemical Properties

TIE-30 Chemical properties of optical glass

The chemical durability of polished glass surfaces depends on the composition of the optical glass. Phosphate crown (PK) and fluor crown (FK) glasses are more sensitive to acidic or alkaline attack compared to borosilicate glasses (e.g. SCHOTT N-BK7®) Therefore, special care has to be taken during the polishing, cleaning and protection of processed surfaces of sensitive glass types.

Please contact us for further information.

The five test methods described below are used to assess the chemical durability of polished glass surfaces.

3.1 Climatic Resistance

Climatic resistance describes the behavior of optical glasses at high relative humidity and high temperatures. A film of white stains can develop on the surface of sensitive glasses that generally cannot be wiped off.

An accelerated procedure is used to test the climatic resistance of the glass, in which polished, uncoated glass plates are exposed to water vapor saturated atmosphere, the temperature of which alternates between 40 °C and 50 °C. This produces a periodic change from moist condensation on the glass surface and subsequent drying.

The glass plates are removed from the climatic chamber after 30 hours of exposure time. The difference in ΔH between the haze before and after testing is used as a measure of the resulting surface change. The measurements are carried out using a spherical hazemeter. Classification is

done based on the increase in transmittance haze ΔH after a 30-hour test period. Table 3.1 lists the climatic resistance classes.

Table 3.1: Classification of optical glasses in climatic resistance classes CR 1– 4

Climatic resistance class CR	1	2	3	4
Increase in haze ΔH	< 0.3 %	≥ 0.3 % < 1.0 %	≥ 1.0 % < 2.0 %	≥ 2.0 %

The glasses in class CR 1 show no visible attacks after being exposed to climatic change for 30 hours. Under normal humidity conditions during the fabrication and storing of optical glass in class CR 1, no surface attack can be expected. On the other hand, class CR 4 optical glasses should be manufactured and stored with caution because these glasses are highly sensitive to environmental influences.

When storing optical polished elements, we recommend applying a protective coating and/or ensuring that relative humidity is kept as low as possible.

3.2 Stain Resistance

The test procedure provides information on possible changes in the glass surface (stain formation) under the influence of slightly acidic water (for example perspiration, acidic condensation) without vaporization.

The stain resistance class is determined using the following procedure: The plane polished glass sample to be tested is pressed onto a test cuvette, which

has a spherical depression of max. 0.25 mm depth that contains a few drops of a test solution.

Test solution I: sodium acetate buffer pH = 4.6
Test solution II: sodium acetate buffer pH = 5.6

Interference color stains develop as a result of decomposition of the surface of the glass by the test solution. The measure for classifying the glass is the time that elapses before the first brown-blue stain occurs at a temperature of 25 °C. Changes in color correspond to certain thicknesses of the surface layer that were previously determined on reference samples. A brown-blue change in color indicates a chemical change in the surface layer of 0.1 µm thickness insofar as the glass is able to form layers. Table 3.2 lists the stain resistance classes.

Table 3.2: Classification of optical glasses in stain resistance classes FR 0–5

Stain resistance class FR	0	1	2	3	4	5
Test solution	I	I	I	I	II	II
Time (h)	100	100	6	1	1	0.2
Stain development	no	yes	yes	yes	yes	yes
Color change	no	yes/no	yes	yes	yes	yes

Stain resistance class FR 0 contains all glasses that show virtually no interference colors, even after 100 hours of exposure to test solution I. Glasses in classification FR 5 must be handled with particular care during processing.

3.3 Acid Resistance

Acid resistance describes the behavior of optical glass that comes in contact with larger quantities of acidic solutions (for example: perspiration, laminating substances, carbonated water, etc.). Acid resistance is determined according to ISO 8424 (1996).

Acid resistance is denoted by either a two or a three digit number. The first or first two digits indicate the acid resistance class SR. The last digit, which is separated by a decimal point, indicates the visible surface changes that occurred as a result of exposure. The last digit is discussed in Chapter 3.5.

The time required to dissolve a layer with a thickness of 0.1 µm at 25 °C serves as a measure of acid resistance. Two aggressive solutions are used to determine acid resistance. A strong acid (nitric acid, c = 0.5 mol/l, pH 0.3) is used for the more resistant glass types, whereas glasses with lower acid resistance are exposed to a weak acidic solution with a pH value of 4.6 (sodium acetate buffer). The layer thickness is calculated from the weight loss per surface area and the density of the glass. Table 3.3 lists the acid resistance classes.

Table 3.3: Classification of optical glasses in acid resistance classes SR 1–53

Acid resistance class SR	1	2	3	4	5		51	52	53
pH value	0.3	0.3	0.3	0.3	0.3	4.6	4.6	4.6	4.6
Time (h)	> 100	10–100	1–10	0.1–1	< 0.1	> 10	1–10	0.1–1	< 0.1

Class SR 5 forms the transition point between the more acid resistant glasses in SR 1–4 and the more acid sensitive glasses in SR 51–53. Class SR 5 includes glasses for which the time for removal of a layer thickness of 0.1 µm at a pH value of 0.3 is less than 0.1 h and at a pH value of 4.6 is greater than 10 hours.

3.4 Alkali and Phosphate Resistance

Both test methods are used to classify the resistance of glasses to aqueous alkaline solution in excess and use the same classification scheme.

The alkali resistance indicates the sensitivity of optical glass in contact with warm, alkaline liquids, such as cooling liquids in grinding and polishing processes. Alkali resistance is determined according to ISO 10629 (1996).

Phosphate resistance describes the behavior of optical glass during cleaning with washing solutions (detergents) that contain phosphates. Phosphate resistance is determined according to ISO 9689 (1990).

Both alkali and phosphate resistance are denoted using two digits separated by a decimal point. The first digit lists the alkali resistance class AR or the phosphate resistance class PR, and the decimal indicates the visible surface change that occurs as a result of exposure.

The alkali resistance class AR indicates the time needed to remove a 0.1 µm layer thickness of glass in an alkaline solution (sodium hydroxide, c = 0.01 mol/l, pH = 12) at 50 °C.

The phosphate resistance class PR indicates the time needed to remove a 0.1 µm layer thickness of glass in a solution that contains alkaline

phosphate (pentasodium triphosphate $Na_5P_3O_{10}$, c = 0.01 mol/l, pH = 10) at a temperature of 50 °C. The layer thickness is calculated from the weight loss per surface area and the density of the glass. Table 3.4 lists the alkali and phosphate resistance classes.

Glasses in class 1 are more resistant to the test solutions than the glasses in class 4. The digit behind the classification identifies the visible surface change that occurs following exposure. The digits are covered in Chapter 3.5.

Table 3.4: Classification of the optical glasses in alkali resistance classes AR 1–4 and phosphate resistance classes PR 1–4

Alkali resistance class AR, Phosphate resistance class PR	1	2	3	4
Time (h)	> 4	1–4	0.25–1	< 0.25

3.5 Identification of Visible Surface Changes

Changes in the surface of the exposed samples are evaluated qualitatively with the naked eye. The definition of the digits behind the classification for acid, alkali, and phosphate resistance is as follows:

.0 no visible changes

.1 clear, but irregular surface (wavy, pockmarked, pitted)

.2 staining and/or interference colors (slight, selective leaching)

.3 tenacious thin whitish layer (stronger, selective leaching, cloudy/hazy/dullish surface)

.4 adhere loosely, thick layer, such as insoluble, friable surface deposits (maybe a cracked and/or peelable surface, surface crust, or cracked surface; strong attack)

3.6 Environmental Aspects, RoHS and REACH

Advanced Optics manufactures, processes, and distributes its materials in accordance with SCHOTT's EHS (Environment, Health, and Safety) management system and adheres to the objectives and procedures of our quality management system. The handling of raw materials, melting of batches and hot forming is done in accordance with established safety procedures. Sludge from cutting, grinding and polishing is treated according to the waste and disposal procedures stipulated by local authorities.

All optical materials in this catalog comply with the requirements of European Directive 2011/65/EU (RoHS II). They do not contain any mercury (Hg), chromiumVI (CrVI), cadmium (Cd), flame retardants PBB and PBDE, Bis (2-ethylhexyl) phthalate (DEHP), Butyl benzyl phthalate (BBP), Dibutyl phthalat (DBP), or Diisobutyl phthalate (DIBP). "N" and "P" glass types comply with the maximum concentration value of 0.1% for lead specified in Annex II of RoHS II. Some classical glass types contain lead oxide to ensure the specific optical characteristics of these products. They are in compliance with RoHS due to exemption 13a documented in Annex III of RoHS II.

In addition, all materials discussed in this catalog comply with the requirements of the European Regulation 1907/2006/EC (REACH: Registration, Evaluation and Authorization of Chemicals).

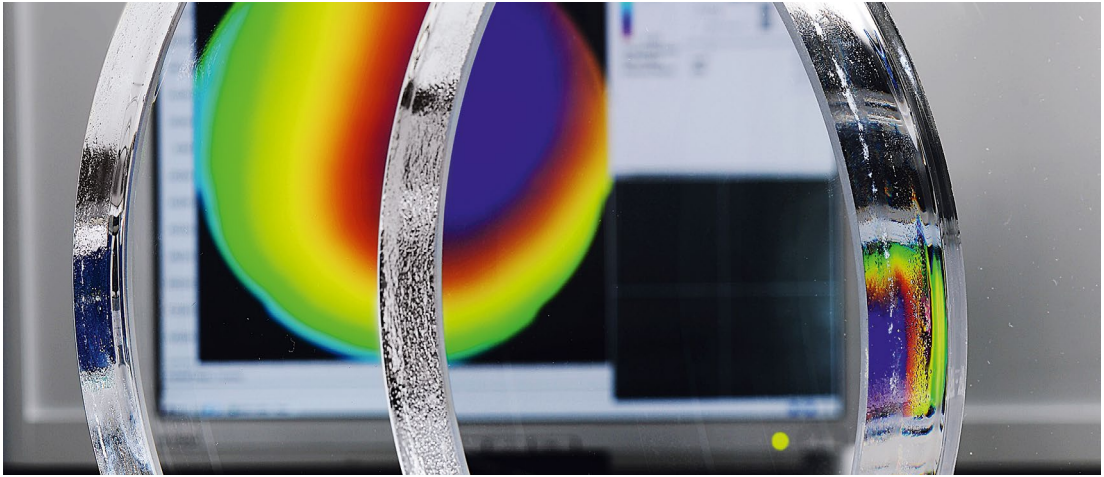
Assuring the availability of our optical raw glass portfolio for all customer applications starts with the material development process. All innovations follow a precise substance and legal requirement gate process in compliance with RoHS II, REACH, and corresponding global requirements.

While updates on legal requirements are traced regionally by external professional specialists in Europe/Africa, the Americas, and Asia, SCHOTT is a part of the leading Glass Associations Networks formed in order to identify compliance issues early.

To ensure compliance with European chemicals regulations such as REACH, SCHOTT Advanced Optics has classified all its glass types and carried out numerous chemical analyses and leaching tests.

With this systematic approach, SCHOTT Advanced Optics has identified a few glasses for registration with the European Chemicals Agency (ECHA). The issued registration numbers have been documented in the respective material safety datasheets.

We are also carefully observing in close contact with our raw material supplier the list of substances of very high concern (SVHC) and the potential inclusion in the Authorization List (Annex XIV of REACH) to comply with information duties and to ensure further use of these substances in our production processes. This is to ensure that customers as down-stream users are also in compliance with REACH whenever SCHOTT glasses are applied. Please refer in addition to the technical safety information or the safety data sheets provided with the glass of your choice.



4 Mechanical Properties

4.1 Knoop Hardness

TIE-31 Mechanical and thermal properties of optical glass

Knoop Hardness expresses the amount of surface changes in a material after indentation of a test diamond at a given pressure and time. The standard ISO 9385 describes the measurement procedure for glasses. In accordance with this standard, the values for Knoop Hardness HK are listed in the data sheets for a test force of 0.9807 N (corresponds to 0.1 kp) and an effective test period of 20 s. The test is performed on polished glass surfaces at room temperature. The data for hardness values are rounded off to 10 HK 0.1/20. Micro hardness is a function of the magnitude of the test force and decreases with increasing test force.

4.2 Viscosity

Glasses run through three viscosity ranges between the melting temperature and room temperature: the melting range, the super cooled melt range, and the solidification range. The viscosity of glass constantly increases during the cooling of the melt ($10^0 - 10^4$ dPa·s). A transition from a liquid to a plastic state can be observed between 10^4 and 10^{13} dPa·s.

The so-called softening point EW identifies the plastic range in which glass parts rapidly deform under their own weight. This is the temperature $T_{10}{}^{7.6}$ at which glass exhibits a viscosity of $10^{7.6}$ dPa·s. The glass structure can be described as solidified or "frozen" above 10^{13} dPa·s. At this viscosity, the internal stress in glass equalizes in approx. 15 minutes.

Another way to identify the transformation range is to observe the change in the rate of relative linear thermal expansion. In accordance with ISO 7884-8, this can be used to determine the so-called transformation temperature T_g. It generally lies close to $T_{10}{}^{13}$.

Precision optical surfaces may deform and refractive indices may change if a temperature of $T_{10}{}^{13} - 200K$ is exceeded during any type of thermal treatment.

TIE-31 Mechanical and thermal properties of optical glass

4.3 Coefficient of Linear Thermal Expansion

The typical curve of linear thermal expansion of glass starts near absolute zero with an increase in gradient to approximately room temperature. Then, a nearly linear increase to the beginning of the noticeable plastic behavior follows. The transformation range is characterized by a distinct bending of the expansion curve that results from the increasing structural movement in the glass. Above this range, expansion shows a nearly linear increase again, but with a noticeably greater rate of increase.

Due to the dependence of the coefficient of linear thermal expansion α on temperature, two average linear thermal expansion coefficients α are usually shown for the following temperature ranges:

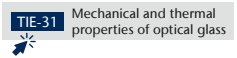
α (– 30 °C; + 70 °C) as the relevant information for characterizing glass behavior at room temperature (listed in the Part II Optical Glass – Properties section).

α (+ 20 °C; + 300 °C) as the standard international value for comparison purposes for orientation during the melting process and for temperature change loading (listed in detailed datasheets for our glasses).

Phosphate crown (PK) and fluor crown (FK) glasses are very sensitive to rapid temperature changes during processing, cleaning and handling operations due to their high coefficient of linear thermal change.

5 Thermal Properties

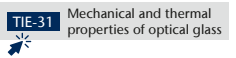
5.1 Thermal Conductivity



The range of values for thermal conductivity for glasses extends from 1.38 W/(m·K) (pure quartz glass) to about 0.5 W/(m·K) (glasses with high lead concentrations). The most commonly used silicate glasses have values between 0.9 and 1.2 W/(m·K).

The thermal conductivities shown in the data sheets apply for a glass temperature of 90 °C.

5.2 Heat Capacity



The mean isobaric specific heat capacity c_p (20 °C; 100 °C) is listed for some glasses as measured from the heat transfer of a hot glass at 100 °C in a liquid calorimeter at 20 °C. The range of values for c_p (20 °C; 100 °C) and the typical heat capacity c_p (20 °C) for silicate glasses lies between 0.42 and 0.84 J/(g·K).

6 Delivery Quality

6.1 Quality Management and Quality Assurance

The Advanced Optics Business Unit of SCHOTT AG in Mainz operates a global Quality Management System on the basis of ISO 9001/ISO 14001/ISO 45001. The certification is performed by LRQA Limited, Birmingham/United Kingdom.

The research laboratories of Advanced Optics in Mainz for the measurement of physical and chemical properties are accredited by the national accreditation body for the Federal Republic of Germany DAkkS, on the basis of the standard series ISO/IEC 17025:2017. Regular round robin tests are performed with the PTB, "Physikalisch-Technische Bundesanstalt" in Braunschweig, Germany. The PTB is a national metrology institute that provides scientific and technical services (http://www.ptb.de/cms/en.html), an institution similar to the NIST in the United States.

Optical glass as a technical material requires well-defined reproducible properties that a designer can rely on. Quality assurance of these properties is based on sample-based statistical measurement, partly 100 % measurement, of the optical and internal quality properties during continuous production of optical glass and on customer-specific individual measurement of cut blanks.

To utilize high-quality materials in professional applications, precise knowledge of glass properties is essential. Continuous improvements in the quality and production of optical glasses consistently challenge measurement capabilities. In the development processes of Advanced Optics, enhancing measurement technology to meet industrial and research needs is an ongoing effort.

6.2 Standard Delivery Quality

If no special quality steps are requested, the glass will be delivered in the refractive index/Abbe number Step 3 with a standard test report. The standard test report refers to a delivery lot that fulfills the standard variation tolerance. The refractive index variation from batch to batch within a lot will not exceed $\pm 1 \cdot 10^{-4}$ ($\pm 2 \cdot 10^{-4}$ for pressings, if requested). The glass is tested for bubbles and inclusions, striae, and stress birefringence.

Production of optical glass is a stable process, with only small variations in the chemical, mechanical and thermal properties of the glass. These properties are statistically controlled data sheet reference values and not measured individually upon order.

6.3 Enhanced Delivery Quality

In addition to our standard delivery quality, SCHOTT offers enhanced delivery quality for various forms of supply, see Table 6.1.

