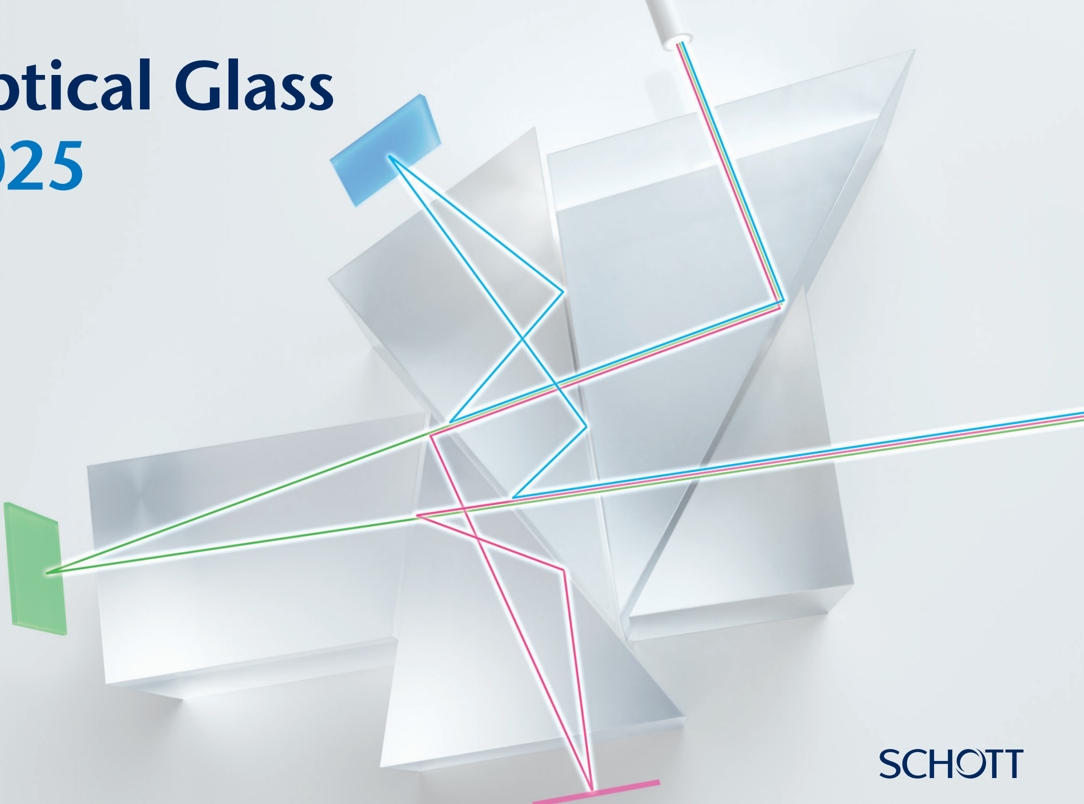
# Optical Glass
# 2025



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.

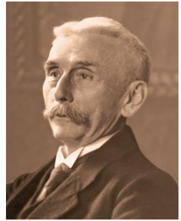
# Foreword

**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

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ISO 45001

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

TIE available

## 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 an environmentally friendly alternative to conventional lead and arsenic-containing 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:**

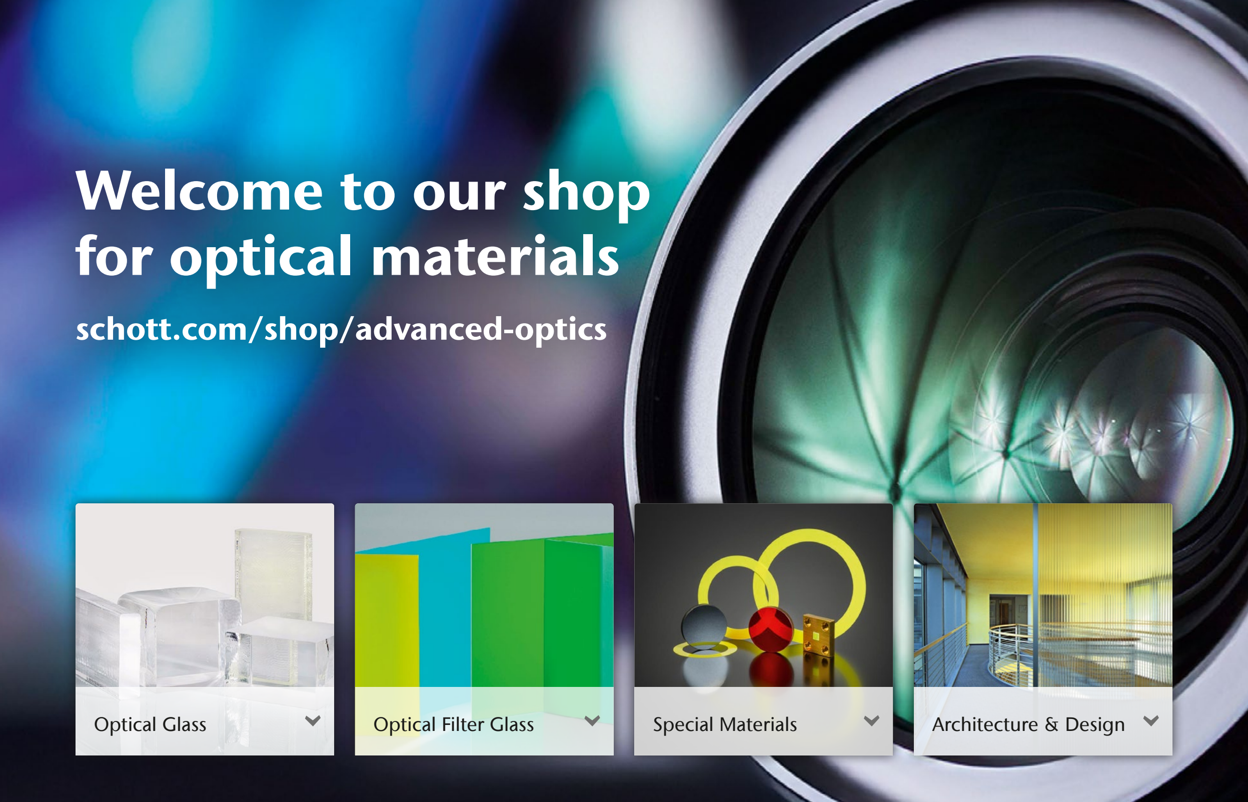
The optical data for the glasses listed in this catalog are meant for use in optical applications and therefore refer to air.

**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.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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 $\nu_d$, and the final three digits indicate the glass density.

