May 19, 2021

SCHOTT Optical Glass

Making High-Quality Optical Glass with Tight Tolerances

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/trainings/academy-of-optics

Whether it's a large mirror used to see deep into space or a small lens for viewing microscopic details, demanding light-based applications require precision optics made of high-quality glass. At SCHOTT, we have been perfecting glass-making processes for more than 130 years. Our stringent quality control procedures and modern processes are pushing glass processing to its limits and enabling the next generation of technological advances.

1. The glass-making process

Today, optical glass is made using a process known as continuous tank melting. To create glass with high transmission and optical quality requires starting with exactly the right amount of extremely pure raw materials.

The glass-making process starts by melting the raw material batches in a tank. Once melted, the liquid flows into the refining chamber where the temperature is increased to reduce the number of bubbles caused by residual chemicals. In this step, the viscosity is reduced, so that the bubbles can rise and out of the melt. The last chamber, known as the stirring or mixing chamber, mixes the liquid glass to increase the homogeneity by reducing the number of striae. The temperature of the glass is adapted to the required temperature of the hot forming process in the feeder.

The glass is then shaped into the required production formats known as hot forming. The most common format is the continuous strip glass of glass with a typical cross section of 160 mm width and varying thickness of a few centimeters. In addition to strips, glass can also be formed into individual blocks or cylindrical shaped molds for arbitrary applications, like for example prisms. The hot formed glass moves through an annealing lehr, the so-called coarse annealing. There it is cooled down carefully to lower the stress level to avoid breakage. This can take up several hours depending on the glass type and format.

Depending on their volume, tanks can make several tons of glass per day. To monitor the glass optical and internal properties, samples are taken from the glass regularly.

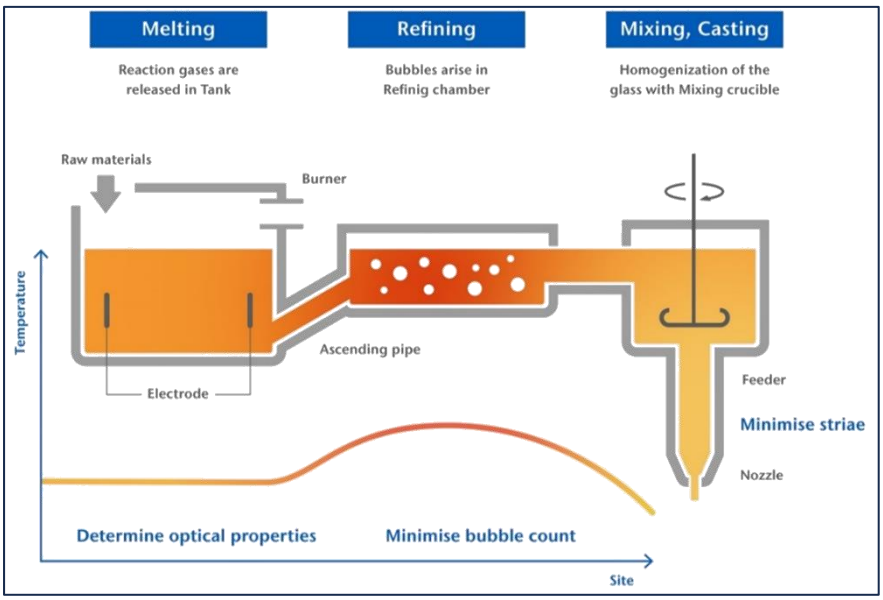

Figure 1: Production process of optical glass.

2. Achieving tight optical tolerances

The tolerance levels required for optical glass typically depends on the performance necessary for the final application. We offer three traditional tolerance steps or any other combination of these tolerances. Step 3, the standard tolerance level for optical glass, features a ±0.0005 tolerance for refractive index (n_d) and an Abbe number (v_d) that is ±0.5% of the catalog value.