Table 6.1: Additional quality steps for various forms of supply

	Glass for hot processing	Pressings	Fine annealed glass	Cut blanks
Refractive index – Abbe number steps	2, 1	2, 1, 0.5	2, 1, 0.5	2, 1, 0.5
Test certificates	Annealing schedule	Standard (S)	Standard (S)	Standard (S)
Measurement accuracy, measurement ranges	With data on the annealing rates for the achievable refractive index – Abbe number steps after fine annealing	If variation tolerance is requested	Standard with enhanced accuracy (SE)	Standard with enhanced accuracy (SE), precision (PZ), dn/dT (DNDT)
Refractive index scattering	S0, S1	LH1, LH2	S0, S1	S0, S1
Homogeneity	–	H1–H3 (Ø < 65 mm)	–	H1–H5
Stress birefringence	–	SK	SK	SK, SSK
Striae	–	–	–	VS*
Bubbles/inclusions	–	VB, EVB	–	VB, EVB
Remarks			At least one surface can be worked	Striae and homogeneity measured in the same direction

* 1–3 test directions possible

The listed quality steps can be combined with one another within a form of supply. However, the availability of melts might be limited, therefore not all combinations are available at any time.

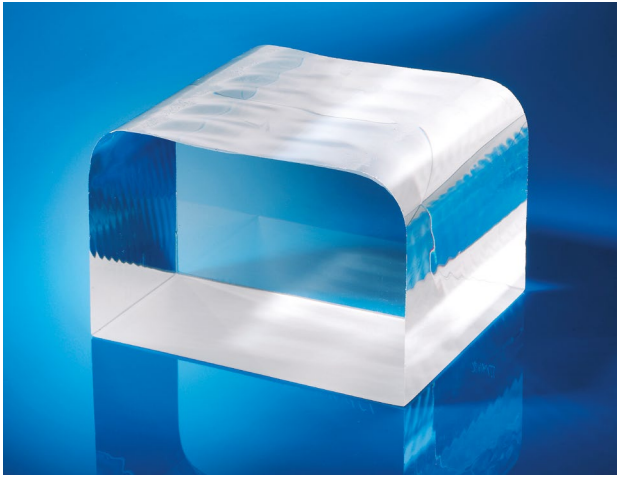
We recommend checking availability with us as early as possible.

Requirements exceeding the quality steps mentioned can also be met. Please ask for further details.

7 Forms of Supply and Tolerances

Advanced Optics excels in mastering the entire value chain, from customer-specific glass development and production to high-precision optical product finishing, processing, and measurement. Leveraging our extensive capabilities in processing (polishing, coating, bonding, etc.), we offer a wide variety of custom-made optical components, including lenses (aspherical, spherical, cylindrical), prisms, mirrors, wafers, substrates, and more. Next, you will find a selection of available supply forms:

7.1 Raw Glass



7.1.1 Blocks

Blocks have up to five unworked, as-cast surfaces. Usually, at least one surface has been worked.

The edges are rounded. Blocks are fine annealed and thus suitable for cold working.

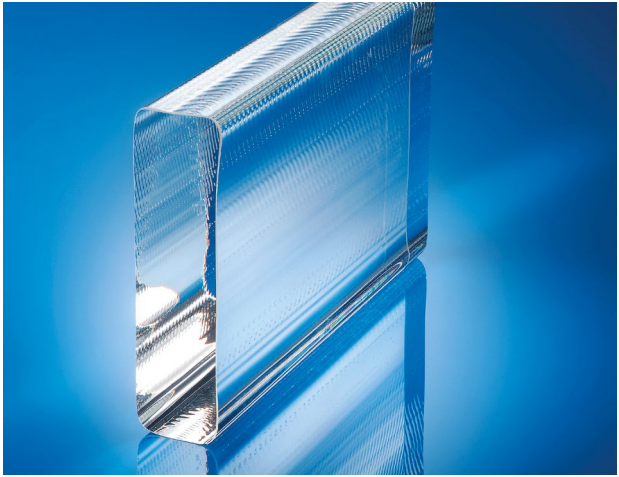
Described by: **length, width, thickness**

7.1.2 Strips

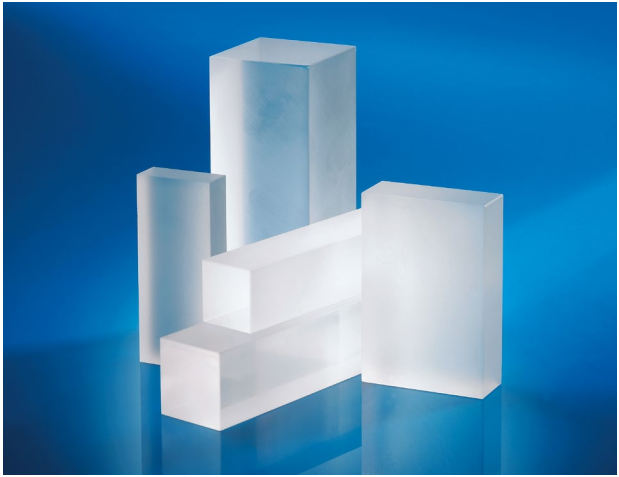
Strips normally have unworked or ground surfaces and broken or cut ends.

Strips are either coarse annealed or fine annealed. Coarse annealed strips are only suitable for reheat pressings.

Described by: **length, width, thickness**



7.2 Cut Blanks



7.2.1 Plates

Plates are quadrilateral fabricated parts.

All six sides are worked; the edges have protective bevels.

Described by: **length, width, thickness**

We achieve surface roughnesses of R_a = 20 – 25 µm with standard processing. Plates with closer dimensional tolerances and finer surfaces are possible upon request.

Table 7.1: Dimensional tolerances and minimum dimensions for plates

Maximum edge length [mm]	Admissible tolerances				Minimum thickness[1)] [mm]
	For edge length		For thickness		
	Standard [mm]	Precision [mm]	Standard [mm]	Precision [mm]	
> 3– 80	±0.2	±0.1	±0.3	±0.15	2
> 80– 120	±0.3	±0.15	±0.5	±0.25	4
> 120– 250	±0.5	±0.25	±0.5	±0.25	6
> 250– 315	±0.9	±0.45	±0.8	±0.4	8
> 315– 400	±1.2	±0.6	±0.8	±0.4	8
> 400– 500	±1.3	±0.65	±0.8	±0.4	20
> 500– 630	±1.5	±0.75	±0.8	±0.4	20
> 630– 800	±1.8	±0.9	±0.8	±0.4	20
> 800–1000	±2.0	±1.0	±0.8	±0.4	20
>1000	Inquire	Inquire	Inquire	Inquire	

[1)] Lower thicknesses than listed are possible. Please ask for details.



7.2.2 Round plates

Round plates are cylindrical parts for which the diameter is larger than the thickness. Round plates are machined on all surfaces.

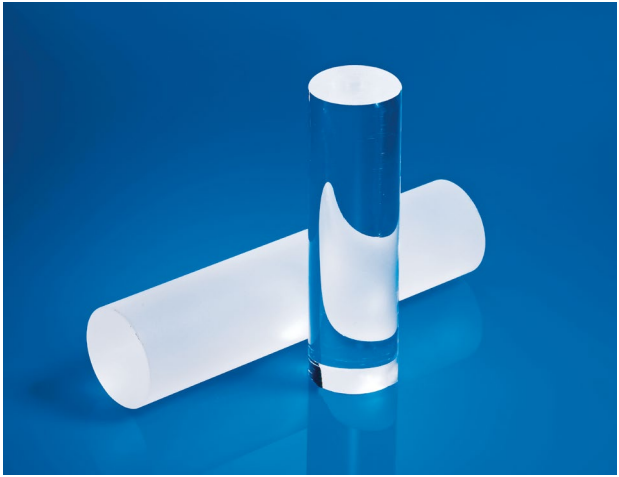
Described by: **diameter, thickness**

We achieve surface roughnesses of R_a = 20 – 25 µm with standard processing. Round plates with closer dimensional tolerances and finer surfaces are possible upon request.

Table 7.2: Dimensional tolerances and minimum dimensions for round plates

	Admissible tolerances				
	For diameter		For thickness		Minimum thickness[1)]
Diameter [mm]	Standard [mm]	Precision [mm]	Standard [mm]	Precision [mm]	[mm]
> 3– 80	±0.2	±0.1	±0.3	±0.15	2
> 80– 120	±0.3	±0.15	±0.5	±0.25	4
> 120– 250	±0.3	±0.15	±0.5	±0.25	6
> 250– 500	±0.5	±0.25	±0.8	±0.4	20
> 500– 800	±0.8	±0.4	±0.8	±0.4	20
> 800–1250	±1.0	±0.5	±0.8	±0.4	40
>1250	Inquire	Inquire	Inquire	Inquire	

[1)] Lower thicknesses than listed are possible. Please ask for more details.



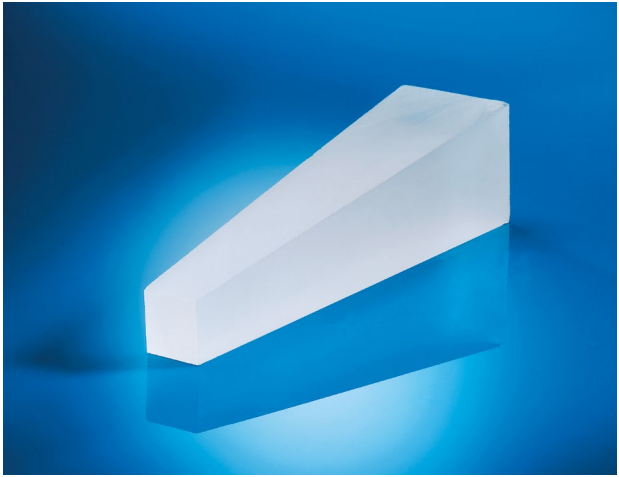
7.2.3 Worked rods

Worked rods are cylindrical parts that are machined on all sides. The length of a rod is always greater than its diameter.

Described by: **diameter, length**

Table 7.3: Dimensions and tolerances for worked rods in the 6–80 mm diameter range

Diameter [mm]	Standard tolerance [mm]	Tolerances, drilled and rounded according to ISO 286				Length range [mm]	Tolerance for length [%]
		[mm]	[mm]	[mm]	[mm]		
6–10	±0.2	h11 +0/–0.09	h10 +0/–0.058	h9 +0/–0.036	h8 +0/–0.022	max. 130	±2
>10–18	±0.2	h11 +0/–0.11	h10 +0/–0.070	h9 +0/–0.043	h8 +0/–0.027	max. 130	±2
>18–30	±0.2	h11 +0/–0.13	h10 +0/–0.084	h9 +0/–0.052	h8 +0/–0.033	max. 130	±2
>30–50	±0.2	h11 +0/–0.16	h10 +0/–0.100	h9 +0/–0.062	h8 +0/–0.039	max. 130	±2
>50–80	±0.3	h11 +0/–0.19	h10 +0/–0.120	h9 +0/–0.074		max. 130	±2



7.2.4 Cut prisms

Cut prisms are prisms produced by cutting and can be ground on all sides.

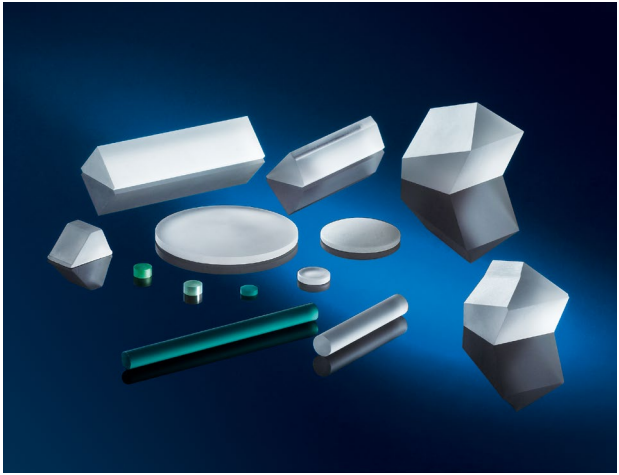
Equilateral and non-equilateral prisms can be produced in various forms (ridge, penta, triple prisms ...) using different fabrication technologies.

Described by: **drawing**

Table 7.4: Dimensions and tolerances for cut prisms

Maximum edge length [mm]	Tolerances for dimensions [mm]	Tolerances for width [mm]
< 50	+1.0/–0	±0.5
50–100	+1.5/–0	±1.0
> 100	+2.0/–0	±1.0

7.3 Pressings



7.3.1 Pressed blanks

Pressed blanks are hot formed parts with mainly round cross sections, defined radii and bevels.

Described by:
diameter, center thickness, radius 1, radius 2, bevels

Table 7.5: Dimensions and tolerances for pressed blanks

Diameter [mm]	Tolerances for diameter [mm]	Tolerances for thickness [mm]	Minimum center thickness [mm]	Minimum edge thickness [mm]	Maximum edge thickness [mm]
5 – 18	±0.075	±0.3	2	1	0.6 ·Ø
> 18 – 30	±0.11	±0.3	3	1.5	0.45·Ø
> 30 – 60	±0.14	±0.3	4	3	0.4 ·Ø
> 60 – 90	±0.175	±0.3	5	4	0.3 ·Ø
> 90 – 120	±0.25	±0.4	6	5	0.3 ·Ø
> 120 – 140	±0.3	±0.4	7	5	0.3 ·Ø
> 140 – 180	±0.4	±0.4	7	6	0.3 ·Ø
> 180 – 250	±0.5	±0.5	10	8	0.3 ·Ø
> 250 – 320	±0.6	±0.6	10	8	0.3 ·Ø

Table 7.6: Dimensions and tolerances for pressed prisms

Maximum edge length [mm]	Tolerances for edge length [mm]	Tolerances for center thickness [mm]	Angular	Socket [mm]
5 – 30	±0.2	±0.3		2
> 30 – 60	±0.3	±0.4		2
> 60 – 90	±0.4	±0.5	±0.5°	2.5
> 90 – 150	±0.5	±0.5		2.5
> 150 – 180	±0.7	±0.7		3
> 180 – 305	±1.0	±1.0		4

7.3.2 Pressed prisms

Pressed prisms are hot formed parts with angled, prismatic shapes.

Other dimensions are possible upon request.

Described by: **drawing**

7.4 Optical Glass Rods for Miniaturized Ball Lenses, Discs & More!

SCHOTT offers the widest range of rods with different geometries, formats and materials.

Optical glass rods from SCHOTT for applications that use small optical components such as ball lenses, rod lenses, aspheres and discs are manufactured with the help of different unique processes.

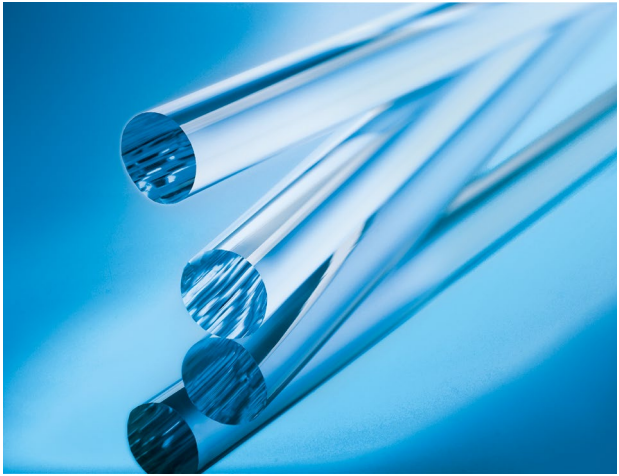


Table 7.7: Optical glass rods – specifications*

	Fire-polished surface		Matt surface	
Description	**Standard quality**	**Premium quality**	**Standard quality**	**Premium quality**
Diameter/tolerance	± 5 % of nominal diameter	± 3 % of nominal diameter	± 0.1 mm	± 0.05 mm
Straightness deviation	max. 0.1 mm/100 mm	max. 0.1 mm/100 mm	max. 0.05 mm/100 mm	max. 0.03 mm/100 mm
Length tolerance	+ 5 mm	+ 2 mm	+ 5 mm	+ 2 mm
Diameter range	< 1.0 – 7.0 mm	< 1.0 – 7.0 mm	2.0 – 12.5 mm	2.0 – 12.5 mm
Surface quality	fire-polished	fire-polished	matt	matt
Length	up to 1000 mm		up to 150 mm	

* Reference to round shape and glass type P-LASF47

7.5 Prisms and lenses from N-BK7HTSultra and N-SSK20

SCHOTT offers the blue laser solarization resistant N-BK7HT variant N-BK7HTSultra and N-SSK20 as polished and coated optical components such as prisms and lenses.



Prisms
SCHOTT offers precision manufactured polished prisms with advanced optical interference coatings. Typical specifications for prisms in the digital projection market are set according to the dichroic RGB prism (Philips Prism) in combination with a total internal reflection (TIR) prism.

Lenses
SCHOTT offers precision manufactured polished spheres and aspheres with high LIDT and low absorption optical interference coatings. Typical applications for lenses from these materials are mostly in the blue laser domain.

Supply Form
N-BK7HTSultra and N-SSK20 are only available as polished or coated prisms and lenses.

8 Optical Glasses for Precision Molding

TIE-40 Optical glass for precision molding

Precision molding is used for mass-producing directly pressed aspheres or freeform surfaces. During the precision molding process, a glass preform with exceptionally high surface quality is shaped into its final aspherical geometry while preserving the preform's surface quality. This low-temperature molding process typically operates between 500 °C and 700 °C, which helps extend the operating lifetime of the mold material.

"P" glasses are low transformation temperature glasses especially for use in precision molding. The letter "P" indicates that these glasses are produced exclusively for precision molding.

In addition, several traditional optical glasses have been identified to be suitable for precision molding, mainly because of their low glass transition temperatures.

Glass types for precision molding are generally coarse annealed. They are produced with a refractive index/Abbe number Step 3/3 based on a 2K/h reference annealing rate. However, the actual refractive index of the glass within the delivery lot may vary from this value.

The rapid cooling rate in precision molding causes a significant drop in the glass's refractive index compared to its initial value. This index drop is the difference between the refractive index after molding and the initial refractive index based on a 2K/h reference annealing rate.