**Table 1.1:** Examples of glass codes

| Glass type | $n_d$ | $\nu_d$ | 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 $n_d/\nu_d$ or $n_e/\nu_e$ 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 $\nu_d$. 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).

| | $n_d$ | $\nu_d$ |
|---|---|---|
| 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.

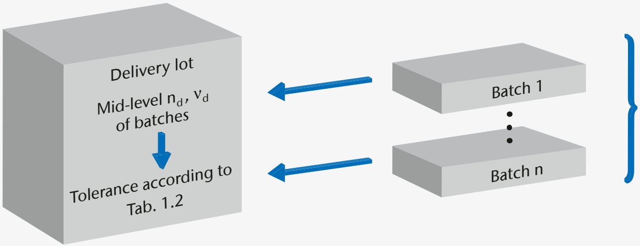
**Table 1.3:** Tolerance for refractive index variation within a lot of fine annealed glass and within a lot of pressings (grades according to ISO 12123:2018/ ISO 10110-18:2018 in parentheses).

| 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

Delivery lot:
Lot of single batches with identical properties

Batch:
A single block of glass or several strips produced in a given period of time with individual $n_d$ and $\nu_d$.




Max. refractive index variation from batch to batch:
SN, S0 or S1 according to Tab. 1.3

SCHOTT is responsible for the combination of batches within a delivery lot.

## 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 | $n_d$, $\nu_d$, $n_e$, $\nu_e$ |
| 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

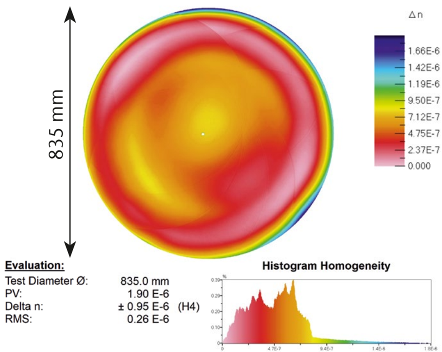
The refractive index homogeneity is a measure for designating deviations in the refractive index in individual pieces of glass. Pieces of glass with a high homogeneity of refractive index can be obtained by undertaking special efforts in the area of melting and fine annealing. The refractive index homogeneity 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

TIE-35 Transmittance of optical glass

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 $\lambda_{80}$ and $\lambda_5$ 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 $\lambda_{80}$ = 330 nm and $\lambda_5$ = 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 ($\lambda_{70}$ and $\lambda_5$) 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 | |
|---|---|---|---|---|---|
| | $n_d$ | $\nu_d$ | $\tau_i$ (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.

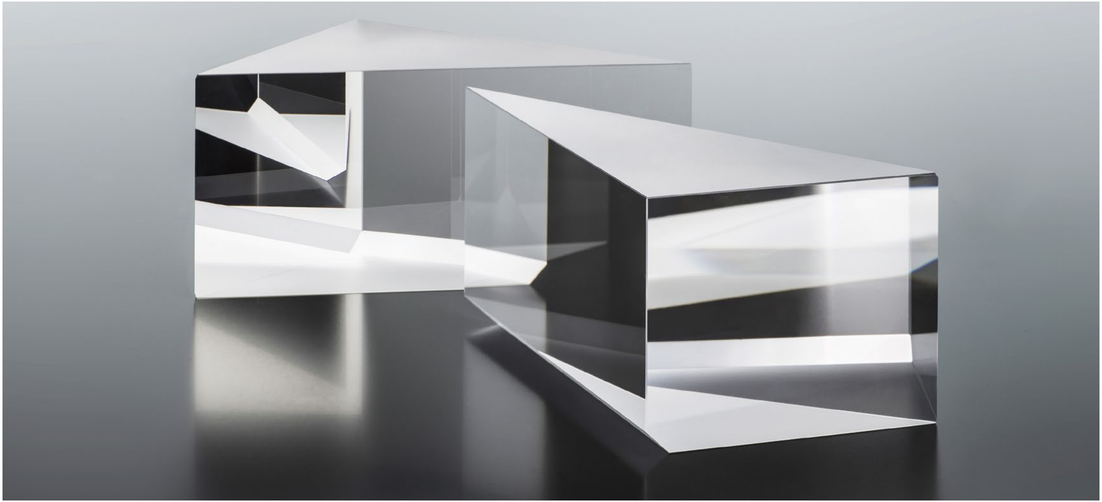
SCHOTT has improved the solarization of N-BK7HT and offers N-BK7HTSultra with a high degree of stabilization against blue laser solarization. The new glass type N-SSK20 features a high degree of solarization resistance against blue laser light as well. N-BK7HTSultra and N-SSK20 are only available as 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 | |
|---|---|---|---|---|---|---|---|
| | | | | | | Shape | Format |
| | | refr. index | dispersion | | | | |
| Refractive index | standard | $\pm 3 \cdot 10^{-5}$ | $\pm 2 \cdot 10^{-5}$ | V-block refractometer | g, F´, F, e, d, C´, C ($\nu_d$, $\nu_e$) | 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 ($\nu_d$, $\nu_e$) | 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<br>height: 22 mm |
| Internal transmittance | | ±0.5 % T<br>±0.3 % T | | Spectro photometer | 250–2500 nm<br>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<br>–100 °C bis +140 °C | prism single side coated | side: 30 mm<br>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

TIE-25 Striae in optical glass

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

TIE-27 Stress in optical glass

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 %<br>< 1.0 % | ≥ 1.0 %<br>< 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 the materials in accordance with SCHOTT's EHS Management System and Environmental Protection to prevent environmental pollution, conserve natural resources and follow 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).

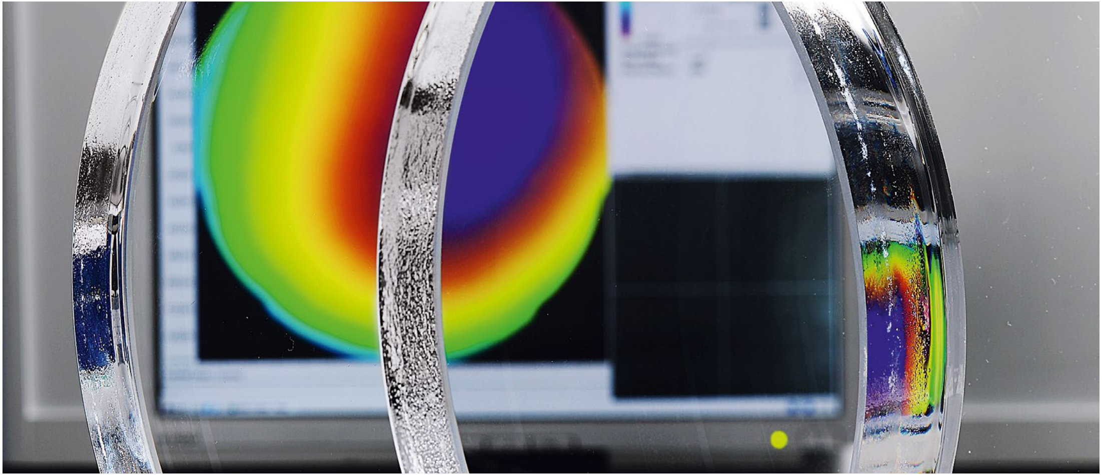
Assuring the availability of our optical raw glass portfolio for all customer applications starts with the material development process. All innovations follow a precise substance and legal requirement gate process in compliance with RoHS II, REACH, and corresponding global requirements.

