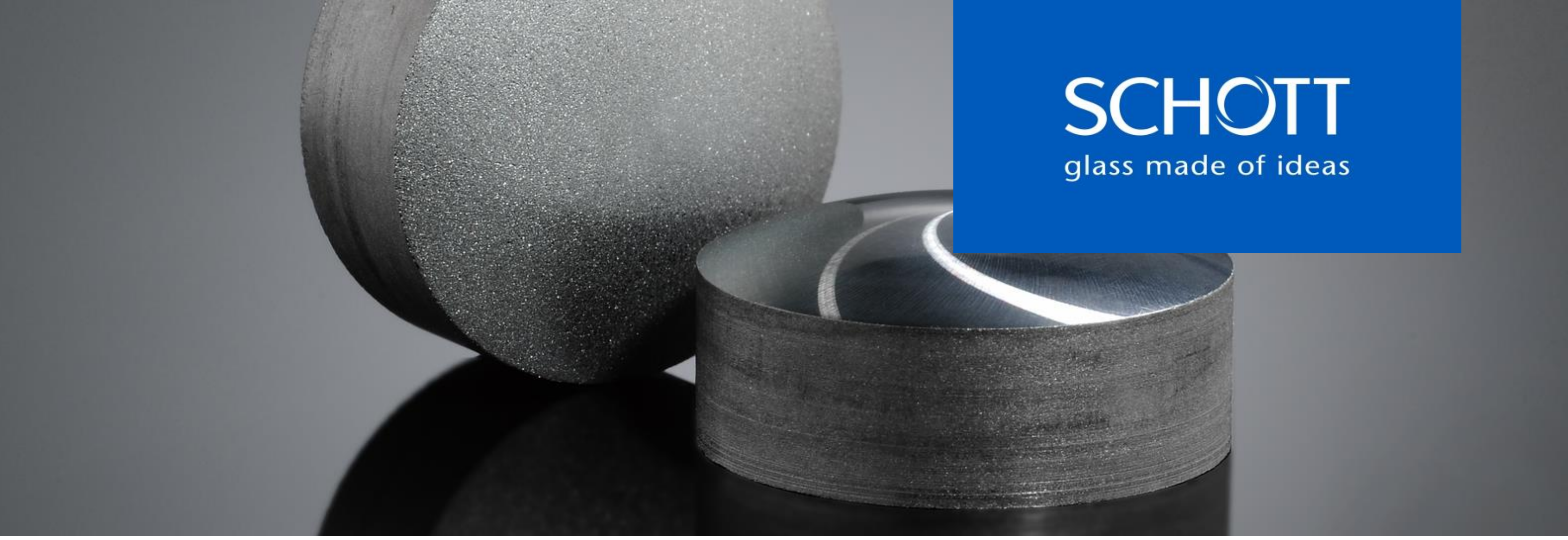

April 27, 2021

SCHOTT Infrared Materials

Processing and Handling Chalcogenide Glasses

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

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Chalcogenide glasses are poised to meet the needs of many future applications thanks to their unique broad transmission that covers the entire infrared (IR) spectrum from the near to the long wave. Thermal imaging devices used for policing, security, and defense all benefit from the clear and crisp images that can be generated using SCHOTT's IR chalcogenide optics.

Our line of chalcogenide glasses are precisely engineered to work seamlessly with other IR materials to create cost-effective, high-performing optical designs for a range of imaging equipment. We make and process all our chalcogenide glass at our facility in Duryea, Pennsylvania, which also houses an R&D team focused on these materials. SCHOTT has the ability to adjust its production of infrared chalcogenide glasses to deliver both large and small volumes.

Chalcogenide glasses feature several unique properties that make them useful for a variety of applications. They feature a low change in index with temperature (dn/dT), which translates to higher optothermal stability. This helps simplify the design of IR lens systems. These glasses can be processed using a variety of methods, including molding, conventional grinding and polishing, or single-point diamond turning. A low glass-liquid transition (T_g) makes them very moldable and thus conducive to mass production processes, which can bring down fabrication costs.