The Part II Optical Glass – Properties section contains the n_d and ν_d values after molding using a SCHOTT reference process. Some of these values are preliminary data based on a theoretical reference annealing rate of 5000 K/h. The catalog value n_d serves as an initial refractive index based on a reference annealing rate of 2 K/h to calculate the index drop.

Furthermore, the index drop can be calculated based on a higher initial reference annealing rate of 25 K/h. For this purpose, the n_d reference value based on an annealing rate of 25 K/h is listed.

The index drop for a given glass type depends on the specific process and geometry of the part and will differ slightly from the values displayed in the Part II Optical Glass – Properties section.

If the refractive index after molding does not meet specific customer requirements, specific index adjustments to the given process conditions are possible upon request.

The optical glasses suitable for precision molding are listed in the Part II Optical Glass – Properties section of this catalog. This includes both the “P” glasses and traditional glasses. The section also provides additional information on low Tg glasses, such as acid resistance (according to JOGIS), grindability (abrasion, according to JOGIS), and the yield point/ sag temperature of the glass.

9 Product Range of Optical Glasses

9.1 Preferred Glasses

The glasses listed in the first part of the data section are preferred glasses. They are produced before any specific customer orders have been received and are usually kept in stock for swift delivery. We can guarantee a reliable long-term supply of these glasses. Preferred glasses are thus recommended for the use of designs in new optical systems and listed in our so-called positive list of optical glasses. The current version of the positive list of optical glasses can be found on our website (www.schott.com/products/optical-glass/downloads).

9.2 Inquiry Glasses

The second part of the Part II Optical Glass – Properties section is comprised of inquiry glasses that are produced on a regular basis in response to specific requests. With some of these glasses, we might have stock available from previous long running projects. However, stock is not generated on purpose without receiving orders from our customers. But even if they are not available in stock, glasses will be manufactured and delivered upon request.

10 Collection of Formulas and Wavelength Table

Relative partial dispersion $P_{x,y}$ for the wavelengths x and y based on the blue F and red C hydrogen line

$$P_{x,y} = (n_x - n_y) / (n_F - n_C) \quad (10.1)$$

or based on the blue F' and red C' cadmium line

$$P'_{x,y} = (n_x - n_y) / (n_{F'} - n_{C'}) \quad (10.2)$$

Linear relationship between the Abbe number and the relative partial dispersion for "normal glasses"

$$P_{x,y} \approx a_{xy} + b_{xy} \cdot \nu_d \quad (10.3)$$

Deviation ΔP from the "normal lines"

$$P_{x,y} = a_{xy} + b_{xy} \cdot \nu_d + \Delta P_{x,y} \quad (10.4)$$

$$\Delta P_{C,t} = (n_C - n_t) / (n_F - n_C) - (0.5450 + 0.004743 \cdot \nu_d) \quad (10.5)$$

$$\Delta P_{C,s} = (n_C - n_s) / (n_F - n_C) - (0.4029 + 0.002331 \cdot \nu_d) \quad (10.6)$$

$$\Delta P_{F,e} = (n_F - n_e) / (n_F - n_C) - (0.4884 - 0.000526 \cdot \nu_d) \quad (10.7)$$

$$\Delta P_{g,F} = (n_g - n_F) / (n_F - n_C) - (0.6438 - 0.001682 \cdot \nu_d) \quad (10.8)$$

$$\Delta P_{i,g} = (n_i - n_g) / (n_F - n_C) - (1.7241 - 0.008382 \cdot \nu_d) \quad (10.9)$$

The position of the normal lines was determined based on value pairs of the glass types K7 and F2.

Sellmeier dispersion formula

$$n^2(\lambda) - 1 = B_1 \lambda^2/(\lambda^2 - C_1) + B_2 \lambda^2/(\lambda^2 - C_2) + B_3 \lambda^2/(\lambda^2 - C_3) \quad (10.10)$$

When calculating the refractive index using the Sellmeier coefficients from the SCHOTT data sheets, the wavelength λ needs to be entered in units of µm.

Change in refractive index and Abbe number during annealing at different annealing rates

$$n_d(h_x) = n_d(h_0) + m_{nd} \cdot \log(h_x/h_0) \quad (10.11)$$

$$\nu_d(h_x) = \nu_d(h_0) + m_{\nu d} \cdot \log(h_x/h_0) \quad (10.12)$$

$$m_{\nu d} = (m_{nd} - \nu_d(h_0) \cdot m_{nF-nC})/(n_F - n_C)^* \quad (10.13)$$

h_0	Beginning annealing rate
h_x	New annealing rate
m_{nd}	Annealing coefficient for the refractive index, depending on glass type
$m_{\nu d}$	Annealing coefficient for the Abbe number, depending on glass type
m_{nF-nC}	Annealing coefficient for the principal dispersion, depending on glass type

* approximated

Measurement accuracy of the Abbe number

$$\sigma_{vd} \approx \sigma_{nF-nC} \cdot \nu_d / (n_F - n_C) \quad (10.14)$$

Spectral internal transmittance

$$\tau_{i\lambda} = \Phi_{e\lambda} / \Phi_{i\lambda} \quad (10.15)$$

Spectral transmittance

$$\tau_\lambda = \tau_{i\lambda} \cdot P_\lambda \quad (10.16)$$

P_λ factor of reflection

Fresnel reflectivity for a light beam with normal incidence, irrespective of polarization

$$R = ((n-1)/(n+1))^2 \quad (10.17)$$

Reflection factor that considers multiple reflections

$$P \approx (1-R)^2/(1-R^2) = 2n/(n^2+1) \quad (10.18)$$

n Refractive index for the wavelength λ

Converting of internal transmittance to another layer thickness

$\log \tau_{i1} / \log \tau_{i2} = d_1 / d_2$ or (10.19)

$\tau_{i2} = \tau_{i1}^{(d_2/d_1)}$ (10.20)

τ_{i1}, τ_{i2} Internal transmittances at thicknesses d_1 and d_2

Stress birefringence, difference in optical path

$\Delta s = 10 \cdot K \cdot d \cdot \sigma$ in nm (10.21)

K Stress optical constant, dependent on glass type in 10^{-6} mm²/N

d Length of light path in the sample in cm

σ Mechanical stress (positive for tensile stress) in N/mm² (= MPa)

Homogeneity from interferometrically measured wave front deviations

$\Delta n = \Delta W / (2 \cdot d)$ (10.22)

$= \Delta W[\lambda] \cdot 632.8 \cdot 10^{-6} / (2 \cdot d[mm])$

when listing the wave front deformation in units of the wavelength and a test wavelength of 632.8 nm (Helium-neon gas laser)

ΔW Wave front deformation with double beam passage (Fizeau interferometric testing)

d Thickness of test piece

Note: The formulas have been chosen carefully and listed.
Nevertheless, SCHOTT cannot be held responsible for errors resulting from their use.

Table 10.1: Wavelengths for selecting frequently used spectral lines

Wavelength [nm]	Designation	Spectral line used	Element
2325.42		Infrared mercury line	Hg
1970.09		Infrared mercury line	Hg
1529.582		Infrared mercury line	Hg
1060.0		Neodymium glass laser	Nd
1013.98	t	Infrared mercury line	Hg
852.11	s	Infrared cesium line	Cs
706.5188	r	Red helium line	He
656.2725	C	Red hydrogen line	H
643.8469	C’	Red cadmium line	Cd
632.8		Helium-neon gas laser	He-Ne
589.2938	D	Yellow sodium line	Na
		(center of the double line)	
587.5618	d	Yellow helium line	He
546.0740	e	Green mercury line	Hg
486.1327	F	Blue hydrogen line	H
479.9914	F’	Blue cadmium line	Cd
435.8343	g	Blue mercury line	Hg
404.6561	h	Violet mercury line	Hg
365.0146	i	Ultraviolet mercury line	Hg
334.1478		Ultraviolet mercury line	Hg
312.5663		Ultraviolet mercury line	Hg
296.7278		Ultraviolet mercury line	Hg
280.4		Ultraviolet mercury line	Hg
248.3		Ultraviolet mercury line	Hg

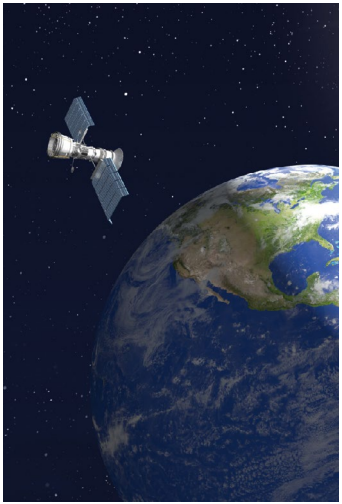
11 Technical Information – TIE



The relevant TIEs can be found under
www.schott.com/products/optical-glass/downloads

Title		
TIE-25:	Striae in optical glass	(Chapter 2.1)
TIE-26:	Homogeneity of optical glass	(Chapter 1.4)
TIE-27:	Stress in optical glass	(Chapter 2.3)
TIE-28:	Bubbles and inclusions in optical glass	(Chapter 2.2)
TIE-29:	Refractive index and dispersion	(Chapter 1.1)
TIE-30:	Chemical properties of optical glass	(Chapter 3)
TIE-31:	Mechanical and thermal properties of optical glass	(Chapter 4.1, 4.3, 5.1, 5.2)
TIE-35:	Transmittance of optical glass	(Chapter 1.5)
TIE-40:	Optical glass for precision molding	(Chapter 8)
TIE-42:	Radiation resistant optical glasses	(Chapter 12.1, 13)

12 Application Notes



TIE-42 Radiation resistant optical glasses

12.1 Optical Glasses Stabilized against Ionizing Radiation

Optical glasses can be stabilized against transmittance loss caused by ionizing radiation by adding cerium (Ce) to the composition. The harsh conditions of ionizing radiation exist, for example, in space missions. SCHOTT offers cerium stabilized glasses in our standard portfolio that cover a broad range on the Abbe diagram.

Radiation resistant glasses have been widely used in space missions such as the VENUS Express Mission 2005 (ESA), Rosetta Comet Mission 2004 (ESA), Juno Mission 2011 (NASA) and OSIRIS-Rex Mission 2016 (NASA).

Requirements

- Transmittance stabilized against ionizing radiation
- Various positions within the Abbe diagram

SCHOTT glasses

BK7G18, K5G20, LF5G19, F2G12, LAK9G15, SF6G05



12.2 Optical Materials for Mobile Applications

Modern smartphone cameras combine multiple lenses from extremely wide-angle to telephoto lenses in one device. The physical volume for lens designs in smartphones is generally restricted.

High index aspheres help to enable compact designs. Folding the optical path with periscope prisms enables optical zooms with high magnification. Low-density optical glass for light weighted designs, higher hardness and environmental resistance to increase the processing yield are additional aspects in glass selection. High transmittance optical glass facilitates brilliant images in twilight environments. Filter glass enables homogeneous spectral filtering independent of incident angle, leading to an excellent and natural color recognition.

Requirements

- High index
- Low density
- Higher hardness
- Environmental robust
- High transmission

SCHOTT glasses

N-LASF55, N-SF14, N-SF6, N-LASF40	High index, low density, higher hardness
NIR cut filters	Wide range of customized spectral characteristics



12.3 Optical Materials for Digital Projection

The optical systems of high-end cinema projectors usually consist of large volume prism assemblies and high-end projection lens systems. These prism assemblies in particular require materials with maximum transmittance and low solarization tendencies due to the high thermal load in application.

Primary colors are generated by blue laser diodes that illuminate phosphor wheels to create yellow light. Wheels with ceramic phosphor have much higher temperature stability and offer significant improvement over conventional solutions.

* only available as polished optical components: Spheres, Aspheres, Prisms

Requirements

- High transmittance
- Large 3D homogeneous optical glass prisms
- Low solarization tendencies
- Ceramic convertor materials

SCHOTT materials

N-BK7HT	Excellent transmittance and homogeneity in multiple directions for prism applications
N-BK7HTSultra*	N-BK7HT variant with lowest blue laser solarization
N-BK10	Low solarization and high homogeneity in multiple directions for prism applications
SF57HTultra	High refractive index, low stress birefringence
Ceramic Converter	Ceramic convertor material with excellent high temperature stability



12.4 Optical Materials for Industrial Lasers

High power lasers are widely used in industrial processes such as laser cutting and welding. The industry standard features lasers with a wavelength around 1 µm in the NIR range and intensities of several kW. Recent advancements have introduced blue lasers, which are more effective for copper welding due to higher blue light absorption. SCHOTT provides glass types with enhanced solarization resistance, along with optical components and laser coatings, tailored for these new laser systems.

Requirements

- Low solarization
- Suitability for reheat pressing for cost effective manufacturing
- High transmittance

SCHOTT glasses

N-BK7	Primarily for mirror substrates
N-BK7HTSultra*	N-BK7HT variant with lowest blue laser solarization
N-SSK20*	Higher refractive index and low solarization under blue light exposure
N-PK51	Low dispersion

* only available as polished optical components: Spheres, Aspheres, Prisms



12.5 Optical Glasses for Automotive Applications

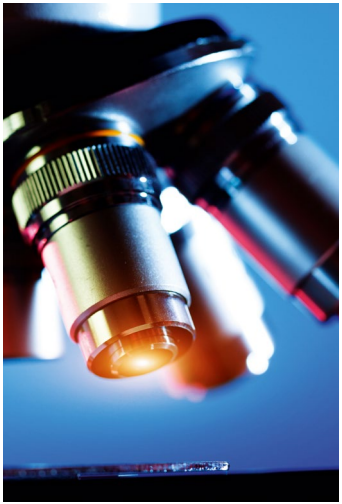
Driver assistance systems in modern cars are equipped with a multitude of cameras to cover almost 360° of the car surroundings (e.g. mirror replacement, rear view, surround view, front view, driver camera systems). These cameras must deliver long lasting good image quality regardless of temperature differences or aggressive climate conditions. Therefore, athermally corrected fixed focus lenses are often used in automotive applications. The front lenses of these systems must also exhibit good chemical resistance.

Requirements

- Precision moldable glasses
- High refractive index glass
- Low or negative dn/dT or very high dn/dT for temperature compensation
- Good chemical resistance

SCHOTT glasses

P-LAK35	Low dn/dT, precision moldable
P-LASF47	High dn/dT, precision moldable
P-SK60	Precision moldable
N-LAK28	Low density, high hardness, low dn/dT



12.6 Optical Glasses for Life Science Applications

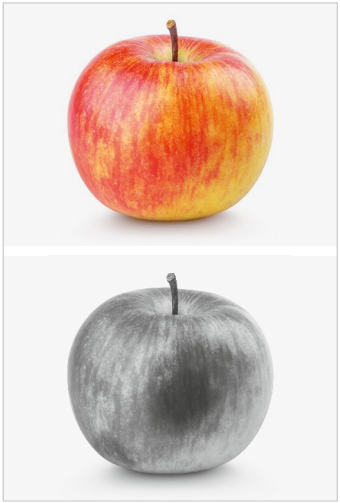
Multiphoton laser scanning microscopy applications and fast DNA sequencing are typical Life Science applications that demand special materials for high-end optical designs. SCHOTT offers a comprehensive portfolio of optical glasses and filters to enable high-end Life Science applications.

Requirements

- High refractive index glass
- Extremely low dispersion glass
- Glasses with large anomalous partial dispersion
- High transmittance
- Customizable filter designs
- Low fluorescence

SCHOTT glasses

N-FK58 XLD	Very low dispersion, excellent low fluorescence and high laser resistance
N-KZFS4	Largest deviation from normal line
N-LAK33B	
N-LASF46B	
N-SF57HTultra	High refractive index and transmittance
N-SSK20	Excellent UV transmission along with a comparatively high refractive index
SF3	Superior transmission and color code at UV edge
BG glasses	
Notch filters	



12.7 Optical Glasses in the Short-Wave Infrared Range

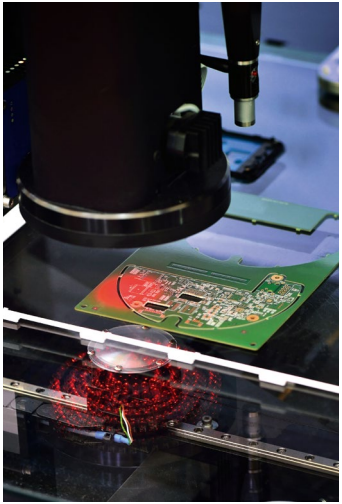
SWIR is the short-wave infrared range from about 1 to 2.7 µm. SWIR applications can be found for example in inspection processes of circuit boards, solar cells, bottles, art and food. With SWIR applications characteristics can be visualized that normally would not be detectable with visible light alone, such as rotten fruits in fruit sorting, fakes in paintings, content levels in opaque bottles. All these machine vision applications employ specific optics that ideally transmit in the visible spectral range and also in the SWIR wavelength range. Optical designs require materials that transmit in the visible and the SWIR range, sometimes even up to 4 µm.

Requirements

- Glasses with good transmittance in the visible spectral range and up to 4 µm

SCHOTT glasses

N-FK58 XLD, N-PK52A, N-FK51A, IRG27	Excellent transmittance in the visible and SWIR range



12.8 Optical Glasses for Machine Vision Applications

Machine Vision applications are used for Inspection and Metrology of a wide range of parts in varied applications. Such applications need compact lenses and optical systems that provide high image resolution, with good contrast. They are used from the UV to the IR spectral range (UV inspection of wafers or e.g. SWIR inspection in food industry).

Telecentric lens design requires color correction glasses in polychromatic applications. Tightest optical tolerances enable a higher resolution and larger field of view and help so to increase the throughput.