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 $\alpha$ on temperature, two average linear thermal expansion coefficients $\alpha$ are usually shown for the following temperature ranges:

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

$\alpha$ (+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

TIE-31 Mechanical and thermal properties of optical glass

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

TIE-31 Mechanical and thermal properties of optical glass

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.

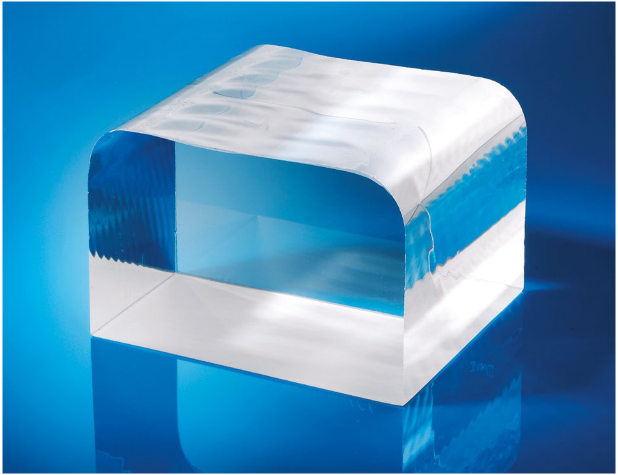
We recommend checking availability with us as early as possible.

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.

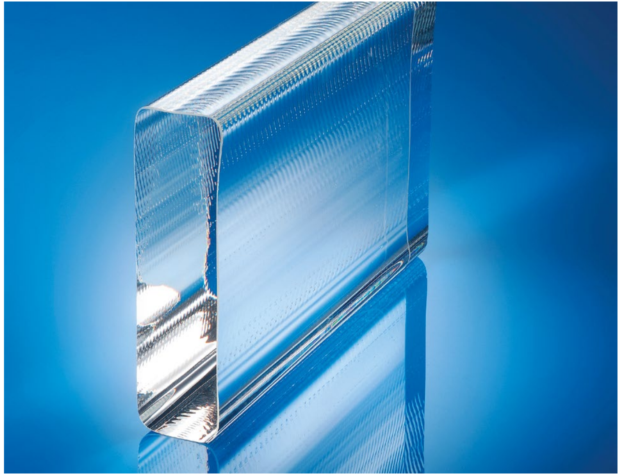
Described by: **length, width, thickness**

### 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.

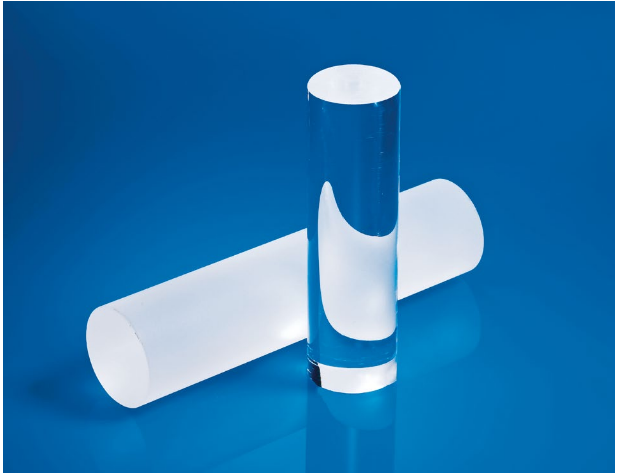
Described by: **diameter, thickness**

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.



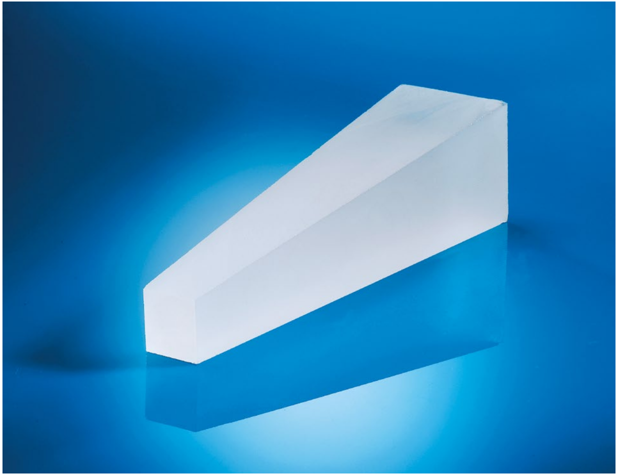
### 7.2.3 Worked rods

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 [mm] | [mm] | [mm] | [mm] | Length range [mm] | Tolerance for length [%] |
|---|---|---|---|---|---|---|---|
| 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.

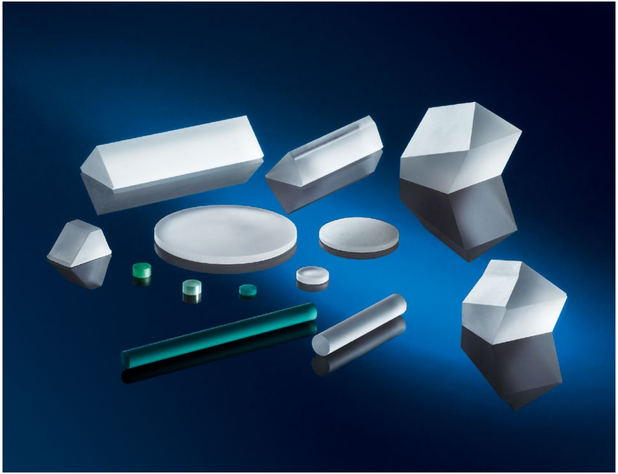
Equilateral and non-equilateral prisms can be produced in various forms (ridge, penta, triple prisms ...) using different fabrication technologies.

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.