Chalcogenide materials are ideal for lightweight applications such as cameras or night vision systems because they weigh about 15% to 40% less than germanium, which is often used for IR applications. The excellent dispersion properties of these glasses also makes them ideal for color correction, and their modulation transfer function (MTF) remains high over a wide temperature range.

Although there is an increasing interest in using chalcogenide glasses, this material does have a reputation for being difficult to work with. Keeping a few considerations in mind can help material processing go smoothly. First, it is important to realize that these IR glasses have a high thermal expansion and a low thermal conductivity. This makes them sensitive to thermal changes, so it is important to cool and heat these materials slowly to prevent thermal shock. Second, the low hardness of these glasses makes them soft. Although this makes it easy to polish these materials, it also means they are more susceptible to surface damage if improper procedures are used.

1. The fabrication procedure

The fabrication process for chalcogenide glasses is designed to reduce oxygen and water contamination in the system because these contaminants can have detrimental effects on IR transmission. The raw materials are placed in an ampoule that is sealed off from air and humidity and then placed into a rocking furnace for melting. Once cooled back to room temperature, the material can be removed from the ampoule. A fine annealing process is then used to reduce any stresses in the material and to create a uniform density and refractive index.

SCHOTT has a stringent process for internal qualification testing. To carry this out, a slice of glass from the top of each boule is tested to make sure it meets internal quality specifications. We look for any striae or inclusions that may cause problems and test the glass's optical properties to ensure the transmission and refractive index are aligned with specifications.

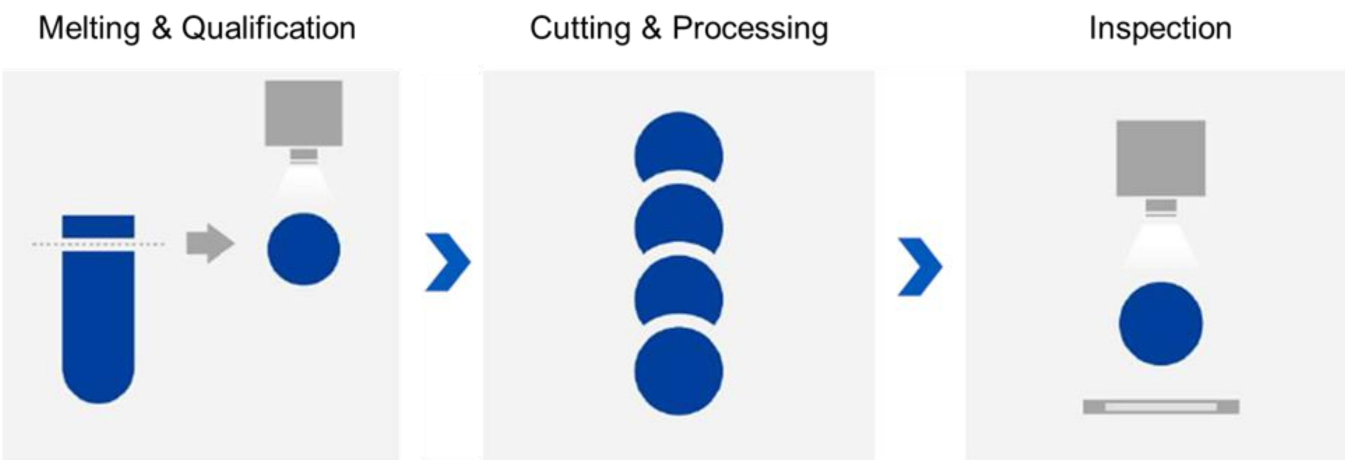

Figure 1: Fabrication and processing steps for SCHOTT IRG glasses.