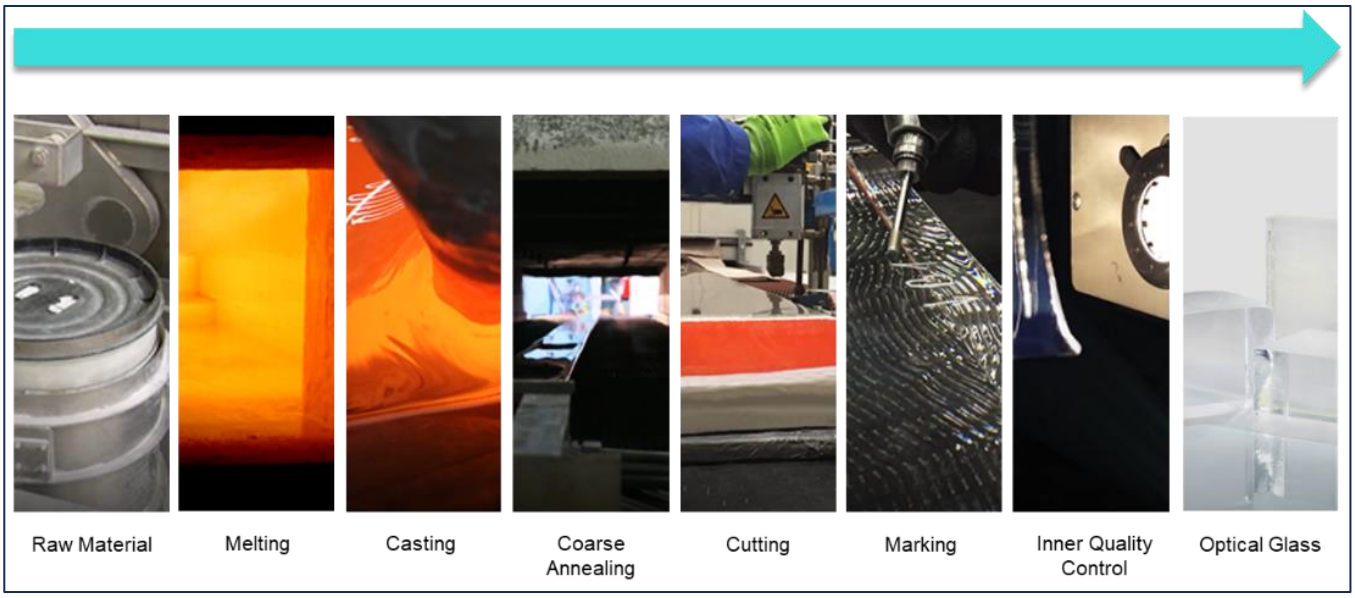

Figure 2: Continuous tank melting to produce optical glass.

For Step 2 the tolerances are ±0.0003 n_d and ±0.3% v_d while Step 1 features a ±0.0002 n_d and ±0.2% v_d, see our catalog.

For selected glass types, we introduced an even tighter tolerance level called Step 0.5, which has tolerances of ±0.0001 n_d and ±0.1% v_d, you can find more details in our flyer. This tolerance level is especially well suited for high-precision lenses used for industrial and biomedical applications. For example, lenses with these tight tolerances can be used to create superior microscope objectives that are used for special techniques that enable imaging resolutions beyond the Abbe limit.

The refractive index is not only controlled by the chemical composition, but also by the annealing history of the glass. To accomplish the tightest tolerances around the catalog values the fine annealing process is crucial. The annealing rate defines the final optical properties n_d and v_d. The annealing rate is limited by the size of the optical glass due to induce stress levels. This leads to different annealing rates like for pressings, annealing takes days or few weeks, while very large parts for astronomy or laser fusion projects can require several months of annealing. For additional information, you can refer to TIE-29.

Each glass parts production history and properties can be identified by its specific assigned batch number. For each glass delivery lot, we provide the customer with the batch numbers, the maximum variation within the lot, the mid-level position of optical values in the delivery lot, and deviations from catalog values (more details in TIE-04).

SCHOTT is continually improving our glass making processes and tightening the achievable tolerance levels to create high-performance optical glass that can meet the needs of even the most challenging applications.

Want to learn more about optical glass?

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