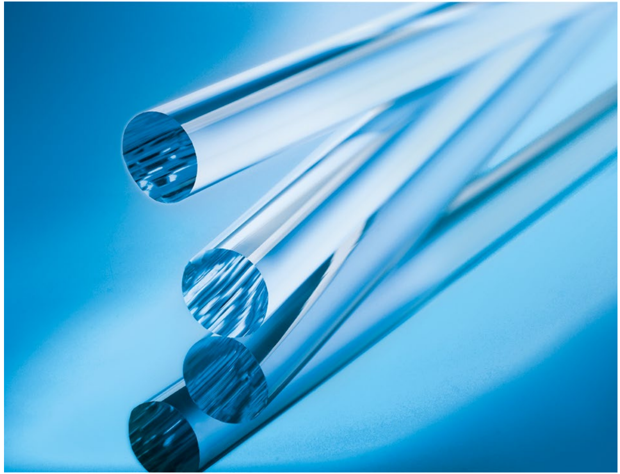


**Table 7.7:** Optical glass rods – specifications*

| | 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 $\nu_d$ 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 $\Delta P$ 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**

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

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**

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

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

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

| | |
|---|---|
| $h_0$ | 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**

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

**Spectral internal transmittance**

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

**Spectral transmittance**

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

$P_{\lambda}$ factor of reflection

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

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

**Reflection factor that considers multiple reflections**

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

$n$ Refractive index for the wavelength $\lambda$

**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)

$\tau_{i1}, \tau_{i2}$ 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

$\sigma$ 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)

$\Delta W$ 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 |

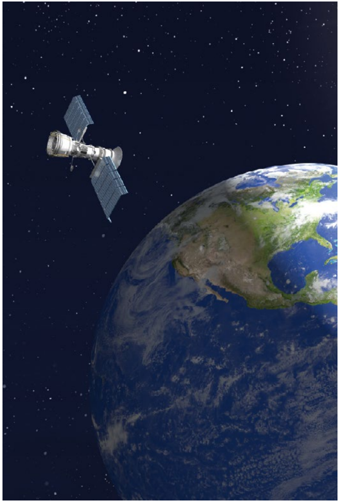
# 11 Technical Information – TIE

TIE available

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

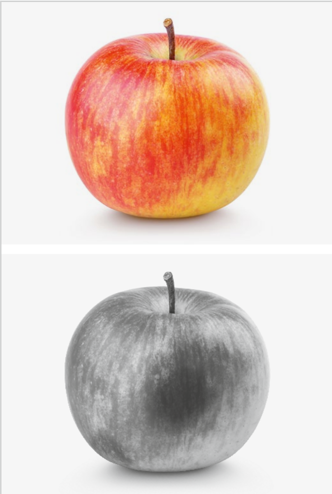
Multiphoton laser scanning microscopy applications and fast DNA sequencing are typical Life Science applications that demand special materials for high-end optical designs. SCHOTT offers a comprehensive portfolio of optical glasses and filters to enable high-end Life Science applications.

### 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

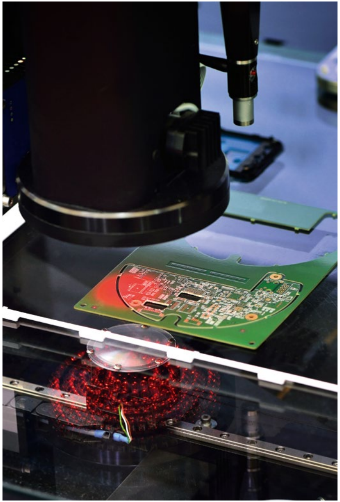
SWIR is the short-wave infrared range from about 1 to 2.7 µm. SWIR applications can be found for example in inspection processes of circuit boards, solar cells, bottles, art and food. With SWIR applications characteristics can be visualized that normally would not be detectable with visible light alone, 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,<br>N-PK52A,<br>N-FK51A,<br>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.

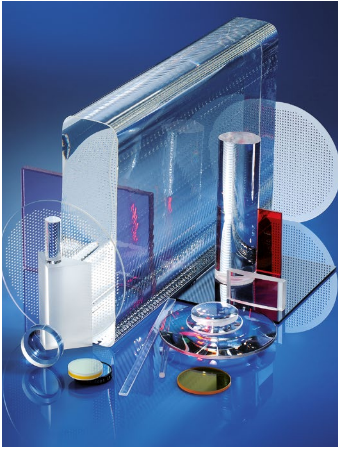
With a product portfolio of more than 120 optical glasses, special materials and components, we master the value chain: from customized glass development to high-precision optical product finishing and metrology.

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



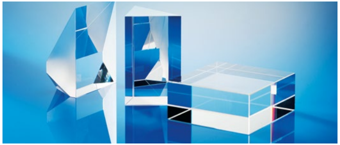
## Optical Glass

**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 range of optical glasses includes environmentally friendly N-glasses, glasses suited to precision molding (low $T_g$ Glass) as well as classic glass types with lead oxide as an essential 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

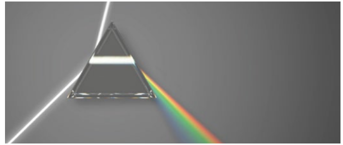
**Optical glass with ultra-high transmittance**

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

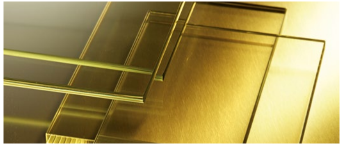
**With high UV transmittance at 365 nm and high refractive index homogeneity**

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

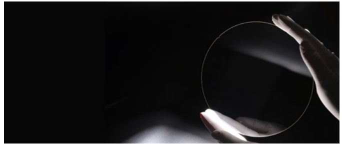
**One of the hardest, most durable and scratch resistant materials**

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**

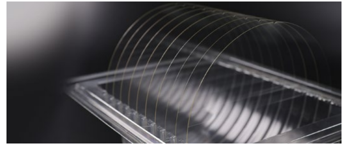
Fused Silica features excellent UV transmission for wavelengths above 180 nm. Its high melting temperature means it can be used in high temperature applications. It does not contain alkaline elements and is well suited for the semiconductor industry.