2. Tips for processing

When processing chalcogenide glasses, it is important to realize that these glasses are made from elements like arsenic that are toxic in their elemental form. Because the glasses are not soluble in water, you do not have to worry about these elements leaching out into your hands. However, inhaling glass particulates can be problematic. For this reason, we recommend processing chalcogenides in a well-ventilated area. It is also important to keep the material at least 25 °C below the glass transition temperature to avoid outgassing. Molding, however, can be performed at higher temperatures because it is a more controlled process. If a process is performed above the glass transition temperature, be sure to use the appropriate ventilation system.

Identifying an effective work-holding technique sets the foundation for all the other processes. A no-heat technique for work-holding is the best option. We often use a thermal plastic pitch, which is a low temperature melting pitch based on an epoxy. You can also use low-melting wax pitch. Using a backer plate will increase the stability during processing or any processes that place torque on the glass, such as core drilling or slicing. However, be sure the backer plate has a similar thermal expansion as the chalcogenide glass.

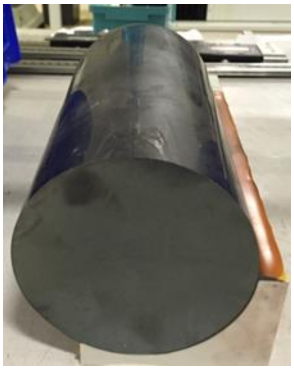

Figure 2: Low temperature pitches are a good working holding solution

Because these IR glasses have a high thermal expansion and low thermal conductivity, heating and cooling the glass slowly is critical. When pitching a large piece of glass, for example, we put the backing plate, pitch, and glass in an oven heated to less than 38 °C. We then increase the oven temperature until it reaches the melting point of the pitch. At that point, we build the assembly and then cool it down to room temperature. It is important to leave time for the assembly to equilibrate to room temperature before starting any processing steps or placing stress on the glass. If you experience failures, it is probably related to how you heated or cooled the glass during this process.

Although we typically create plano blanks between 3 to 200 millimeters, we can also make lens blanks and other specialty geometries.

These glasses can be cut with blade cutting on a CNC or using any kind of saw, including single- or multi-wire saws. The low hardness of these materials does make them more susceptible to heat stress from the tooling used for cutting or drilling. Keeping enough coolant flowing during the processes will help keep heat away from the glass. Also be aware that very fine-gritted tooling will generate more heat, which can cause smearing. Thus, it is often beneficial to use tooling with a courser grit. Be sure to check for any tool wear or defects in the saw blades or diamond grit because these can cause larger defects on the IR material than you might experience with other glass types.

Figure 3: SCHOTT provides a variety of glass geometries to meet customer needs.

In terms of finishes, chalcogenide glass parts can have a matte finish or be made into a finished or polished blank. Both single- and double-sided grinding and polishing techniques work well with this material. However, because the glass is very soft, it will grind down and polish very quickly compared to many other glasses. This means that you can remove a lot of material quickly if using an aggressive grinding pad material.

