SCHOTT
glass made of ideas

February 10, 2021

SCHOTT Optical Glass

Refractive Index: Four Things You Need to Know

Introduction

SCHOTT Academy of Optics is a free, online seminar series designed to take your industry knowledge and expertise to new levels.

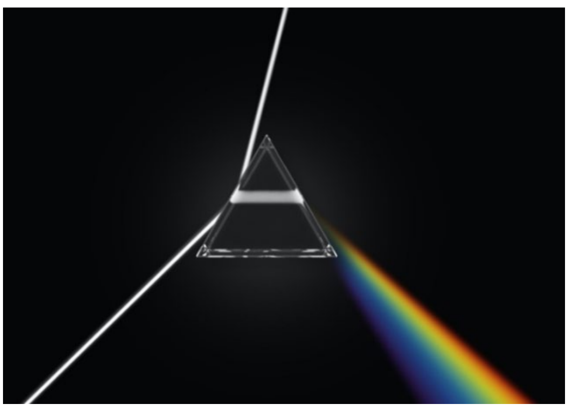
Throughout the series, you will learn from leading glass and material experts as they cover various topics pertaining to the optics industry.

Visit our website for more information or to register for an upcoming seminar: www.schott.com/academy-of-optics

1. What is the refractive index & why is it important?

One of the most important properties of glass is its refractive index (RI). RI describes how light bends when it enters glass. The speed at which the light can travel through the material determines this.

You can use the RI to create optical components that manipulate light in many ways. It is also responsible for the light-guiding ability of optical fibers, the reflectivity of optical coatings and the focusing capacity of lenses.



RI measurements for optical glass must be reliable and at least 10x more accurate than measurements for window glass. For this reason, you will likely see a RI of 1.51680 for optical glass.

Dispersion occurs when a rainbow or a prism splits white light into many colors. This occurs because the RI changes because of the color or wavelength of the light. The ABBE number provides an approximate measure of the material's dispersion.

2. How to read a glass data sheet

When developing an optical design, it is critical to use glass with controlled optical properties. A data sheet can help with this because it includes the specific tolerance limits available for a given glass material.

At the top of the data sheet, you will find the glass name as well as its chemical composition. Because of the precision required for optical glass, chemical composition is typically reproducible to within 0.1 % per element.

The RI is very apparent on a data sheet. More than two-thirds of the data will be dedicated to the RI and related measurements such as the ABBE number, dispersion and transmittance.

The data sheet also provides information about the striae content, short-range variations of the RI in the glass. You will also find data on the inclusion quality (driven by the production), stress birefringence and the homogeneity of all the properties specified.

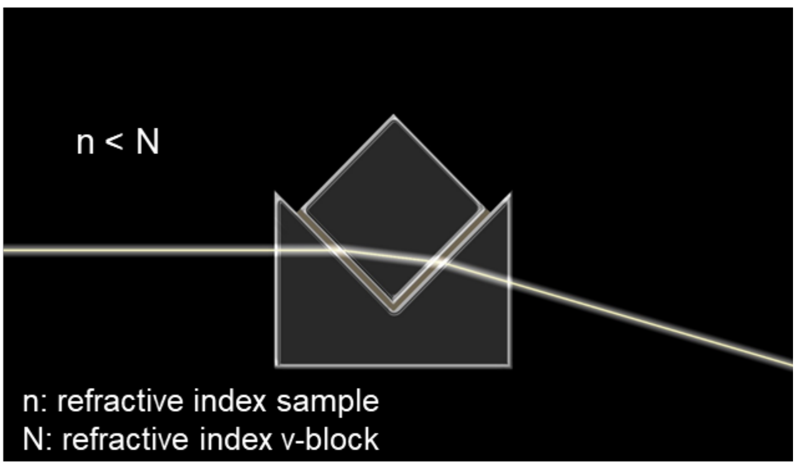
Lastly, you will find a section on the data sheet dedicated to RI as a function of wavelength. You will also see Sellmeier coefficients to calculate the RI at any wavelengths not included on the data sheet.