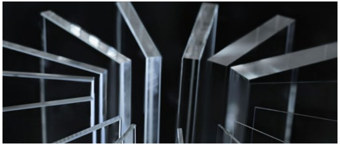
## RealView®

**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.

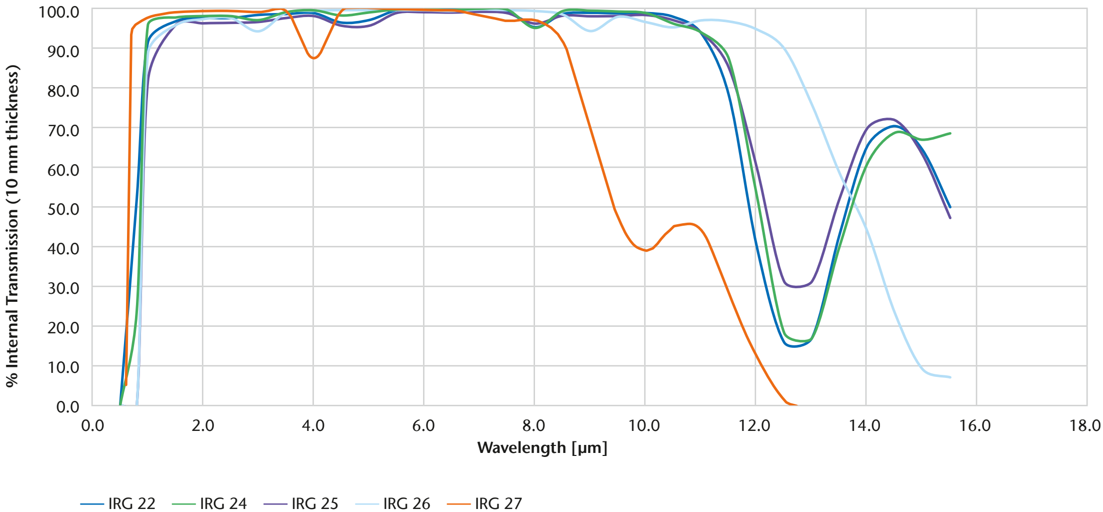
## Infrared Chalcogenide Glasses IRG

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

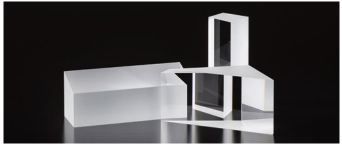
### Aspheres for superior image quality

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

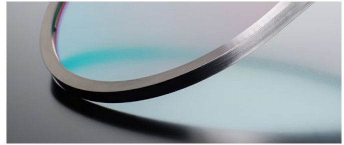
**Perfect custom optical components**

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

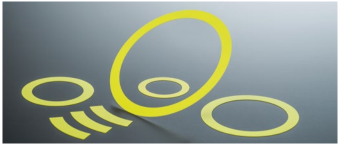
**Precisely manufactured parts**

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

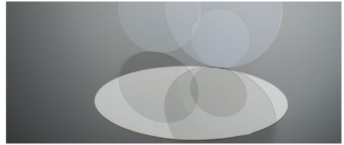
**Brighter than the sun**

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**

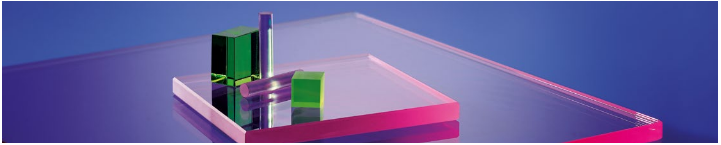
SCHOTT's Static Ceramic Laser Phosphor Converters offer superior luminance, high irradiance and brightness for applications such as digital projection, machine vision & metrology, life science, stage- and searchlights. Static solutions allow you to increase light output for your light source with no 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.



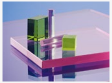
## Active Glass for Laser Applications

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 $\lambda/10$ flatness.

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

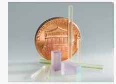
## Active Materials



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

## Active Components

- Rods
- Slabs/plates



## Passive Materials

- 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 Components

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

# Optical Filters

## 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.

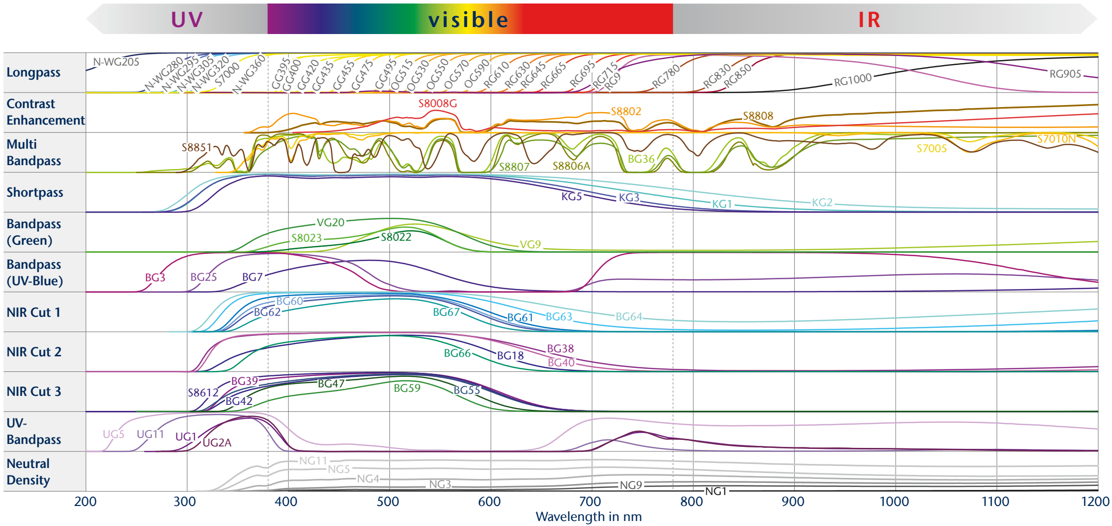
Optical filter glass is known for its selective absorption in the visible wavelength range. Optical filter glasses appear to be colored if their filter effect lies within the visible light spectrum. Numerous colorants with different concentrations and many different base glasses have been developed to 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

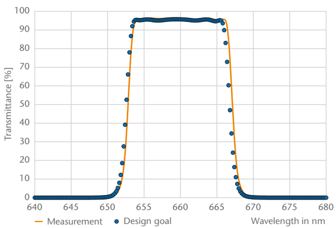
Interference filters that use the interference effect to obtain a spectral function are manufactured by depositing thin layers with different refractive indices onto a substrate. These filters are used for applications in medical technology, for analytics in measurements, environmental, biotech, chemical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

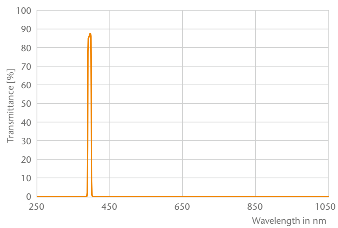
Our product range comprises various types of interference filters:
bandpass filters, edge filters, notch filters, UV-bandpass filters, hard and scratch-resistant filters, i-line filters, VERIL linear variable filters, optimized AR and broadband-AR coated filters, beamsplitters, neutral density filters, 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.