Requirements

- High refractive index glass
- Extremely low dispersion glass
- Glasses with large anomalous partial dispersion
- High transmittance
- Tight optical tolerances

SCHOTT glasses

N-FK58 XLD	Very low dispersion, good processability and high laser resistance
N-KZFS4	Largest deviation from normal line
N-LAK33B	
N-LASF46B	
N-SF57HTultra	High refractive index and transmittance



12.9 Optical Glasses for High-End Surveillance Systems

Lenses and optical systems in outdoor civilian and military high-end security and surveillance applications typically demand robustness, compactness, high resolution and excellent performance in any weather and temperature conditions.

Requirements

- High refractive index glass
- Extremely low dispersion glass
- Glasses with large anomalous partial dispersion
- High transmittance
- Good chemical resistance

SCHOTT glasses

N-FK58 XLD	Very low dispersion, good processability
N-SF57HTultra	High refractive index and transmittance
P-LAK35	Low dn/dT, good chemical resistance
P-LASF47	High dn/dT, good chemical resistance
P-SK60	



12.10 Optical Glasses for Professional Movie Camera Lenses

Professional movie cameras are used for cinematography, mobile broadcasting and videography. Constantly growing resolution (up to 8K currently) requires complex high resolution lens designs with larger apertures and excellent color correction.

Requirements

- High refractive index glass
- Extremely low dispersion glass
- Glasses with large anomalous partial dispersion
- High transmittance
- High homogeneity
- Availability in large dimensions

SCHOTT glasses

N-FK51A	Low dispersion, excellent homogeneity
N-KZFS11	Large deviation from normal line, excellent homogeneity
N-SF57HTultra	High refractive index and transmittance
N-BK7HT	Excellent transmittance and homogeneity in multiple directions and available in large sizes for prism and lens applications

13 SCHOTT Advanced Optics at a Glance

SCHOTT Advanced Optics, with its extensive technological expertise, is a valuable partner for its customers in developing products and customized solutions for applications in optics, lithography, astronomy, opto-electronics, life sciences, and research.

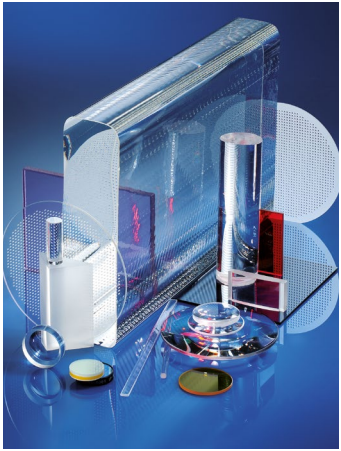
With a product portfolio of more than 120 optical glasses, special materials and components, we master the value chain: from customized glass development to high-precision optical product finishing and metrology.

SCHOTT Advanced Optics – Your Partner for Excellence in Optics.

This chapter will give you an overview of the SCHOTT Advanced Optics product portfolio. It consists of the following products:

- Optical Materials, such as optical glass, HT- & HTultra glasses, active & passive laser glass, sapphire, glass wafers with high refractive index and infrared chalcogenide glasses
- Optical Components, such as lenses, plano-plano optics, prisms, and ceramic converters
- Optical Filters, e.g. NIR cutoff filters, contrast enhancement filters, optical filter glass as well as interference filters

Optical Materials





Optical Glass

More than 120 high-quality optical glasses

For more than 140 years, SCHOTT Advanced Optics has been offering a large portfolio of high-quality optical glasses to meet the needs of a broad variety of optical as well as industrial applications, ranging from consumer products to high-power optics at the cutting edge of research.

Our product range includes “N” glass types, which are manufactured without the use of lead or arsenic; glasses for precision molding (low T_g glass); and traditional glass types containing lead oxide as a key component for outstanding optical properties.

In addition, we offer versions of our glasses with a particularly high transmission (HT & HTultra Glasses) and with high homogeneity.



HT & HTultra Glass

Optical glass with ultra-high transmittance

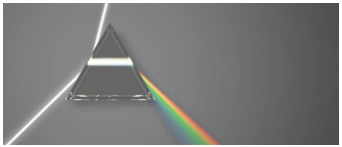
As part of its extensive portfolio of optical glass types, SCHOTT has been offering special glass versions that are known for their superior transmittance and which are particularly well-suited to digital projection and high-power optical systems.



HTSultra Glass

Blue laser solarization stabilized glass

SCHOTT has elevated its high transmittance N-BK7HT glass to the next level with N-BK7HTSultra. Due to its improved solarization stability it maintains its high transmittance even under intense blue light. This feature is crucial for applications such as digital projection and industrial laser machining.



XLD Glass

Optical glass with extreme low dispersion

To indicate optical glasses with the highest Abbe numbers $\nu_d > 90$, SCHOTT gives such glasses the suffix XLD (eXtreme Low Dispersion). Due to their unique partial dispersion, these glasses offer outstanding apochromatic correction capabilities. These fluorophosphate glasses were developed for excellent processing properties.



High Homogeneity Glass

Extremely high homogeneity for large high-precision optical lenses

Optical glasses that are used in high power laser and astronomical applications require extremely high homogeneity. SCHOTT manufactures high-quality glasses up to homogeneity class H5 and now offers several glass types up to quality level H4 that are available from stock.



Low T_g Glass

Optical glass suitable for use in precision molding

Precision molding is a technology for the volume production of complex lenses, e.g. aspheres, for various applications such as digital cameras and smartphones, telecommunications, lens arrays or microscopy applications.



i-Line Glass

With high UV transmittance at 365 nm and high refractive index homogeneity

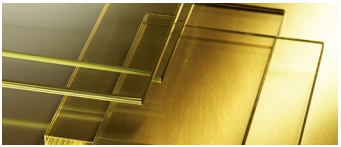
i-Line glasses are optical glass types named after the i wavelength, which offer both high UV transmittance at 365 nm and high refractive index homogeneity. These glass types can be found in lithography applications such as i-line steppers and wafer scanners.



Radiation Resistant Glass

With high radiation resistance and different dispersion properties

SCHOTT Advanced Optics offers a variety of radiation resistant glass types with different dispersion properties. These glass types are well-suited to use in surroundings with ionizing radiation. Radiation resistant glass is provided in the form of cut blanks, pressings, and rods as well as finished optical components.



Radiation Shielding Glass

Extraordinary optical properties and high radiation resistance against ionizing radiation

Specially developed radiation shielding glasses in the density range from 2.5 to 5.2 g/cm^3 covering a variety of optical and shielding properties, allowing for the custom design of radiation shielding windows with a perfect combination of high shielding capability and resistance against ionizing radiation.



Sapphire

One of the hardest, most durable and scratch resistant materials

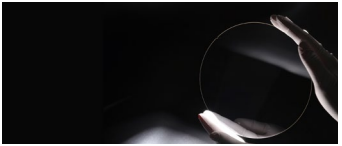
Sapphire offers a broad transmission range from UV to mid-infrared wavelengths (250 – 5000 nm). This material is capable of withstanding extreme environmental conditions and fluctuations in temperature. SCHOTT offers sapphire in processed shapes according to the customer's specifications.



Fused Silica

Pure non-crystalline silicon dioxide glass

Fused Silica features excellent UV transmission for wavelengths above 180 nm. Its high melting temperature means it can be used in high temperature applications. It does not contain alkaline elements and is well suited for the semiconductor industry.

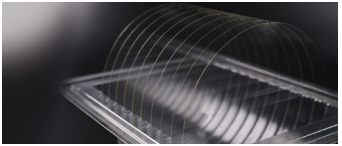


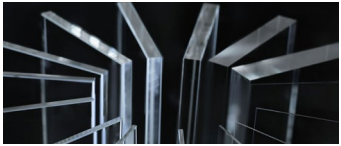
RealView®

Glass wafers with high refractive index

Optical glass with $n_d > 1.6$ high transmittance and high homogeneity for augmented reality waveguides.

Specially developed glasses combining a refractive index beyond 1.6 in extreme homogeneity with high transmission in the VIS for minimal losses in light guiding at maximum total internal reflection angle. Wafers with extreme geometrical precision up to a diameter of 300 mm with tight total thickness variation, local slope, and roughness specifications to support precise image reproduction.







Borosilicate Glass

Robust material for optical applications

Technical glasses such as BOROFLOAT® 33 offer strong mechanical and chemical resistance for challenging applications. The manufacturing process is a large-scale and well-controlled process, which makes these glasses cost effective.

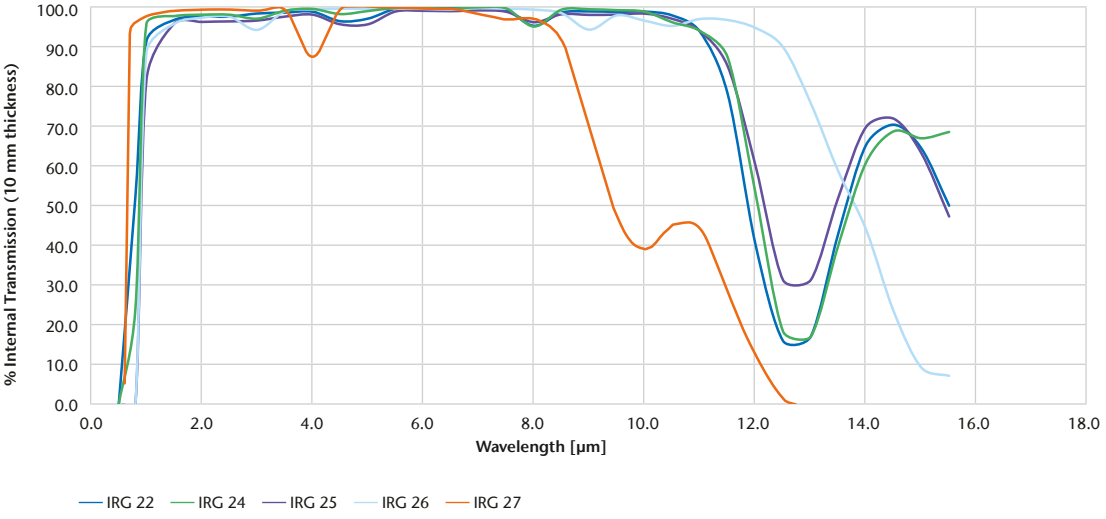
Infrared Chalcogenide Glasses IRG

The IR glasses have excellent transmission in the SWIR, MWIR, & LWIR. Physical properties such as low dn/dT and low dispersion enable optical engineers to design color corrected optical systems without thermal defocusing. The IRG family of chalcogenide glasses is optimized for pairing within the family of IR glasses and with other IR materials to support cost effective and high performance optical designs. These glasses encompass the common IR transmission bands 3 – 5 µm and 8 – 12 µm, but can transmit as low as 0.7 µm. Furthermore, the IR series of glasses can be processed by conventional grinding and polishing, single point diamond turning, or molding.

USP's

- Low dn/dT
- Lower density vs. Ge 14 – 39 % lighter
- High color correction
- No constraints due to high temperature
- IRG 26/IRG 27 Germanium free compositions

Internal Transmission of Infrared Glass IRG 22, IRG 24, IRG 25, IRG 26, IRG 27 with Thickness 10.0 mm (Typical Values)



Optical Components

Different products for various applications

SCHOTT offers a broad range of different component types for applications in optics, lithography and science. Known for its cutting-edge innovations, its highest product quality and its service excellence, Advanced Optics is integrated from material development to finishing operations.

We master the entire value chain! Processed products include precision-molded, polished and coated aspherical lenses, prisms, optical glass filters and interference filters as well as precision components, such as CNC-processed parts, plane-parallel substrates and wafers.

Further details about our comprehensive portfolio of high precision optical components can be found online at: www.schott.com/products/optical-components



Aspherical Lenses

Aspheres for superior image quality

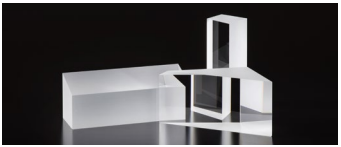
Due to their unique surface structure, aspherical lenses eliminate monochromatic aberrations and therefore deliver superior overall image quality. One aspherical lens can replace the function of multiple spherical elements, enabling a compact, lightweight design.



Spherical Lenses

As singlets and doublets in different shapes

Spherical lenses are used in many different applications, such as cameras, projectors and microscopes, to collect, focus and diverge light and are often components of lens systems that perform an achromatic function.



Prisms

Perfect custom optical components

Prisms are transparent optical elements with flat polished surfaces that refract, reflect or disperse light. They can be positioned inside an optical system and offer excellent thermal stability. Used via total internal reflection, the light loss in the optical path is minimized.



Windows & Substrates

Highest precision made of various materials

Substrates are components that serve as the base to be coated to produce products like interference filters. Windows are transparent, mostly plano-plano parallel polished and/or coated components that are used in optical systems to achieve highly-efficient, distortion-free light and perfect image transmission.



Coating

The full spectrum of optical coatings

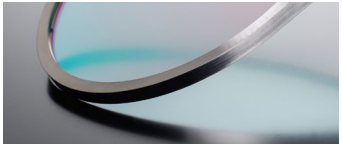
SCHOTT employs a wide range of modern thin film coating technologies to cover the broad spectrum of industry requirements. Since we are also a leading supplier of optical filter glass, we can expand our customer options by combining filter glass and thin film technology to create uniquely customized optical components.



CNC Machining

Precisely manufactured parts

Our wide variety of high-performance CNC machines makes it possible to produce almost any geometry. This offers our customers freedom in their designs. Access to SCHOTT's own inventory of various optical glasses makes it possible, for example, to speed up prototyping.



Assembly

Optical and mechanical mounting

Customized mounts (e.g., positioning, optical centering, etc.) that can be assembled in a clean room environment. Furthermore, necessary measuring instruments including 3D optical measurements; profilometers and interferometers are in place.



Dynamic Ceramic Converter

Brighter than the sun

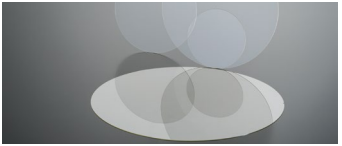
SCHOTT's Dynamic Ceramic Laser Phosphor Converters provide high luminescence for consistently bright and clear light sources. Made from pure inorganic phosphor material, they guarantee high temperature stability, excellent heat conductivity, long lifetimes, and superb reliability. These converters are ideal for a wide range of devices for example in projectors or searchlights.



Static Ceramic Converter

Enabler for high luminance light sources

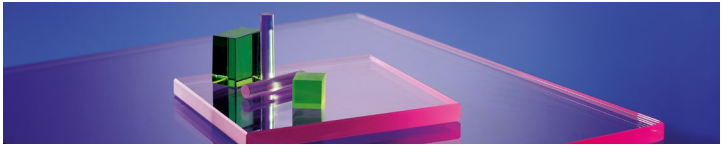
SCHOTT's Static Ceramic Laser Phosphor Converters offer superior luminance, high irradiance and brightness for applications such as digital projection, machine vision & metrology, life science, stage- and searchlights. Static solutions allow you to increase light output for your light source with no moving parts. They close the green gap, are easy to integrate with lighting devices or optical fibers and provide low maintenance as well as total cost of ownership.



Optical Wafers

Ultra-flat polished substrates for optical applications

SCHOTT offers ultra-flat polished wafers for optical applications with a well-controlled total-thickness-variation below 1 µm for 300 mm diameter wafers. Available wafer material families are: Optical Glasses, Technical Glasses, Fused Silica, Glass Ceramics and Sapphire.





Active Glass for Laser Applications

SCHOTT offers a wide range of active laser glasses for high power, ultra-short pulse, laser range finding and medical applications. These entire glasses can be tailored to a specific application, e.g. for flash lamp or diode pumping. Platinum-particle-free melting developed at SCHOTT enables the highly fluent operation of phosphate laser glass components without laser-induced damage; large volume laser slabs in apertures of up to 400 mm and in mass quantities enable high energy storage for the inertial confinement fusion program; and zig-zag slabs and large diameter laser rods produced in the highest optical quality and homogeneity help to renable high performance for laser systems which process materials.

The glass is obtainable with the use of active laser rods, slabs or disks. AR and HR coatings for all laser wavelengths with high LIDT are obtainable. All components are manufactured per customers' specifications and can be polished up to λ/10 flatness.

To complement this, SCHOTT offers a broad range of passive laser components such as mirrors and windows.



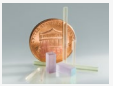
- Active laser glasses (neodymium doped, erbium doped) e.g., APG, IOG, LG, BLG
- Silicate-based glasses
- Phosphate-based glasses

Active Materials

Active Components

- Rods
- Slabs/plates









- Passive laser glasses e.g., S7000, S7005, S7010N
- Wide range of optical glasses and special variants (e.g., SCHOTT N-BK7®)
- ZERODUR®
- N-BK7HTSultra

Passive Materials

Passive Components

- Aspherical lenses
- Mirrors & windows
- Beamsplitters & polarizers
- Polished prisms
- Optical filters
- Flowtubes







Optical Filter Glass

Colored filter glasses from the entire spectrum

SCHOTT Advanced Optics offers one of the world's broadest portfolios of optical filter glasses for a full spectral solution that meets your requirements. These filter glasses enable applications in analytics, photography, medical technology and laser protection.