Information on the temperature dependence of the RI is included as well as partial dispersions, which are important for optical design. Although dispersion data is available on the data sheet, be careful about comparing numbers from different vendors. Even optical glass measured at the exact same optical position can exhibit a wide variation in dispersion.

3. How to measure refractive index

Because RI properties are so important, it is critical to measure them very precisely. A V-block refractometer measures how light bends or deflects as it enters a glass part.

To use this instrument, place a block of glass on top of the V-block for measurement. If the RI of the sample matches that of the V-block, then light travels through the two-glass assembly without any deflection. However, light deflection occurs if the RI of the sample is smaller or larger than that of the V-block.



At SCHOTT, we custom built a V-block refractometer that not only acquires measurements with higher accuracy than commercial systems but also makes the process more efficient by incorporating automation.

This custom instrument can analyze stacks of 10 glasses (one of which can be the reference material) sequentially without any need to reload the instrument.

It can measure RI over standard wavelengths from 436 to 656 nanometers (nm) with an uncertainty of up to 3×10^{-5} and perform enhanced measurements down to 365 nm and up to 1014 nm with an uncertainty of 2×10^{-5}. You will find the values from the enhanced measurements listed in brackets on our data sheets.

SCHOTT also developed an ultraviolet-to-infrared RI measurement system (URIS) for more accurate measurements. This spectrometer uses a minimum deviation method to measure RI with an accuracy of up to 0.4×10^{-5} over a larger wavelength range of 185 to 2300 nm.

It also exhibits reproducibility of up to 1×10^{-6} over periods of up to ten years. We are always looking at ways to improve these measurements. Recently, a team of engineers at SCHOTT built a new URIS spectrometer that uses modern components for even higher accuracy.

Because it is difficult to find another instrument for comparison, we are taking part in an international round robin test to see how it measures up to the most accurate systems around the world. We also actively participate in developing standards related to measuring RI with high accuracies.

4. Understanding transmittance & the refractive index

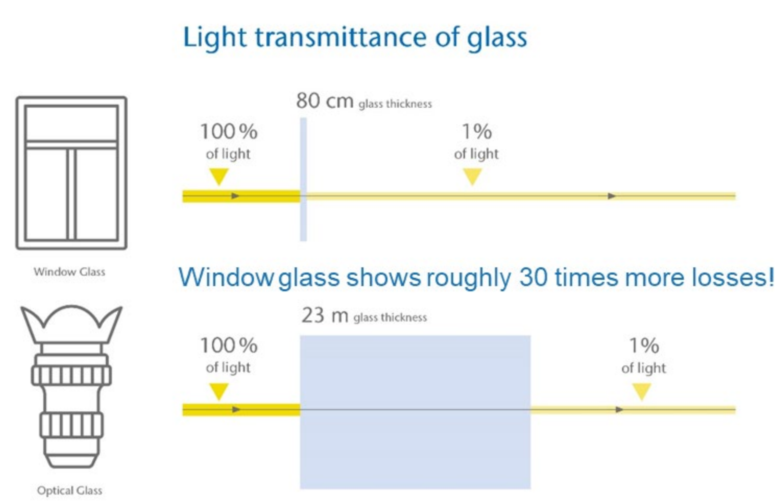
Transmittance occurs when light passes through an object without being reflected, scattered or absorbed.

For example, even though window glass has 30x more losses compared to optical glass, optical glass with a higher RI appears yellowish. This occurs due to reduced transmittance at the edge of the blue-violet region.

On the other hand, optical glass with a lower RI appears white. Optical glass usually shows high transmittance from 300 nm to just over 2300 nm.

The close relationship between transmittance and the RI creates limitations in glass development. For example, you cannot achieve a high RI and low dispersion at the same time.

Achieving a glass with the most desirable properties is also constrained by the fact that glass needs to be amorphous (without crystals). The chemistry necessary to achieve this becomes more and more complex as you approach the crystallization limits for the material.



Want to learn more about the refractive index & optical glass properties?

For more information and resources on our optical glass portfolio, visit our website:
www.schott.com/products/optical-glass