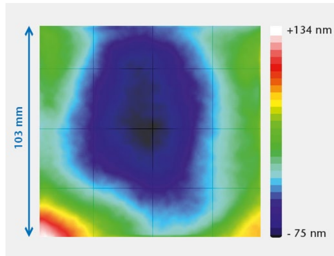
Perfect consistency between measurement and production




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 | $n_d$ | $\nu_d$ | $n_F - n_C$ | $n_e$ | $\nu_e$ | $n_{F'} - n_{C'}$ | $n_r$ | $n_C$ | $n_{F'}$ | $n_g$ | $n_h$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **N-FK58****<br>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***<br>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***<br>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***<br>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**<br>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**<br>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***<br>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 | $\alpha$ (–30/+70) | $T_g$ | $T_{10^{7.6}}$ | $\rho$ | HK | $\tau_i$ (10/400) | $\tau_i$ (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 |



XLD
FK
PK
PSK
LAF
BK
K
ZK
LASF
BAK
SK
SF
KF
BALF
SSK
LAK
KZFS
LLF
BAF
Low $T_g$
LF
F
BASF
Rad. Res.

| Glass type | $n_d$ | $\nu_d$ | $n_F - n_C$ | $n_e$ | $\nu_e$ | $n_{F'} - n_{C'}$ | $n_r$ | $n_C$ | $n_{F'}$ | $n_g$ | $n_h$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **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 | $\alpha$ (–30/+70) | $T_g$ | $T_{10}{}^{7.6}$ | $\rho$ | HK | $\tau_i$ (10/400) | $\tau_i$ (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 | $n_d$ | $\nu_d$ | $n_F - n_C$ | $n_e$ | $\nu_e$ | $n_{F'} - n_{C'}$ | $n_r$ | $n_C$ | $n_{F'}$ | $n_g$ | $n_h$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **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 | $\alpha$ (−30/+70) | $T_g$ | $T_{10^{7.6}}$ | $\rho$ | HK | $\tau_i$ (10/400) | $\tau_i$ (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 | $n_d$ | $\nu_d$ | $n_F - n_C$ | $n_e$ | $\nu_e$ | $n_{F'} - n_{C'}$ | $n_r$ | $n_C$ | $n_{F'}$ | $n_g$ | $n_h$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| N-SK14<br>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*<br>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 | $\alpha$ (−30/+70) | $T_g$ | $T_{10^{7.6}}$ | $\rho$ | HK | $\tau_i$ (10/400) | $\tau_i$ (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 | $n_d$ | $\nu_d$ | $n_F - n_C$ | $n_e$ | $\nu_e$ | $n_{F'} - n_{C'}$ | $n_r$ | $n_C$ | $n_{F'}$ | $n_g$ | $n_h$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **N-KF9**<br>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**<br>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**<br>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**<br>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**<br>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**<br>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<br>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**<br>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**<br>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 | $\alpha$ (−30/+70) | $T_g$ | $T_{10^{7.6}}$ | $\rho$ | HK | $\tau_i$ (10/400) | $\tau_i$ (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 | $n_d$ | $\nu_d$ | $n_F - n_C$ | $n_e$ | $\nu_e$ | $n_{F'} - n_{C'}$ | $n_r$ | $n_C$ | $n_{F'}$ | $n_g$ | $n_h$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **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 | $\alpha$ (−30/+70) | $T_g$ | $T_{10^{7.6}}$ | $\rho$ | HK | $\tau_i$ (10/400) | $\tau_i$ (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 | $n_d$ | $\nu_d$ | $n_F - n_C$ | $n_e$ | $\nu_e$ | $n_{F'} - n_{C'}$ | $n_r$ | $n_C$ | $n_{F'}$ | $n_g$ | $n_h$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **LLF1**<br>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**<br>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**<br>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**<br>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**<br>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 | $\alpha$ (−30/+70) | $T_g$ | $T_{10}{}^{7.6}$ | $\rho$ | HK | $\tau_i$ (10/400) | $\tau_i$ (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 | $n_d$ | $\nu_d$ | $n_F - n_C$ | $n_e$ | $\nu_e$ | $n_{F'} - n_{C'}$ | $n_r$ | $n_C$ | $n_{F'}$ | $n_g$ | $n_h$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **LF5**<br>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**<br>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**<br>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**<br>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**<br>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**<br>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**<br>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 | $\alpha$ (−30/+70) | $T_g$ | $T_{10^{7.6}}$ | $\rho$ | HK | $\tau_i$ (10/400) | $\tau_i$ (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 | $n_d$ | $\nu_d$ | $n_F - n_C$ | $n_e$ | $\nu_e$ | $n_{F'} - n_{C'}$ | $n_r$ | $n_C$ | $n_{F'}$ | $n_g$ | $n_h$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | $\alpha$ (−30/+70) | $T_g$ | $T_{10^{7.6}}$ | $\rho$ | HK | $\tau_i$ (10/400) | $\tau_i$ (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 | $n_d$ | $\nu_d$ | $n_F - n_C$ | $n_e$ | $\nu_e$ | $n_{F'} - n_{C'}$ | $n_r$ | $n_C$ | $n_{F'}$ | $n_g$ | $n_h$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **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 | $\alpha$ (−30/+70) | $T_g$ | $T_{10^{7.6}}$ | $\rho$ | HK | $\tau_i$ (10/400) | $\tau_i$ (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 | $n_d$ | $\nu_d$ | $n_F - n_C$ | $n_e$ | $\nu_e$ | $n_{F'} - n_{C'}$ | $n_r$ | $n_C$ | $n_{F'}$ | $n_g$ | $n_h$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **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 | $\alpha$ (−30/+70) | $T_g$ | $T_{10^{7.6}}$ | $\rho$ | HK | $\tau_i$ (10/400) | $\tau_i$ (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 | $n_d$ | $\nu_d$ | $n_F - n_C$ | $n_e$ | $\nu_e$ | $n_{F'} - n_{C'}$ | $n_r$ | $n_C$ | $n_{F'}$ | $n_g$ | $n_h$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **N-SF14**<br>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**<br>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**<br>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**<br>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**<br>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**<br>923209.400 | 1.92286 | 20.88 | 0.044199 | 1.93322 | 20.70 | 0.045076 | 1.90368 | 1.91039 | 1.95739 | 1.98285 | |
| **SF1**<br>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***<br>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**<br>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**<br>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 | $\alpha$ (−30/+70) | $T_g$ | $T_{10^{7.6}}$ | $\rho$ | HK | $\tau_i$ (10/400) | $\tau_i$ (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 | $n_d$ | $\nu_d$ | $n_F - n_C$ | $n_e$ | $\nu_e$ | $n_{F'} - n_{C'}$ | $n_r$ | $n_C$ | $n_{F'}$ | $n_g$ | $n_h$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **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 | $\alpha$ (−30/+70) | $T_g$ | $T_{10^{7.6}}$ | $\rho$ | HK | $\tau_i$ (10/400) | $\tau_i$ (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 | $n_d$ | $\nu_d$ | $n_F - n_C$ | $n_e$ | $\nu_e$ | $n_{F'} - n_{C'}$ | $n_r$ | $n_C$ | $n_{F'}$ | $n_g$ | $n_h$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **N-KZFS2****<br>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***<br>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***<br>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****<br>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**/*****<br>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 | $\alpha$ (−30/+70) | $T_g$ | $T_{10^{7.6}}$ | $\rho$ | HK | $\tau_i$ (10/400) | $\tau_i$ (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 | $n_d$ | $\nu_d$ | $n_F - n_C$ | $n_e$ | $\nu_e$ | $n_{F'} - n_{C'}$ | $n_r$ | $n_C$ | $n_{F'}$ | $n_g$ | $n_h$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **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 $n_d$ | $\nu_d$ | SR-J | WR-J | $\alpha$ (−30/+70) | $\alpha$ (20/300) | $T_g$ | AT | $\rho$ | HK | Abrasion Aa | $\tau_i$ (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