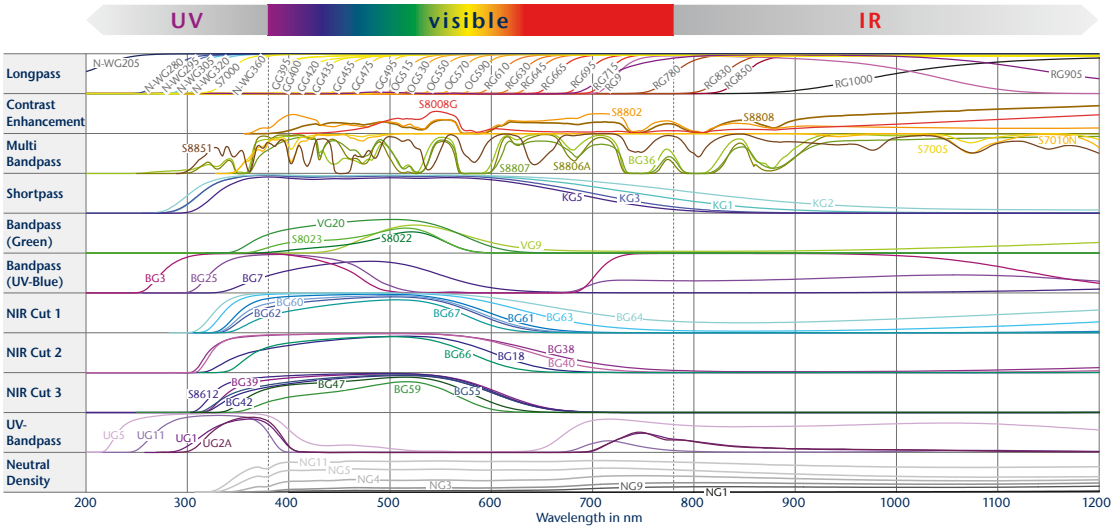
Optical filter glass is known for its selective absorption in the visible wavelength range. Optical filter glasses appear to be colored if their filter effect lies within the visible light spectrum. Numerous colorants with different concentrations and many different base glasses have been developed to facilitate the development of an assortment of filters, some with extreme filter properties, in the largest possible spectral region.

SCHOTT's optical filter glasses include the following filter types in the wavelength range above 200 nm:

- Bandpass filters
- Longpass filters
- Shortpass filters
- Neutral density filters
- Contrast enhancement filters
- Multiband filters

Pocket Catalog
Optical Filter Glass 2024

Internal transmittance of SCHOTT filter glasses





Interference Filters

Coated filters for the entire spectral range

Interference filters that use the interference effect to obtain a spectral function are manufactured by depositing thin layers with different refractive indices onto a substrate. These filters are used for applications in medical technology, for analytics in measurements, environmental, biotech, chemical and medical, fluorescence microscopy, and more.

SCHOTT supplies a range of geometries and sizes of interference filters within the spectral range of 200 nm to 3000 nm. These products are developed, designed and manufactured according to customer specifications. Interference filters offer excellent climatic resistance and extremely stable spectral characteristics with respect to temperature and humidity changes.

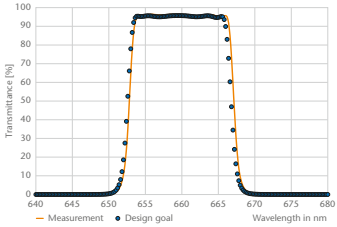
Our product range comprises various types of interference filters:
bandpass filters, edge filters, notch filters, UV-bandpass filters, hard and scratch-resistant filters, i-line filters, VERIL linear variable filters, optimized AR and broadband-AR coated filters, beamsplitters, neutral density filters, mirror coatings (dichroic or metallic), and black absorber coatings.

The whole process chain for interference filters from a single source

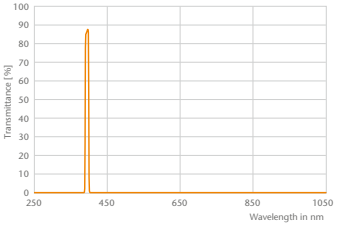
Custom-made designs are calculated by a whole group of scientists and engineers. Substrates are polished and transferred directly to the coating. An extensive clean-room production facility with different coating technologies can meet almost any requirement. Our sophisticated set of measurement equipment guarantees perfect quality control for any feature of the filter.



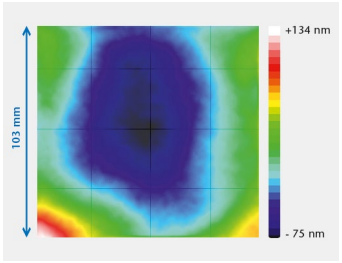
Perfect consistency between measurement and production



Bandpass with broad blocking T < 10^{-5}



Low transmitted wavefront distortion



Change Index – Part II Optical Glass – Properties Section

SCHOTT Advanced Optics is committed to supporting our customers by continuously improving our existing product offerings, as well as expanding our portfolio. We are also committed to providing detailed information regarding the properties of our glasses, therefore enabling our customers to perform their own work more effectively. As a result, we've created the following table to identify pertinent changes to our optical glasses, as well as additions to our line. All relevant changes are additionally marked as well in blue in our Part II Optical Glass – Properties Section. If you have any questions regarding these products, please contact one of our representatives directly.

N-BK7HTSultra, N-SSK20	added
K7, N-ZK7, LAFN7, N-LAF35	Now inquiry glass
N-SK14	T_g and density changed
N-LAK22, N-LAF7	Transmittance and color code changed
N-LAF2, N-SF66	$T_{10}^{7.6}$ changed
P-LAF37	Transmittance chanced
F2G12	CTE, $T_{10}^{7.6}$, density, HK, transmittance and color code changed

Optical Glass 2025

Properties

Glass type	n_d	ν_d	$n_F - n_C$	n_e	ν_e	$n_{F'} - n_{C'}$	n_r	n_C	$n_{F'}$	n_g	n_h
N-FK58** 456909.365	1.45600	90.90	0.005017	1.45720	90.47	0.005053	1.45358	1.45446	1.45976	1.46216	1.46436
N-FK5* 487704.245	1.48749	70.41	0.006924	1.48914	70.23	0.006965	1.48410	1.48535	1.49266	1.49593	1.49894
N-FK51A* 487845.368	1.48656	84.47	0.005760	1.48794	84.07	0.005804	1.48379	1.48480	1.49088	1.49364	1.49618
N-PK51* 529770.386	1.52855	76.98	0.006867	1.53019	76.58	0.006923	1.52527	1.52646	1.53372	1.53704	1.54010
N-PK52A 497816.370	1.49700	81.61	0.006090	1.49845	81.21	0.006138	1.49408	1.49514	1.50157	1.50450	1.50720
N-PSK3 552635.291	1.55232	63.46	0.008704	1.55440	63.23	0.008767	1.54811	1.54965	1.55885	1.56302	1.56688
N-PSK53A* 618634.357	1.61800	63.39	0.009749	1.62033	63.10	0.009831	1.61334	1.61503	1.62534	1.63007	1.63445

*** Available in step 0.5 ** SCHOTT XLD Glass (eXtreme Low Dispersion)**

$P_{g,F}$	$\Delta P_{g,F}$	CR	FR	SR	AR	PR	α (–30/+70)	T_g	$T_{10}^{7.6}$	ρ	HK	τ_i (10/400)	τ_i (10/420)	CC
0.5347	0.0438	1	1	52.3	3.3	4.3	13.7	445	508	3.65	372	0.996	0.996	33/--
0.5290	0.0036	2	1	4	2	2.3	9.2	466	672	2.45	520	0.998	0.997	30/26
0.5359	0.0342	1	0	52.3	2.2	4.3	12.7	464	527	3.68	345	0.997	0.997	34/28
0.5401	0.0258	1	0	52.3	3.3	4.3	12.4	487	568	3.86	415	0.994	0.994	34/29
0.5377	0.0311	1	0	52.3	3.3	4.3	13.0	467	538	3.70	355	0.997	0.996	34/28
0.5365	–0.0005	3	0	2.2	2	2	6.2	599	736	2.91	630	0.994	0.994	33/28
0.5424	0.0052	1	1	53.3	2.3	4.3	9.6	606	699	3.57	415	0.985	0.992	36/31

Glass type	n_d	ν_d	$n_F - n_C$	n_e	ν_e	$n_{F'} - n_{C'}$	n_r	n_C	$n_{F'}$	n_g	n_h
SCHOTT N-BK7®** 517642.251	1.51680	64.17	0.008054	1.51872	63.96	0.008110	1.51289	1.51432	1.52283	1.52668	1.53024
N-BK7HT* 517642.251	1.51680	64.17	0.008054	1.51872	63.96	0.008110	1.51289	1.51432	1.52283	1.52668	1.53024
N-BK7HTSultra*/** 517642.251 New	1.51680	64.17	0.008054	1.51872	63.96	0.008110	1.51289	1.51432	1.52283	1.52668	1.53024
N-BK10 498670.239	1.49782	66.95	0.007435	1.49960	66.78	0.007481	1.49419	1.49552	1.50337	1.50690	1.51014
N-K5 522595.259	1.52249	59.48	0.008784	1.52458	59.22	0.008858	1.51829	1.51982	1.52910	1.53338	1.53734
K10 501564.252	1.50137	56.41	0.008888	1.50349	56.15	0.008967	1.49713	1.49867	1.50807	1.51243	1.51649
N-ZK7A 508610.247	1.50805	61.04	0.008323	1.51004	60.84	0.008384	1.50403	1.50550	1.51429	1.51829	1.52198

*** Available in step 0.5 ** Only available as polished optical components: Spheres, Aspheres, Prisms**

$P_{g,F}$	$\Delta P_{g,F}$	CR	FR	SR	AR	PR	α (−30/+70)	T_g	$T_{10}^{7.6}$	ρ	HK	τ_i (10/400)	τ_i (10/420)	CC
0.5349	−0.0009	1	0	1	2.3	2.3	7.1	557	719	2.51	610	0.997	0.997	33/29
0.5349	−0.0009	1	0	1	2.3	2.3	7.1	557	719	2.51	610	0.998	0.998	33/29
0.5349	−0.0009	1	0	1	2	2.3	7.1	565	716	2.50	548	0.999	0.999	32/29
0.5303	−0.0008	1	0	1	1	1	5.8	551	753	2.39	560	0.996	0.996	31/27
0.5438	0.0000	1	0	1	1	1	8.2	546	720	2.59	530	0.995	0.996	34/30
0.5475	−0.0015	1	0	1	1	1.2	6.5	459	691	2.52	470	0.994	0.995	33/30
0.5368	−0.0043	1	0	2	1.2	2.2	4.61	519	729	2.47	530	0.990	0.992	34/29

Glass type	n_d	ν_d	$n_F - n_C$	n_e	ν_e	$n_{F'} - n_{C'}$	n_r	n_C	$n_{F'}$	n_g	n_h
N-BAK1 573576.319	1.57250	57.55	0.009948	1.57487	57.27	0.010039	1.56778	1.56949	1.58000	1.58488	1.58941
N-BAK2 540597.286	1.53996	59.71	0.009043	1.54212	59.44	0.009120	1.53564	1.53721	1.54677	1.55117	1.55525
N-BAK4 569560.305	1.56883	55.98	0.010162	1.57125	55.70	0.010255	1.56400	1.56575	1.57649	1.58149	1.58614
N-BAK4HT 569560.305	1.56883	55.98	0.010162	1.57125	55.70	0.010255	1.56400	1.56575	1.57649	1.58149	1.58614
N-SK2* 607567.355	1.60738	56.65	0.010722	1.60994	56.37	0.010821	1.60230	1.60414	1.61547	1.62073	1.62562
N-SK2HT 607567.355	1.60738	56.65	0.010722	1.60994	56.37	0.010821	1.60230	1.60414	1.61547	1.62073	1.62562
N-SK4 613586.354	1.61272	58.63	0.010450	1.61521	58.37	0.010541	1.60774	1.60954	1.62059	1.62568	1.63042
N-SK5 589613.330	1.58913	61.27	0.009616	1.59142	61.02	0.009692	1.58451	1.58619	1.59635	1.60100	1.60530
N-SK11 564608.308	1.56384	60.80	0.009274	1.56605	60.55	0.009349	1.55939	1.56101	1.57081	1.57530	1.57946

*** Available in step 0.5**

$P_{g,F}$	$\Delta P_{g,F}$	CR	FR	SR	AR	PR	α (−30/+70)	T_g	$T_{10}^{7.6}$	ρ	HK	τ_i (10/400)	τ_i (10/420)	CC
0.5472	0.0002	2	1	3.3	1.2	2	7.6	592	746	3.19	530	0.996	0.996	33/29
0.5437	0.0004	2	0	1	1	2.3	8.0	554	727	2.86	530	0.997	0.997	32/28
0.5487	−0.0010	1	0	1.2	1	1	7.0	581	725	3.05	550	0.992	0.995	36/33
0.5487	−0.0010	1	0	1.2	1	1	7.0	581	725	3.05	550	0.993	0.996	36/33
0.5477	−0.0008	2	0	2.2	1	2.3	6.0	659	823	3.55	550	0.994	0.994	33/28
0.5477	−0.0008	2	0	2.2	1	2.3	6.0	659	823	3.55	550	0.996	0.997	33/28
0.5448	−0.0004	3	1	51.2	2	2	6.5	658	769	3.54	580	0.990	0.993	36/32
0.5400	−0.0007	3	1	4.4	2	1.3	5.5	660	791	3.30	590	0.992	0.994	34/29
0.5411	−0.0004	2	0	2	1	2.3	6.5	610	760	3.08	570	0.990	0.994	34/29

Glass type	n_d	ν_d	$n_F - n_C$	n_e	ν_e	$n_{F'} - n_{C'}$	n_r	n_C	$n_{F'}$	n_g	n_h
N-SK14 603606.344	1.60311	60.60	0.009953	1.60548	60.34	0.010034	1.59834	1.60008	1.61059	1.61542	1.61988
N-SK16* 620603.358	1.62041	60.32	0.010285	1.62286	60.08	0.010368	1.61548	1.61727	1.62814	1.63312	1.63773

*** Available in step 0.5**

$P_{g,F}$	$\Delta P_{g,F}$	CR	FR	SR	AR	PR	α (−30/+70)	T_g	$T_{10}{}^{7.6}$	ρ	HK	τ_i (10/400)	τ_i (10/420)	CC
0.5415	−0.0003	4	2	51.3	2	2.3	6.0	654	773	3.43	600	0.990	0.993	35/29
0.5412	−0.0011	4	4	53.3	3.3	3.2	6.3	636	750	3.58	600	0.988	0.992	36/30

Glass type	n_d	ν_d	$n_F - n_C$	n_e	ν_e	$n_{F'} - n_{C'}$	n_r	n_C	$n_{F'}$	n_g	n_h
N-KF9 523515.250	1.52346	51.54	0.010156	1.52588	51.26	0.010258	1.51867	1.52040	1.53114	1.53620	1.54096
N-BALF4 580539.311	1.57956	53.87	0.010759	1.58212	53.59	0.010863	1.57447	1.57631	1.58769	1.59301	1.59799
N-BALF5 547536.261	1.54739	53.63	0.010207	1.54982	53.36	0.010303	1.54255	1.54430	1.55510	1.56016	1.56491
N-SSK2 622533.353	1.62229	53.27	0.011681	1.62508	52.99	0.011795	1.61678	1.61877	1.63112	1.63691	1.64232
N-SSK5 658509.371	1.65844	50.88	0.012940	1.66152	50.59	0.013075	1.65237	1.65455	1.66824	1.67471	1.68079
N-SSK8 618498.327	1.61773	49.83	0.012397	1.62068	49.54	0.012529	1.61192	1.61401	1.62713	1.63335	1.63923
N-SSK20* New 626502.345	1.62568	50.20	0.012464	1.62865	49.92	0.012593	1.61984	1.62194	1.63512	1.64132	1.64712
N-LAK7 652585.384	1.65160	58.52	0.011135	1.65425	58.26	0.011229	1.64628	1.64821	1.65998	1.66539	1.67042
N-LAK8 713538.375	1.71300	53.83	0.013245	1.71616	53.61	0.013359	1.70668	1.70897	1.72297	1.72944	1.73545

*** Only available as polished optical components: Spheres, Aspheres, Prisms**

$P_{g,F}$	$\Delta P_{g,F}$	CR	FR	SR	AR	PR	α (−30/+70)	T_g	$T_{10}^{7.6}$	ρ	HK	τ_i (10/400)	τ_i (10/420)	CC
0.5558	−0.0014	1	0	1	1	1	9.6	476	640	2.50	480	0.986	0.994	37/34
0.5520	−0.0012	1	0	1	1	1	6.5	578	661	3.11	540	0.985	0.992	37/33
0.5532	−0.0004	1	0	1	2	1	7.3	558	711	2.61	600	0.983	0.991	37/34
0.5526	−0.0016	1	0	1.2	1	1	5.8	653	801	3.53	570	0.981	0.990	37/33
0.5575	−0.0007	2	3	52.2	2.2	3.2	6.8	645	751	3.71	590	0.959	0.976	38/34
0.5602	0.0002	1	0	1	1.3	1	7.2	616	742	3.27	570	0.950	0.975	39/35
0.5553	−0.0041	1	0	1	1	1	6.7	560	719	3.45	582	0.997	0.998	31/26
0.5433	−0.0021	3	2	53.3	3.3	4.3	7.1	618	716	3.84	600	0.988	0.991	35/29
0.5450	−0.0083	3	2	52.3	1	3.3	5.6	643	717	3.75	740	0.977	0.988	37/30