Low $T_g$

Rad. Res.

| Glass type | $n_d$ | $\nu_d$ | $n_F - n_C$ | $n_e$ | $\nu_e$ | $n_{F'} - n_{C'}$ | $n_r$ | $n_C$ | $n_{F'}$ | $n_g$ | $n_h$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **N-PK51**<br>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**<br>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**<br>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****<br>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**<br>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**<br>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**<br>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**<br>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**<br>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**<br>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 $n_d$ | After Molding*2 $\nu_d$ | SR-J | WR-J | $\alpha$ (–30/+70) | $\alpha$ (20/300) | $T_g$ | AT | $\rho$ | HK | Abrasion Aa | $\tau_i$ (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 | $n_d$ | $\nu_d$ | $n_F - n_C$ | $n_e$ | $\nu_e$ | $n_{F'} - n_{C'}$ | $n_r$ | $n_C$ | $n_{F'}$ | $n_g$ | $n_h$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **BK7G18**<br>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**<br>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***<br>584408.322 | 1.58397 | 40.83 | 0.014301 | 1.58736 | 40.55 | 0.014484 | 1.57739 | 1.57974 | 1.59489 | 1.60228 | |
| **LF5G19**<br>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**<br>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**<br>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**<br>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 | $\alpha$ (–30/+70) | $T_g$ | $T_{10^{7.6}}$ | $\rho$ | HK | $\tau_i$ (10/400) | $\tau_i$ (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 | $n_d$ | $\nu_d$ | $n_F - n_C$ | $n_e$ | $\nu_e$ | $n_{F'} - n_{C'}$ | $n_r$ | $n_C$ | $n_{F'}$ | $n_g$ | $n_h$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **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 | $\alpha$ (−30/+70) | $T_g$ | $T_{10^{7.6}}$ | $\rho$ | HK | $\tau_i$ (10/400) | $\tau_i$ (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 | $n_d$ | $\nu_d$ | $n_F - n_C$ | $n_e$ | $\nu_e$ | $n_{F'} - n_{C'}$ | $n_r$ | $n_C$ | $n_{F'}$ | $n_g$ | $n_h$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **N-SF19**<br>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**<br>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**<br>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**<br>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**<br>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**<br>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**<br>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**<br>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**<br>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**<br>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 | $\alpha$ (−30/+70) | $T_g$ | $T_{10^{7.6}}$ | $\rho$ | HK | $\tau_i$ (10/400) | $\tau_i$ (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 | $n_d$ | $\nu_d$ | $n_F - n_C$ | $n_e$ | $\nu_e$ | $n_{F'} - n_{C'}$ | $n_r$ | $n_C$ | $n_{F'}$ | $n_g$ | $n_h$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **SFL6**<br>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**<br>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**<br>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**<br>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**<br>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 | $\alpha$ (−30/+70) | $T_g$ | $T_{10^{7.6}}$ | $\rho$ | HK | $\tau_i$ (10/400) | $\tau_i$ (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 | $n_d$ | $\nu_d$ | $n_F - n_C$ | $n_e$ | $\nu_e$ | $n_{F'} - n_{C'}$ | $n_r$ | $n_C$ | $n_{F'}$ | $n_g$ | $n_h$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **P-BK7**<br>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**<br>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**<br>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**<br>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**<br>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**<br>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**<br>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**<br>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**<br>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 $n_d$ | After Molding*2 $\nu_d$ | SR-J | WR-J | $\alpha$ (−30/+70) | $\alpha$ (20/300) | $T_g$ | AT | $\rho$ | HK | Abrasion Aa | $\tau_i$ (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 $\nu_d$ with density |
| **$n_x$, $\nu_x$, $n_x - n_y$** | – | 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) |
| **$\alpha(-30/+70)$** | – | 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 |
| $\rho$ | – | Density in $g/cm^3$ |
| **HK** | – | Knoop hardness (ISO 9385) |
| **$\tau_i(10/400)$** | – | Internal transmittance at 400 nm; glass thickness: 10 mm |
| **$\tau_i(10/420)$** | – | 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) |
| **$n_d$, $\nu_d$ 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 |
| **$\alpha(20/300)$** | – | 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.

# Imprint

**Publisher**
SCHOTT AG
Hattenbergstrasse 10
55122 Mainz
Germany
Phone +49 (0)6131/66-1812
Fax +49 (0)3641/2888-9047
info.optics@schott.com
schott.com

**Design, Typesetting and Lithography**
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**Printer**
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SCHOTT AG, Hattenbergstrasse 10, 55122 Mainz, Germany
Phone +49 (0)6131/66-1812, info.optics@schott.com