Glass type	n_d	ν_d	$n_F - n_C$	n_e	ν_e	$n_{F'} - n_{C'}$	n_r	n_C	$n_{F'}$	n_g	n_h
N-LAK9* 691547.351	1.69100	54.71	0.012631	1.69401	54.48	0.012738	1.68497	1.68716	1.70051	1.70667	1.71239
N-LAK10 720506.369	1.72003	50.62	0.014224	1.72341	50.39	0.014357	1.71328	1.71572	1.73077	1.73779	1.74438
N-LAK12 678552.410	1.67790	55.20	0.012281	1.68083	54.92	0.012396	1.67209	1.67419	1.68717	1.69320	1.69882
N-LAK14 697554.363	1.69680	55.41	0.012575	1.69980	55.19	0.012679	1.69077	1.69297	1.70626	1.71237	1.71804
N-LAK21 640601.374	1.64049	60.10	0.010657	1.64304	59.86	0.010743	1.63538	1.63724	1.64850	1.65366	1.65844
N-LAK22 651559.377	1.65113	55.89	0.011650	1.65391	55.63	0.011755	1.64560	1.64760	1.65992	1.66562	1.67092
N-LAK28 744508.409	1.74429	50.77	0.014660	1.74778	50.54	0.014797	1.73734	1.73985	1.75535	1.76257	1.76931
N-LAK33B 755523.422	1.75500	52.30	0.014436	1.75844	52.07	0.014566	1.74814	1.75062	1.76589	1.77296	1.77954
N-LAK34 729545.402	1.72916	54.50	0.013379	1.73235	54.27	0.013493	1.72277	1.72509	1.73923	1.74575	1.75180

*** Available in step 0.5**

$P_{g,F}$	$\Delta P_{g,F}$	CR	FR	SR	AR	PR	α (−30/+70)	T_g	$T_{10}^{7.6}$	ρ	HK	τ_i (10/400)	τ_i (10/420)	CC
0.5447	−0.0071	3	3	52	1.2	4.3	6.3	656	722	3.51	700	0.980	0.988	37/31
0.5515	−0.0072	2	2	52.3	1	3	5.7	636	714	3.69	780	0.964	0.980	38/33
0.5485	−0.0024	3	1	53.3	3.3	4.3	7.6	614	714	4.10	560	0.976	0.981	37/31
0.5427	−0.0079	3	2	52.3	1	3	5.5	661	734	3.63	730	0.981	0.988	36/27
0.5411	−0.0017	4	2	53.2	4.3	4.3	6.8	639	716	3.74	600	0.979	0.985	37/31
0.5467	−0.0031	2	2	51.2	1	2.3	6.6	689		3.77	600	0.991	0.993	34/28
0.5499	−0.0085	2	1	52.3	1	3.3	5.7	625		4.09	740	0.950	0.980	40/34
0.5473	−0.0085	1	1	51.3	1	2	5.8	668	750	4.22	797	0.980	0.988	37/28
0.5443	−0.0079	1	0	52.3	1	2.3	5.8	668	740	4.02	740	0.981	0.989	37/28

Glass type	n_d	ν_d	$n_F - n_C$	n_e	ν_e	$n_{F'} - n_{C'}$	n_r	n_C	$n_{F'}$	n_g	n_h
LLF1 548458.294	1.54814	45.75	0.011981	1.55099	45.47	0.012118	1.54256	1.54457	1.55725	1.56333	1.56911
N-BAF4 606437.289	1.60568	43.72	0.013853	1.60897	43.43	0.014021	1.59926	1.60157	1.61624	1.62336	1.63022
N-BAF10 670471.375	1.67003	47.11	0.014222	1.67341	46.83	0.014380	1.66339	1.66578	1.68083	1.68801	1.69480
N-BAF51 652450.333	1.65224	44.96	0.014507	1.65569	44.67	0.014677	1.64551	1.64792	1.66328	1.67065	1.67766
N-BAF52 609466.305	1.60863	46.60	0.013061	1.61173	46.30	0.013211	1.60254	1.60473	1.61856	1.62521	1.63157

$P_{g,F}$	$\Delta P_{g,F}$	CR	FR	SR	AR	PR	α (−30/+70)	T_g	$T_{10}^{7.6}$	ρ	HK	τ_i (10/400)	τ_i (10/420)	CC
0.5660	−0.0009	1	0	1	2	1	8.1	431	628	2.94	450	0.997	0.998	33/31
0.5733	0.0030	1	0	1	1.2	1.3	7.2	580	709	2.89	610	0.946	0.976	39/35
0.5629	−0.0016	1	0	4.3	1.3	1	6.2	660	790	3.75	620	0.950	0.976	39/35
0.5670	−0.0012	2	0	5.4	1.3	1	8.4	569	712	3.33	560	0.954	0.976	39/34
0.5678	0.0024	1	0	1	1.3	1	6.9	594	716	3.05	600	0.950	0.975	39/35

Glass type	n_d	ν_d	$n_F - n_C$	n_e	ν_e	$n_{F'} - n_{C'}$	n_r	n_C	$n_{F'}$	n_g	n_h
LF5 581409.322	1.58144	40.85	0.014233	1.58482	40.57	0.014413	1.57489	1.57723	1.59231	1.59964	1.60668
N-F2 620364.265	1.62005	36.43	0.017020	1.62408	36.16	0.017258	1.61229	1.61506	1.63310	1.64209	1.65087
F2 620364.360	1.62004	36.37	0.017050	1.62408	36.11	0.017284	1.61227	1.61503	1.63310	1.64202	1.65064
F2HT 620364.360	1.62004	36.37	0.017050	1.62408	36.11	0.017284	1.61227	1.61503	1.63310	1.64202	1.65064
F5 603380.347	1.60342	38.03	0.015867	1.60718	37.77	0.016078	1.59616	1.59875	1.61556	1.62381	1.63176
N-BASF2 664360.315	1.66446	36.00	0.018457	1.66883	35.73	0.018720	1.65607	1.65905	1.67862	1.68838	1.69792
N-BASF64 704394.320	1.70400	39.38	0.017875	1.70824	39.12	0.018105	1.69578	1.69872	1.71765	1.72690	1.73581

$P_{g,F}$	$\Delta P_{g,F}$	CR	FR	SR	AR	PR	α (−30/+70)	T_g	$T_{10}^{7.6}$	ρ	HK	τ_i (10/400)	τ_i (10/420)	CC
0.5748	−0.0003	2	0	1	2.3	2	9.1	419	585	3.22	450	0.997	0.997	34/31
0.5881	0.0056	1	0	1	1	1	7.8	569	686	2.65	600	0.946	0.980	39/36
0.5828	0.0002	1	0	1	2.3	1.3	8.2	434	594	3.60	420	0.994	0.996	35/32
0.5828	0.0002	1	0	1	2.3	1.3	8.2	434	594	3.60	420	0.996	0.997	35/32
0.5795	−0.0003	1	0	1	2.3	2	8.0	438	608	3.47	450	0.993	0.995	35/32
0.5890	0.0057	1	0	1	1	1	7.1	619	766	3.15	580	0.891	0.954	41/36
0.5769	−0.0006	1	0	3.2	1.2	1	7.3	582	712	3.20	650	0.924	0.950	40/35

Glass type	n_d	ν_d	$n_F - n_C$	n_e	ν_e	$n_{F'} - n_{C'}$	n_r	n_C	$n_{F'}$	n_g	n_h
N-LAF2 744449.430	1.74397	44.85	0.016588	1.74791	44.57	0.016780	1.73627	1.73903	1.75659	1.76500	1.77298
N-LAF7 750348.373	1.74950	34.82	0.021525	1.75459	34.56	0.021833	1.73972	1.74320	1.76602	1.77741	1.78854
N-LAF21 788475.428	1.78800	47.49	0.016593	1.79195	47.25	0.016761	1.78019	1.78301	1.80056	1.80882	1.81657
N-LAF33 786441.436	1.78582	44.05	0.017839	1.79007	43.80	0.018038	1.77751	1.78049	1.79937	1.80837	1.81687
N-LAF34 773496.424	1.77250	49.62	0.015568	1.77621	49.38	0.015719	1.76515	1.76780	1.78427	1.79196	1.79915

$P_{g,F}$	$\Delta P_{g,F}$	CR	FR	SR	AR	PR	α (−30/+70)	T_g	$T_{10}^{7.6}$	ρ	HK	τ_i (10/400)	τ_i (10/420)	CC
0.5656	−0.0027	2	3	52.2	1	2.2	8.1	653	734	4.30	530	0.933	0.965	40/34
0.5894	0.0042	1	2	51.3	1.2	1.2	7.3	568	669	3.73	530	0.905	0.948	41/36
0.5555	−0.0084	1	1	51.3	1	1.3	6.0	653	729	4.28	730	0.966	0.981	39/32
0.5626	−0.0071	1	2	52.2	1	3	5.6	600	673	4.36	730	0.963	0.978	39/32
0.5518	−0.0085	1	1	51.3	1	1	5.8	668	745	4.24	770	0.980	0.988	38/30

Glass type	n_d	ν_d	$n_F - n_C$	n_e	ν_e	$n_{F'} - n_{C'}$	n_r	n_C	$n_{F'}$	n_g	n_h
N-LASF9 850322.441	1.85025	32.17	0.026430	1.85650	31.93	0.026827	1.83834	1.84255	1.87058	1.88467	1.89845
N-LASF31A 883408.551	1.88300	40.76	0.021663	1.88815	40.52	0.021921	1.87298	1.87656	1.89950	1.91050	1.92093
LASF35 022291.541	2.02204	29.06	0.035170	2.03035	28.84	0.035721	2.00628	2.01185	2.04916	2.06805	2.08663
N-LASF40 834373.443	1.83404	37.30	0.022363	1.83935	37.04	0.022658	1.82380	1.82745	1.85114	1.86275	1.87393
N-LASF41 835431.485	1.83501	43.13	0.019361	1.83961	42.88	0.019578	1.82599	1.82923	1.84972	1.85949	1.86872
N-LASF43 806406.426	1.80610	40.61	0.019850	1.81081	40.36	0.020089	1.79691	1.80020	1.82122	1.83137	1.84106
N-LASF44* 804465.444	1.80420	46.50	0.017294	1.80832	46.25	0.017476	1.79609	1.79901	1.81731	1.82594	1.83405
N-LASF45 801350.363	1.80107	34.97	0.022905	1.80650	34.72	0.023227	1.79066	1.79436	1.81864	1.83068	1.84237
N-LASF46B 904313.451	1.90366	31.32	0.028852	1.91048	31.09	0.029289	1.89065	1.89526	1.92586	1.94130	1.95647
N-LASF55 954306.486	1.95380	30.56	0.031211	1.96118	30.33	0.031688	1.93976	1.94473	1.97783	1.99454	2.01096

*** Available in step 0.5**

$P_{g,F}$	$\Delta P_{g,F}$	CR	FR	SR	AR	PR	α (–30/+70)	T_g	$T_{10}^{7.6}$	ρ	HK	τ_i (10/400)	τ_i (10/420)	CC
0.5934	0.0037	1	0	2	1	1	7.4	683	817	4.41	515	0.799	0.901	41/36*
0.5667	–0.0085	1	0	2.3	1	1	6.7	719	830	5.51	650	0.933	0.960	38/33*
0.5982	0.0033	1	0	1.3	1	1.3	7.4	774		5.41	810	0.634	0.787	45/37*
0.5786	–0.0024	1	1	51.2	1	1.3	5.8	590	677	4.43	580	0.891	0.937	39/35*
0.5629	–0.0083	1	1	4	1	1	6.2	651	739	4.85	760	0.948	0.967	37/32*
0.5703	–0.0052	1	1	51.3	1	2	5.5	614	699	4.26	720	0.919	0.954	42/34
0.5572	–0.0084	1	1	4	1	1	6.2	655	742	4.44	770	0.963	0.980	40/31
0.5859	0.0009	1	0	3.2	1	1	7.4	647	773	3.63	630	0.857	0.924	44/35
0.5956	0.0045	1	0	3.3	1	1	6.0	611	703	4.51	712	0.815	0.901	41/37*
0.5961	0.0037	1	0	2.3	1	1	6.6	718	796	4.86	710	0.650	0.810	44/37*

* Wavelength for transmittance 0.7 and 0.05

Glass type	n_d	ν_d	$n_F - n_C$	n_e	ν_e	$n_{F'} - n_{C'}$	n_r	n_C	$n_{F'}$	n_g	n_h
N-SF1 717296.303	1.71736	29.62	0.024219	1.72308	29.39	0.024606	1.70651	1.71035	1.73605	1.74919	1.76224
N-SF2 648338.272	1.64769	33.82	0.019151	1.65222	33.56	0.019435	1.63902	1.64210	1.66241	1.67265	1.68273
N-SF4 755274.315	1.75513	27.38	0.027583	1.76164	27.16	0.028044	1.74286	1.74719	1.77647	1.79158	1.80668
N-SF5* 673323.286	1.67271	32.25	0.020858	1.67763	32.00	0.021177	1.66330	1.66664	1.68876	1.69998	1.71106
N-SF6 805254.337	1.80518	25.36	0.031750	1.81266	25.16	0.032304	1.79114	1.79608	1.82980	1.84738	1.86506
N-SF6HT 805254.337	1.80518	25.36	0.031750	1.81266	25.16	0.032304	1.79114	1.79608	1.82980	1.84738	1.86506
N-SF6HTultra 805254.337	1.80518	25.36	0.031750	1.81266	25.16	0.032304	1.79114	1.79608	1.82980	1.84738	1.86506
N-SF8 689313.290	1.68894	31.31	0.022005	1.69413	31.06	0.022346	1.67904	1.68254	1.70589	1.71775	1.72948
N-SF10 728285.305	1.72828	28.53	0.025524	1.73430	28.31	0.025941	1.71688	1.72091	1.74800	1.76191	1.77578
N-SF11 785257.322	1.78472	25.68	0.030558	1.79192	25.47	0.031088	1.77119	1.77596	1.80841	1.82533	1.84235

*** Available in step 0.5**

$P_{g,F}$	$\Delta P_{g,F}$	CR	FR	SR	AR	PR	α (–30/+70)	T_g	$T_{10}^{7.6}$	ρ	HK	τ_i (10/400)	τ_i (10/420)	CC
0.6037	0.0097	1	0	1	1	1	9.1	553	660	3.03	540	0.867	0.946	41/36
0.5950	0.0081	1	0	1	1.2	1	6.7	608	731	2.72	539	0.928	0.970	40/36
0.6096	0.0118	1	0	1.3	1	1	9.5	570	661	3.15	520	0.830	0.916	43/36
0.5984	0.0088	1	0	1	1	1	7.9	578	693	2.86	620	0.905	0.963	40/36
0.6158	0.0146	1	0	2	1	1	9.0	589	669	3.37	550	0.821	0.919	44/37
0.6158	0.0146	1	0	2	1	1	9.0	589	669	3.37	550	0.877	0.937	44/37
0.6158	0.0146	1	0	2	1	1	9.0	589	669	3.37	550	0.887	0.945	43/37
0.5999	0.0087	1	0	1	1	1	8.6	567	678	2.90	600	0.901	0.950	41/36
0.6066	0.0108	1	0	1	1	1	9.4	559	652	3.05	540	0.837	0.924	42/36
0.6156	0.0150	1	0	1	1	1	8.5	592	688	3.22	615	0.815	0.919	44/37

Glass type	n_d	ν_d	$n_F - n_C$	n_e	ν_e	$n_{F'} - n_{C'}$	n_r	n_C	$n_{F'}$	n_g	n_h
N-SF14 762265.312	1.76182	26.53	0.028715	1.76859	26.32	0.029204	1.74907	1.75356	1.78405	1.79986	1.81570
N-SF15 699302.292	1.69892	30.20	0.023142	1.70438	29.96	0.023511	1.68854	1.69222	1.71677	1.72933	1.74182
N-SF57 847238.353	1.84666	23.78	0.035604	1.85504	23.59	0.036247	1.83099	1.83650	1.87432	1.89423	1.91440
N-SF57HT 847238.353	1.84666	23.78	0.035604	1.85504	23.59	0.036247	1.83099	1.83650	1.87432	1.89423	1.91440
N-SF57HTultra 847238.353	1.84666	23.78	0.035604	1.85504	23.59	0.036247	1.83099	1.83650	1.87432	1.89423	1.91440
N-SF66 923209.400	1.92286	20.88	0.044199	1.93322	20.70	0.045076	1.90368	1.91039	1.95739	1.98285	
SF1 717295.446	1.71736	29.51	0.024307	1.72310	29.29	0.024687	1.70647	1.71031	1.73610	1.74916	1.76201
SF2* 648339.386	1.64769	33.85	0.019135	1.65222	33.60	0.019412	1.63902	1.64210	1.66238	1.67249	1.68233
SF3 740282.464	1.74000	28.20	0.026244	1.74620	27.98	0.026667	1.72829	1.73242	1.76027	1.77446	1.78846
SF4 755276.479	1.75520	27.58	0.027383	1.76167	27.37	0.027829	1.74300	1.74730	1.77636	1.79121	1.80589

*** Available in step 0.5**

$P_{g,F}$	$\Delta P_{g,F}$	CR	FR	SR	AR	PR	α (–30/+70)	T_g	$T_{10}^{7.6}$	ρ	HK	τ_i (10/400)	τ_i (10/420)	CC
0.6122	0.0130	1	0	1	1	1	9.4	566	657	3.12	515	0.891	0.946	42/36
0.6038	0.0108	1	0	1	1	1	8.0	580	692	2.92	610	0.857	0.941	42/37
0.6216	0.0178	1	0	1	1	1	8.5	629	716	3.53	520	0.733	0.872	42/37*
0.6216	0.0178	1	0	1	1	1	8.5	629	716	3.53	520	0.793	0.896	41/37*
0.6216	0.0178	1	0	1	1	1	8.5	629	716	3.53	520	0.830	0.917	40/37*
0.6394	0.0307	1	0	1	1	1	5.9	710	800	4.00	440	0.504	0.758	45/39*
0.5983	0.0042	2	1	3.2	2.3	3	8.1	417	566	4.46	390	0.967	0.984	39/34
0.5886	0.0017	1	0	2	2.3	2	8.4	441	600	3.86	410	0.981	0.990	37/33
0.6020	0.0056	1	2	4.3	2.3	2.3	8.4	415	548	4.64	380	0.940	0.971	40/35
0.6036	0.0062	1	2	4.3	2.3	3.3	8.0	420	552	4.79	390	0.954	0.980	40/35

* Wavelength for transmittance 0.7 and 0.05

Glass type	n_d	ν_d	$n_F - n_C$	n_e	ν_e	$n_{F'} - n_{C'}$	n_r	n_C	$n_{F'}$	n_g	n_h
SF5 673322.407	1.67270	32.21	0.020885	1.67764	31.97	0.021195	1.66327	1.66661	1.68876	1.69986	1.71069
SF6 805254.518	1.80518	25.43	0.031660	1.81265	25.24	0.032201	1.79117	1.79609	1.82970	1.84707	1.86436
SF6HT 805254.518	1.80518	25.43	0.031660	1.81265	25.24	0.032201	1.79117	1.79609	1.82970	1.84707	1.86436
SF10 728284.428	1.72825	28.41	0.025633	1.73430	28.19	0.026051	1.71681	1.72085	1.74805	1.76198	1.77579
SF11 785258.474	1.78472	25.76	0.030467	1.79190	25.55	0.030997	1.77125	1.77599	1.80834	1.82518	1.84208
SF56A 785261.492	1.78470	26.08	0.030092	1.79180	25.87	0.030603	1.77136	1.77605	1.80800	1.82449	1.84092
SF57 847238.551	1.84666	23.83	0.035536	1.85504	23.64	0.036166	1.83102	1.83650	1.87425	1.89393	1.91366
SF57HTultra* 847238.551	1.84666	23.83	0.035536	1.85504	23.64	0.036166	1.83102	1.83650	1.87425	1.89393	1.91366

*** Available in step 0.5**

$P_{g,F}$	$\Delta P_{g,F}$	CR	FR	SR	AR	PR	α (–30/+70)	T_g	$T_{10}^{7.6}$	ρ	HK	τ_i (10/400)	τ_i (10/420)	CC
0.5919	0.0023	1	1	2	2.3	3	8.2	425	580	4.07	410	0.980	0.989	37/33
0.6102	0.0092	2	3	51.3	2.3	3.3	8.1	423	538	5.18	370	0.915	0.967	42/36
0.6102	0.0092	2	3	51.3	2.3	3.3	8.1	423	538	5.18	370	0.941	0.977	41/36
0.6046	0.0085	1	0	1	1.2	2	7.5	454	595	4.28	430	0.862	0.967	41/37
0.6147	0.0142	1	0	1	1.2	1	6.1	503	635	4.74	450	0.525	0.867	44/39
0.6098	0.0098	1	1	3.2	2.2	3.2	7.9	429	556	4.92	380	0.857	0.959	42/37
0.6160	0.0123	2	5	52.3	2.3	4.3	8.3	414	507	5.51	350	0.847	0.941	40/37*
0.6160	0.0123	2	5	52.3	2.3	4.3	8.3	414	507	5.51	350	0.924	0.971	39/36*

* Wavelength for transmittance 0.7 and 0.05

Glass type	n_d	ν_d	$n_F - n_C$	n_e	ν_e	$n_{F'} - n_{C'}$	n_r	n_C	$n_{F'}$	n_g	n_h
N-KZFS2** 558540.255	1.55836	54.01	0.010338	1.56082	53.83	0.010418	1.55337	1.55519	1.56612	1.57114	1.57580
N-KZFS4* 613445.300	1.61336	44.49	0.013785	1.61664	44.27	0.013929	1.60688	1.60922	1.62380	1.63071	1.63723
N-KZFS5* 654397.304	1.65412	39.70	0.016477	1.65803	39.46	0.016675	1.64649	1.64922	1.66667	1.67511	1.68318
N-KZFS8** 720347.320	1.72047	34.70	0.020763	1.72539	34.47	0.021046	1.71099	1.71437	1.73637	1.74724	1.75777
N-KZFS11/***** 638424.320	1.63775	42.41	0.015038	1.64132	42.20	0.015198	1.63069	1.63324	1.64915	1.65670	1.66385

* **Available in step 0.5**
** **Available in step 0.5 for fine annealed glass only**
*** **Available as prism only on request**

$P_{g,F}$	$\Delta P_{g,F}$	CR	FR	SR	AR	PR	α (−30/+70)	T_g	$T_{10}{}^{7.6}$	ρ	HK	τ_i (10/400)	τ_i (10/420)	CC
0.5419	−0.0111	1	4	52.3	4.3	4.2	4.4	482	600	2.54	490	0.985	0.990	34/30
0.5590	−0.0100	1	1	3.4	1.2	1	7.3	536	664	3.00	520	0.979	0.984	36/32
0.5710	−0.0060	1	0	1	1	1	6.4	584	739	3.04	555	0.976	0.983	37/32
0.5833	−0.0021	1	0	1	1	1	7.8	509	635	3.20	570	0.963	0.976	38/33
0.5605	−0.0120	1	1	3.4	1	1	6.6	551		3.20	530	0.987	0.990	36/30

Glass type	n_d	ν_d	$n_F - n_C$	n_e	ν_e	$n_{F'} - n_{C'}$	n_r	n_C	$n_{F'}$	n_g	n_h
P-SK57 587596.301	1.58700	59.60	0.009849	1.58935	59.36	0.009928	1.58227	1.58399	1.59440	1.59917	1.60359
P-SK60 610579.308	1.61035	57.90	0.010541	1.61286	57.66	0.010628	1.60530	1.60714	1.61828	1.62340	1.62815
P-LAK35 693532.385	1.69350	53.20	0.013036	1.69661	52.95	0.013156	1.68732	1.68955	1.70334	1.70974	1.71569
P-SF69 723292.293	1.72250	29.23	0.024718	1.72883	29.00	0.025116	1.71144	1.71535	1.74158	1.75502	1.76840
P-LAF37 755457.399	1.75550	45.66	0.016546	1.75944	45.42	0.016722	1.74775	1.75054	1.76804	1.77633	1.78414
P-LASF47 806409.454	1.80610	40.90	0.019709	1.81078	40.66	0.019941	1.79696	1.80023	1.82110	1.83112	1.84064
P-SF68 005210.619	2.00520	21.00	0.047867	2.01643	20.82	0.048826	1.98449	1.99171	2.04262	2.07018	
N-FK51A 487845.368	1.48656	84.47	0.005760	1.48794	84.07	0.005804	1.48379	1.48480	1.49088	1.49364	1.49618
N-FK5 487704.245	1.48749	70.41	0.006924	1.48914	70.23	0.006965	1.48410	1.48535	1.49266	1.49593	1.49894
N-PK52A 497816.370	1.49700	81.61	0.006090	1.49845	81.21	0.006138	1.49408	1.49514	1.50157	1.50450	1.50720

$P_{g,F}$	$\Delta P_{g,F}$	n_d ref.*1	After Molding*2 n_d	ν_d	SR-J	WR-J	α (–30/+70)	α (20/300)	T_g	AT	ρ	HK	Abrasion Aa	τ_i (10/400)	CC
0.5412	–0.0024	1.58596	1.5843	59.4	4	1	7.2	8.9	493	522	3.01	535	124	0.994	34/31
0.5427	–0.0037	1.60918	1.6068	57.7	4	3	7.1	8.9	507	547	3.08	601	86	0.997	33/29
0.5482	–0.0061	1.69234	1.6904	53.0	4	3	8.1	9.7	508	544	3.85	616	119	0.988	36/29
0.6050	0.0104	1.72006	1.7155	29.7	1	1	9.0	11.1	508	547	2.93	612	142	0.915	41/36
0.5590	–0.0080	1.75396	1.7508	45.5	4	1	6.3	7.8	506	546	3.99	697	67	0.976	37/31
0.5671	–0.0079	1.80449	1.8016	40.8	3	1	6.0	7.3	530	580	4.54	620	70	0.967	39/33
0.6392	0.0308	2.00365	1.9958	20.9	4	1	8.4	9.7	428	468	6.19	404	298	0.007	49/41*
0.5359	0.0342	1.48597	1.4847	84.2	3	1	12.7	14.8	464	503	3.68	345	528	0.997	34/28
0.5290	0.0036	1.48666	1.485	70.2	5	4	9.2	10.0	466	557	2.45	520	109	0.998	30/27
0.5377	0.0311	1.49640	1.4952	81.3	4	1	13.0	15.0	467	520	3.70	355	526	0.997	34/28

*1 n_d reference value (annealing rate 25 K/h) *2 As pressed at SCHOTT; for details, please consult SCHOTT
* Wavelength for transmittance 0.7 and 0.05

Glass type	n_d	ν_d	$n_F - n_C$	n_e	ν_e	$n_{F'} - n_{C'}$	n_r	n_C	$n_{F'}$	n_g	n_h
N-PK51 529770.386	1.52855	76.98	0.006867	1.53019	76.58	0.006923	1.52527	1.52646	1.53372	1.53704	1.54010
N-KZFS2 558540.255	1.55836	54.01	0.010338	1.56082	53.83	0.010418	1.55337	1.55519	1.56612	1.57114	1.57580
N-KZFS4 613445.300	1.61336	44.49	0.013785	1.61664	44.27	0.013929	1.60688	1.60922	1.62380	1.63071	1.63723
N-KZFS11** 638424.320	1.63775	42.41	0.015038	1.64132	42.20	0.015198	1.63069	1.63324	1.64915	1.65670	1.66385
N-KZFS5 654397.304	1.65412	39.70	0.016477	1.65803	39.46	0.016675	1.64649	1.64922	1.66667	1.67511	1.68318
N-KZFS8 720347.320	1.72047	34.70	0.020763	1.72539	34.47	0.021046	1.71099	1.71437	1.73637	1.74724	1.75777
N-LAF33 786441.436	1.78582	44.05	0.017839	1.79007	43.80	0.018038	1.77751	1.78049	1.79937	1.80837	1.81687
N-LASF46B 904313.451	1.90366	31.32	0.028852	1.91048	31.09	0.029289	1.89065	1.89526	1.92586	1.94130	1.95647
SF57 847238.551	1.84666	23.83	0.035536	1.85504	23.64	0.036166	1.83102	1.83650	1.87425	1.89393	1.91366
SF57HTultra 847238.551	1.84666	23.83	0.035536	1.85504	23.64	0.036166	1.83102	1.83650	1.87425	1.89393	1.91366

**** Available as prism only on request**

$P_{g,F}$	$\Delta P_{g,F}$	n_d ref.*1	After Molding*2 n_d	ν_d	SR-J	WR-J	α (–30/+70)	α (20/300)	T_g	AT	ρ	HK	Abrasion Aa	τ_i (10/400)	CC
0.5401	0.0258	1.52784	1.5267	76.7	3	1	12.4	14.1	487	528	3.86	415	592	0.994	34/29
0.5419	–0.0111	1.55666	1.5534	53.7	6	6	4.4	5.4	472	533	2.54	490	70	0.985	34/30
0.5590	–0.0100	1.61227	1.6100	44.5	6	4	7.3	8.2	536	597	3.00	520	130	0.979	36/32
0.5605	–0.0120	1.63658	1.6341	42.3			6.6	7.6	551		3.20	530	74	0.987	36/30
0.5710	–0.0060	1.65272	1.6498	39.8	1	1	6.4	7.4	584	648	3.04	555	122	0.976	37/32
0.5833	–0.0021	1.71896	1.7158	34.8	1	1	7.8	9.4	509	561	3.20	570	152	0.963	38/33
0.5626	–0.0071	1.78425	1.7811	43.9	6	1	5.6	6.7	600	628	4.36	730	67	0.963	39/32
0.5956	0.0045	1.90165	1.8977	31.4	1	2	6.0	7.1	611	649	4.51	712	55	0.847	40/36*
0.6160	0.0123	1.84608	1.8447	23.6	6	1	8.3	9.2	414	449	5.51	350	344	0.847	40/37*
0.6160	0.0123	1.84608	1.8447	23.7	6	1	8.3	9.2	414	449	5.51	350	344	0.924	39/36*

*1 n_d reference value (annealing rate 25 K/h) *2 As pressed at SCHOTT; for details, please consult SCHOTT
* Wavelength for transmittance 0.7 and 0.05

Glass type	n_d	ν_d	$n_F - n_C$	n_e	ν_e	$n_{F'} - n_{C'}$	n_r	n_C	$n_{F'}$	n_g	n_h
BK7G18 520636.252	1.51975	63.58	0.008174	1.52170	63.36	0.008233	1.51579	1.51724	1.52587	1.52981	1.53345
K5G20 523568.259	1.52344	56.76	0.009222	1.52564	56.47	0.009308	1.51906	1.52065	1.53040	1.53494	1.53919
LF5G15* 584408.322	1.58397	40.83	0.014301	1.58736	40.55	0.014484	1.57739	1.57974	1.59489	1.60228	
LF5G19 597399.330	1.59655	39.89	0.014954	1.60010	39.60	0.015153	1.58970	1.59214	1.60799	1.61578	1.62330
F2G12 621366.360	1.62072	36.56	0.016979	1.62474	36.30	0.017212	1.61298	1.61573	1.63373	1.64261	1.65121
LAK9G15 691548.353	1.69064	54.76	0.012612	1.69364	54.53	0.012721	1.68462	1.68680	1.70013	1.70630	1.71205
SF6G05 809253.520	1.80906	25.27	0.032015	1.81661	25.08	0.03257	1.79491	1.79988	1.83387		

*** Inquiry glass**

$P_{g,F}$	$\Delta P_{g,F}$	CR	FR	SR	AR	PR	α (−30/+70)	T_g	$T_{10}^{7.6}$	ρ	HK	τ_i (10/400)	τ_i (10/420)	CC
0.5376	0.0007		0	1	2		7.0	585	722	2.52	580	0.764	0.905	41/37
0.5500	0.0017		0	1	1		9.0	483	679	2.59	510	0.821	0.924	41/37
0.5759	0.0008	2	0	1	1.3	2.3	9.3	407	578	3.22	446	0.569	0.833	43/37
0.5803	0.0036	2–3	2	3.4	2.2	3	10.7	474	606	3.30	410	0.276	0.657	45/39
0.5831	0.0008	1	0	1	1.3	2.3	7.6	435	612	3.61	411	0.246	0.618	46/39
0.5462	−0.0055	1–2	2	53.0	1.3	4.3	6.3	634	710	3.53	721	0.292	0.634	46/38
0.6121	0.0108	4	3	51.3	2.3	3.3	7.8	427	529	5.20	360		–	52/46*

* Wavelength for transmittance 0.7 and 0.05

Glass type	n_d	ν_d	$n_F - n_C$	n_e	ν_e	$n_{F'} - n_{C'}$	n_r	n_C	$n_{F'}$	n_g	n_h
FK3 464658.227	1.46450	65.77	0.007063	1.46619	65.57	0.007110	1.46106	1.46232	1.46978	1.47315	1.47625
N-ZK7** 508612.249	1.50847	61.19	0.008310	1.51045	60.98	0.008370	1.50445	1.50592	1.51470	1.51869	1.52238
K7 511604.253	1.51112	60.41	0.008461	1.51314	60.15	0.008531	1.50707	1.50854	1.51748	1.52159	1.52540
N-BAF3 583466.279	1.58272	46.64	0.012495	1.58569	46.35	0.012637	1.57689	1.57899	1.59222	1.59857	1.60463
BAFN6 589485.317	1.58900	48.45	0.012158	1.59189	48.16	0.012291	1.58332	1.58536	1.59823	1.60436	1.61017
N-KZFS4HT 613445.300	1.61336	44.49	0.013785	1.61664	44.27	0.013929	1.60688	1.60922	1.62380	1.63071	1.63723
N-PSK53 620635.360	1.62014	63.48	0.009769	1.62247	63.19	0.009851	1.61547	1.61717	1.62749	1.63223	1.63662
N-SK10 623570.364	1.62278	56.98	0.010929	1.62539	56.70	0.011029	1.61759	1.61947	1.63102	1.63638	1.64137
N-SK15 623580.362	1.62296	58.02	0.010737	1.62552	57.75	0.010832	1.61785	1.61970	1.63105	1.63629	1.64116
KZFSN5 654396.346	1.65412	39.63	0.016507	1.65803	39.40	0.016701	1.64644	1.64920	1.66668	1.67512	1.68319

**** Not available in step 1/1; for designs with tight tolerances N-ZK7A recommended**

$P_{g,F}$	$\Delta P_{g,F}$	CR	FR	SR	AR	PR	α (−30/+70)	T_g	$T_{10}^{7.6}$	ρ	HK	τ_i (10/400)	τ_i (10/420)	CC
0.5329	−0.0003	2	3	52.4	2	1	8.2	362	622	2.27	380	0.994	0.995	33/30
0.5370	−0.0039	1	0	2	1.2	2.2	4.5	539	721	2.49	530	0.990	0.992	34/29
0.5422	0.0000	3	0	2	1	2.3	8.4	513	712	2.53	520	0.996	0.996	33/30
0.5669	0.0015	1	0	1	1	1	7.2	583	714	2.79	560	0.959	0.981	39/35
0.5625	0.0002	2	0	2	2	1	7.8	549		3.17	540	0.971	0.981	38/33
0.5590	−0.0100	1	1	3.4	1.2	1	7.3	536	664	3.00	520	0.985	0.988	36/32
0.5423	0.0053	2	1	52.3	1.2	4.3	9.4	618	709	3.60	440	0.985	0.992	36/31
0.5474	−0.0005	3	3	52.2	2	2.2	6.8	633	758	3.64	550	0.988	0.994	36/32
0.5453	−0.0009	3	3	52.2	2	3.2	6.7	641	752	3.62	620	0.984	0.990	36/31
0.5700	−0.0071	3	2	52.3	4.3	4.3	4.5	501		3.46	460	0.976	0.987	37/34