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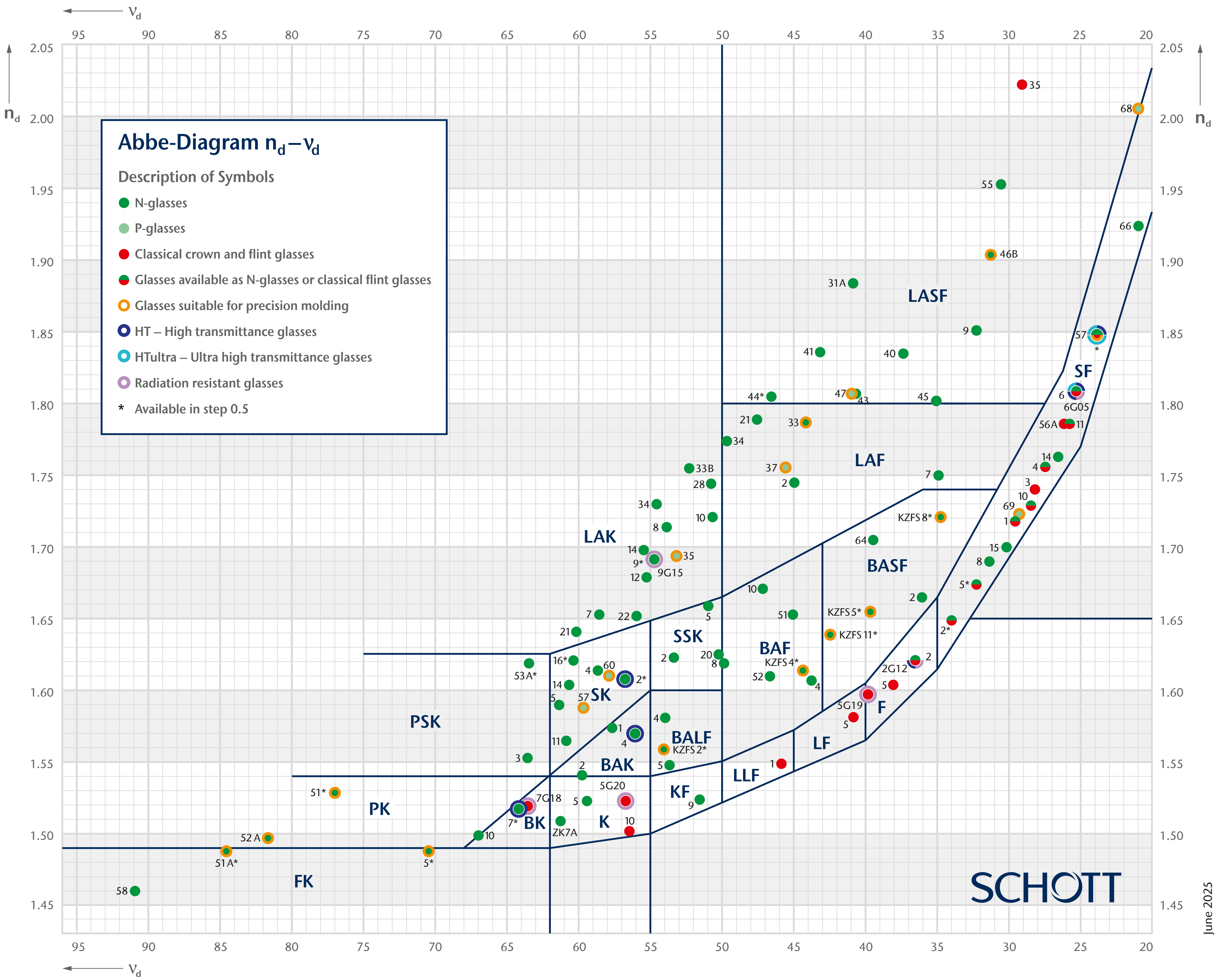
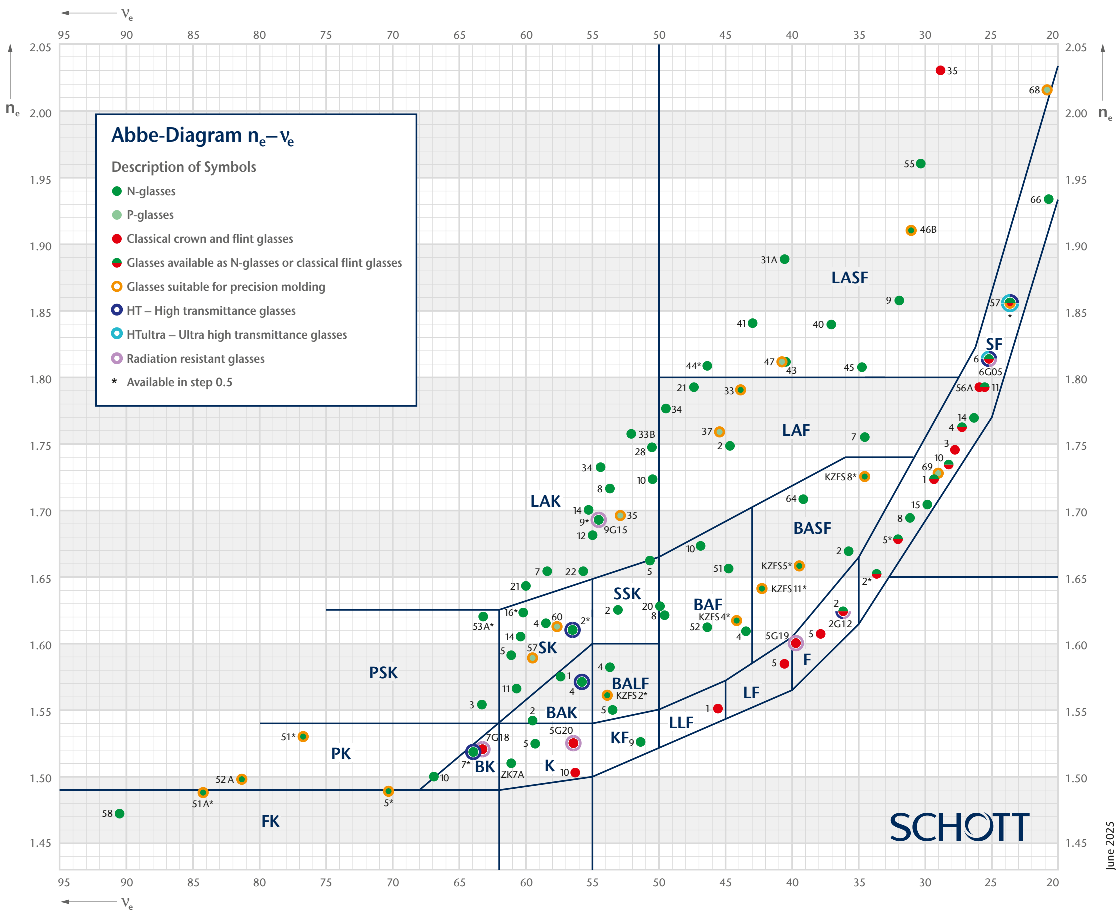
# Abbe-Diagram $n_d - \nu_d$



# Abbe-Diagram $n_e$–$\nu_e$




# $P_{g,F}$-Diagram