Glass type	n_d	ν_d	$n_F - n_C$	n_e	ν_e	$n_{F'} - n_{C'}$	n_r	n_C	$n_{F'}$	n_g	n_h
N-SF19 667331.290	1.66679	33.12	0.020131	1.67154	32.86	0.020435	1.65769	1.66092	1.68228	1.69309	1.70377
KZFS12 696363.384	1.69600	36.29	0.019179	1.70055	36.06	0.019425	1.68717	1.69033	1.71065	1.72059	1.73017
N-SF64 706302.299	1.70591	30.23	0.023350	1.71142	29.99	0.023720	1.69544	1.69914	1.72392	1.73657	1.74912
N-LAF3 717480.414	1.71700	47.96	0.014950	1.72055	47.68	0.015112	1.71001	1.71252	1.72834	1.73585	1.74293
N-LAF35 743494.412	1.74330	49.40	0.015047	1.74688	49.16	0.015194	1.73620	1.73876	1.75467	1.76212	1.76908
LAFN7 750350.438	1.74950	34.95	0.021445	1.75458	34.72	0.021735	1.73970	1.74319	1.76592	1.77713	1.78798
N-LAK33A 754523.422	1.75393	52.27	0.014424	1.75737	52.04	0.014554	1.74707	1.74956	1.76481	1.77187	1.77845
N-SF56 785261.328	1.78470	26.10	0.030071	1.79179	25.89	0.030587	1.77137	1.77607	1.80800	1.82460	1.84126
N-LAF36 800424.443	1.79952	42.37	0.018871	1.80400	42.12	0.019090	1.79076	1.79390	1.81387	1.82345	1.83252
N-LASF45HT 801350.363	1.80107	34.97	0.022905	1.80650	34.72	0.023227	1.79066	1.79436	1.81864	1.83068	1.84237

$P_{g,F}$	$\Delta P_{g,F}$	CR	FR	SR	AR	PR	α (−30/+70)	T_g	$T_{10}^{7.6}$	ρ	HK	τ_i (10/400)	τ_i (10/420)	CC
0.5976	0.0095	1	0	1	1.2	1	7.2	598	707	2.90	630	0.901	0.950	40/36
0.5778	−0.0050	4	1	53.3	4.3	4.3	5.2	492	549	3.84	440	0.919	0.963	40/35
0.6028	0.0099	1	0	1	1.2	1	8.5	572	685	2.99	620	0.850	0.934	42/37
0.5603	−0.0028	2	3	52.3	1.2	3.3	7.6	646	740	4.14	580	0.954	0.976	39/34
0.5523	−0.0084	2	1	52.3	1	3.3	5.3	589	669	4.12	660	0.976	0.987	38/30
0.5825	−0.0025	3	1	53.3	2.2	4.3	5.3	500	573	4.38	520	0.937	0.976	40/35
0.5473	−0.0086	1	1	51	1	2	5.8	669	744	4.22	740	0.976	0.988	38/30
0.6139	0.0140	1	0	1	1.3	1	8.7	592	691	3.28	560	0.799	0.905	44/37
0.5659	−0.0067	1	2	52.3	1	3.3	5.7	579	670	4.43	680	0.946	0.967	40/33
0.5859	0.0009	1	0	3.2	1	1	7.4	647	773	3.63	630	0.886	0.941	43/35

* Wavelength for transmittance 0.7 and 0.05

Glass type	n_d	ν_d	$n_F - n_C$	n_e	ν_e	$n_{F'} - n_{C'}$	n_r	n_C	$n_{F'}$	n_g	n_h
SFL6 805254.337	1.80518	25.39	0.031708	1.81265	25.19	0.032260	1.79116	1.79609	1.82977	1.84733	1.86500
SFL57 847236.355	1.84666	23.62	0.035841	1.85510	23.43	0.036489	1.83089	1.83643	1.87451	1.89456	1.91488
SF57HT 847238.551	1.84666	23.83	0.035536	1.85504	23.64	0.036166	1.83102	1.83650	1.87425	1.89393	1.91366
N-LASF9HT 850322.441	1.85025	32.17	0.026430	1.85650	31.93	0.026827	1.83834	1.84255	1.87058	1.88467	1.89845
N-LASF46A 904313.445	1.90366	31.32	0.028853	1.91048	31.09	0.029287	1.89064	1.89526	1.92586	1.94129	1.95645

$P_{g,F}$	$\Delta P_{g,F}$	CR	FR	SR	AR	PR	α (–30/+70)	T_g	$T_{10}^{7.6}$	ρ	HK	τ_i (10/400)	τ_i (10/420)	CC
0.6159	0.0148	1	0	2	1	1	9.0	585		3.37	570	0.850	0.920	45/37
0.6218	0.0177	1	0	1.3	1	1.3	8.7	598	700	3.55	580	0.525	0.770	44/38*
0.6160	0.0123	2	5	52.3	2.3	4.3	8.3	414	519	5.51	350	0.847	0.964	40/37*
0.5934	0.0037	1	0	2	1	1	7.4	683	817	4.41	515	0.843	0.915	40/36*
0.5953	0.0042	1	0	3	1	1	6.0	638	733	4.45	666	0.815	0.905	41/37*

Glass type	n_d	ν_d	$n_F - n_C$	n_e	ν_e	$n_{F'} - n_{C'}$	n_r	n_C	$n_{F'}$	n_g	n_h
P-BK7 516641.243	1.51640	64.06	0.008061	1.51832	63.87	0.008115	1.51248	1.51392	1.52243	1.52628	1.52982
P-PK53 527662.283	1.52690	66.22	0.007957	1.52880	65.92	0.008022	1.52309	1.52447	1.53288	1.53673	1.54029
P-SK57Q1 586595.301	1.58600	59.50	0.009849	1.58835	59.26	0.009928	1.58127	1.58299	1.59340	1.59817	1.60260
P-SK58A 589612.297	1.58913	61.15	0.009634	1.59143	60.93	0.009707	1.58449	1.58618	1.59636	1.60100	1.60530
N-KZFS4HT 613445.300	1.61336	44.49	0.013785	1.61664	44.27	0.013929	1.60688	1.60922	1.62380	1.63071	1.63723
P-SF8 689313.290	1.68893	31.25	0.022046	1.69414	31.01	0.022386	1.67901	1.68252	1.70591	1.71778	1.72950
P-LASF50 809405.454	1.80860	40.46	0.019985	1.81335	40.22	0.020223	1.79934	1.80266	1.82382	1.83399	1.84367
P-LASF51 810409.458	1.81000	40.93	0.019792	1.81470	40.68	0.020025	1.80082	1.80411	1.82506	1.83512	1.84467
P-SF67 907214.424	1.90680	21.40	0.042374	1.91675	21.23	0.043191	1.88833	1.89480	1.93985	1.96401	

$P_{g,F}$	$\Delta P_{g,F}$	n_d ref.*1	After Molding*2 n_d	ν_d	SR-J	WR-J	α (–30/+70)	α (20/300)	T_g	AT	ρ	HK	Abrasion Aa	τ_i (10/400)	CC
0.5335	–0.0025	1.51576	1.5144	63.9	1	4	6.0	7.3	498	546	2.43	627	66	0.997	33/30
0.5408	0.0084	1.52567	1.5232	66	3	1	13.3	16.0	383	418	2.83	335	977	0.994	36/31
0.5414	–0.0024	1.58496	1.5833	59.4	4	1	7.2	8.9	493	522	3.01	535	124	0.994	34/31
0.5386	–0.0023	1.58795	1.5860	60.8	4	2	6.8	8.4	510	551	2.97	662	102	0.994	35/31
0.5590	–0.0100	1.61227	1.6100	44.5	6	4	7.3	8.2	536	597	3.00	520	130	0.985	36/32
0.5991	0.0079	1.68623	1.6814	31.7	1	1	9.4	11.1	524	580	2.90	533	200	0.924	40/36
0.5680	–0.0078	1.80699	1.8036	40.3			5.9	7.3	527	571	4.54	655	62	0.967	39/32
0.5670	–0.0080	1.80842	1.8055	40.8	3	1	6.0	7.4	526	570	4.58	722	66	0.967	39/33
0.6334	0.0256	1.90439	1.8998	21.6	1	1	6.2	7.4	539	601	4.24	440	309	0.276	48/39*

*1 n_d reference value (annealing rate 25 K/h) *2 As pressed at SCHOTT; for details, please consult SCHOTT
* Wavelength for transmittance 0.7 and 0.05

Glossary

Glass Code – International glass code of refractive index n_d and Abbe number ν_d with density

n_x, ν_x, $n_x - n_y$ – Refractive index, Abbe number, and dispersion at various wavelengths

$P_{g,F}$, $\Delta P_{g,F}$ – Relative partial dispersion and deviation of relative partial dispersion from the normal line between g and F line

CR – Climatic resistance class

FR – Stain resistance class

SR – Acid resistance class (ISO 8424)

AR – Alkali resistance class (ISO 10629)

PR – Phosphate resistance class (ISO 9689)

α(–30/+70) – Coefficient of linear thermal expansion between –30 °C and +70 °C in 10^{-6}/K

T_g – Transformation temperature in °C (ISO 7884-8)

$T_{10^{7.6}}$ – Temperature of the glass at a viscosity of $10^{7.6}$ dPa · s

ρ – Density in g/cm³

HK – Knoop hardness (ISO 9385)

τ_i(10/400) – Internal transmittance at 400 nm; glass thickness: 10 mm

τ_i(10/420) – Internal transmittance at 420 nm; glass thickness: 10 mm

CC – Color Code: Wavelength for transmittance 0.80 (at*: 0.70) and 0.05; glass thickness: 10 mm (ISO 12123:2018)

Only precision molding glasses:

Abrasion Aa – Grindability according to JOGIS

n_d ref. – n_d reference value (annealing rate 25 K/h)

n_d, ν_d after molding – As pressed at SCHOTT (preliminary data based on annealing rate of 5000 K/h)

SR-J – Acid resistance class according to JOGIS

WR-J – Water resistance class according to JOGIS

AT – Yield point/sag temperature in °C

α(20/300) – Coefficient of linear thermal expansion between +20 °C and +300 °C in 10^{-6}/K

JOGIS – Japanese Optical Glass Industrial Standards

The data listed is the most accurate data currently available. We reserve the right to make changes due to technical progress.
The leading document is the glass catalogue online available, refer to www.schott.com.

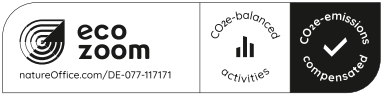
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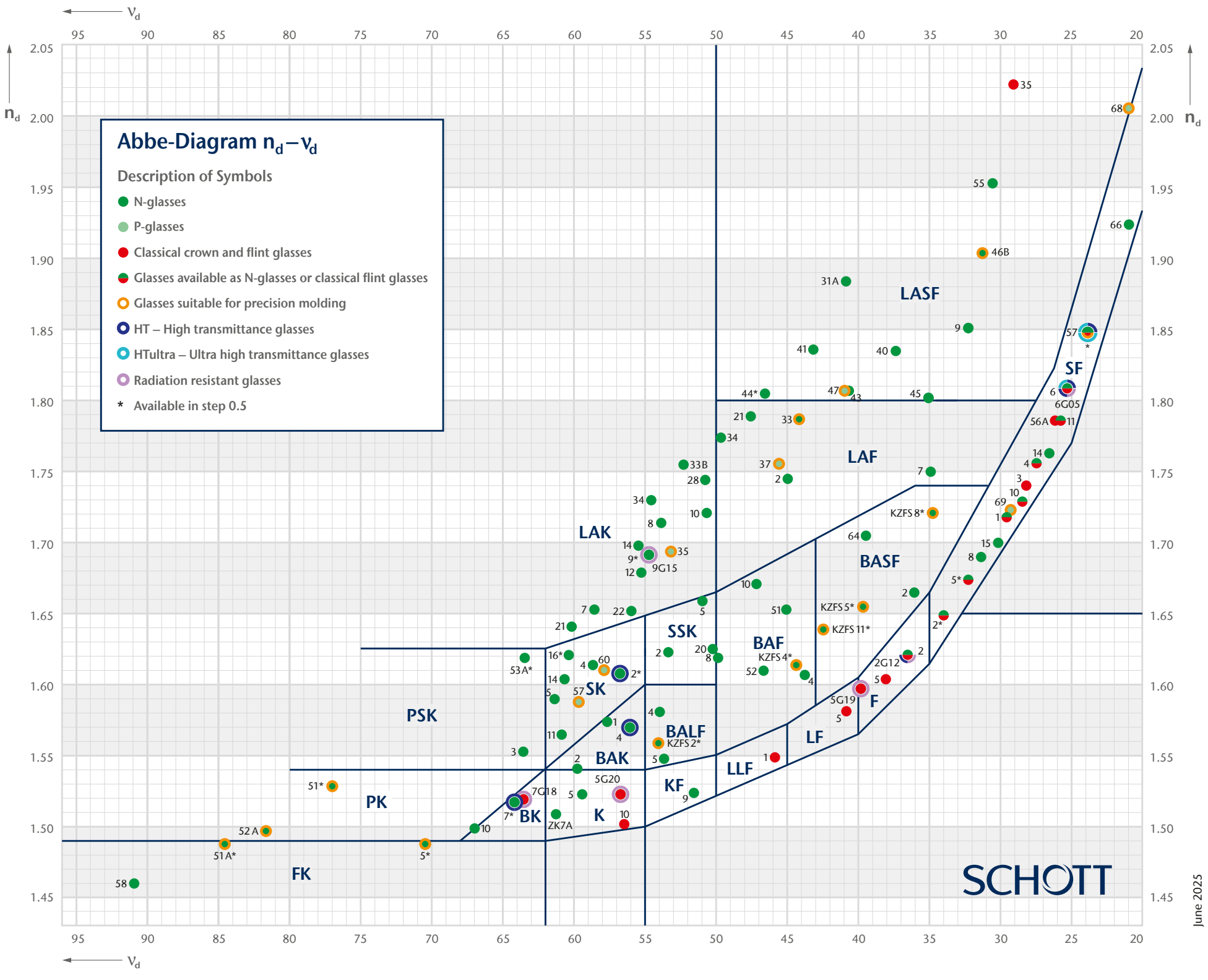


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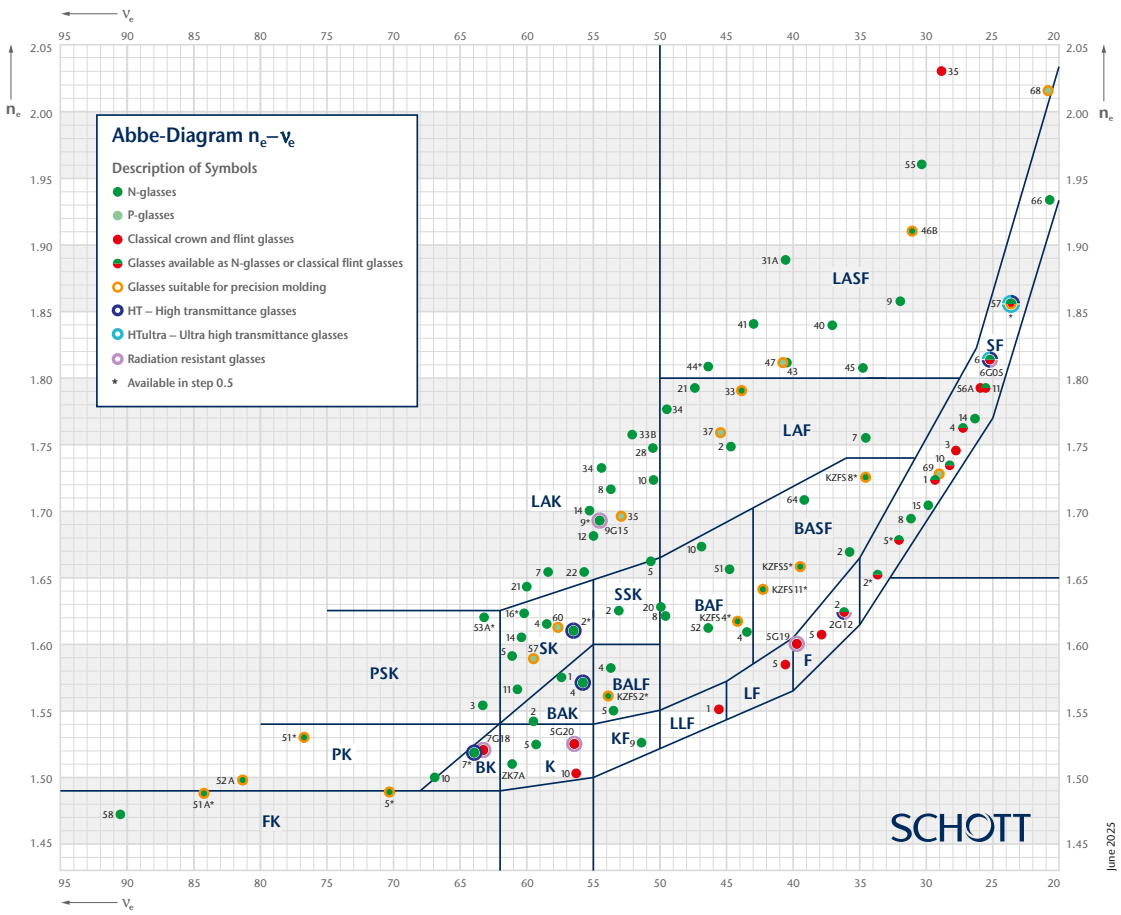
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Abbe-Diagram $n_d - \nu_d$



Abbe-Diagram n_e–ν_e



$P_{g,F}$-Diagram