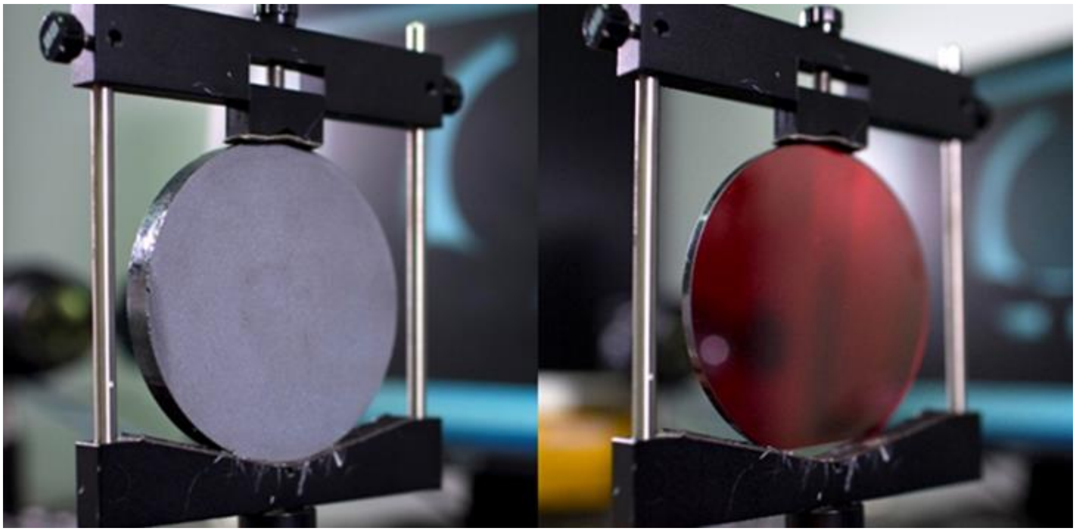

Figure 4: SCHOTT provides both matte (left) and polished (right) blanks to easily fit into our customer's workflow.

This glass is a slightly more prone to defects than other oxide glasses. You may see a burned surface if a slurry Baume is too low, too much pressure is used for polishing, or processing times are excessive. Also, if a particulate gets under a piece of glass during processing it can easily create a pull-out chip or scratch that drags. Using enough slurry or coolant flowing on the pad can help prevent these defects.

3. How to clean, handle and store parts

When cleaning and handling these glass parts, keep in mind that this material can easily scratch. Thus, handling should be minimized. Cleaning should be done with a soft, preferably lint-free, cloth. Even a Kimwipe with some pressure will scratch the surface of a polished piece of chalcogenide glass. Acetone, isopropanol, or distilled water work well for cleaning but avoid using strong bases because they can etch the surface.

When cleaning a large batch of parts, bathing techniques using an optics detergent or very dilute dish detergent can be used. Be sure to rinse very well afterwards using temperature-controlled water baths.

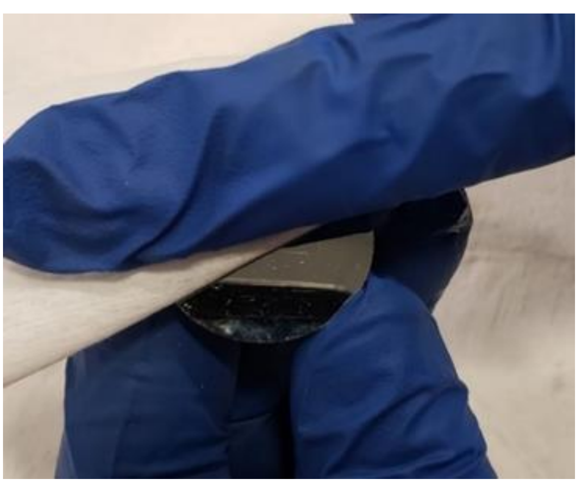

Figure 5: Gentle wiping with acetone or alcohol removes surface residue.

We discourage the use of ultrasonics because it exploits surface defects and can cause breakage.

Proper storage for chalcogenide glass parts is important because they can be affected by humidity or extended exposure to UV light. If polished parts are exposed to moisture or too much UV light, they may form a haziness on the surface. This thin, superficial layer can be easily removed by polishing or with another resurfacing technique. To prevent this haziness from forming, store the parts in a low-humidity environment or in vacuum packaging. Although this is critical for protecting uncoated parts, it is not as important for blanks with a matte finish because they will undergo additional processing that removes the surface layers.

Chalcogenide glasses are an excellent choice for a growing number of IR applications. With the right practices and procedures, working with these glasses can be just as easy as working with any other traditional oxide glass.

Figure 6: Temperature controlled cleaning baths work well for large batches of parts.

Figure 7: Surface scratches (left) and haziness (right) are common issues when working with chalcogenides that can be avoided through proper processing, handling and storage protocols.

Want to learn more about IRG material?

Check out these related resources:

- SCHOTT Internal Qualification Standards for Chalcogenide Glasses According to ISO 19740, 19741 and 19742
- Quality Assurance Techniques for Optical Grade Chalcogenide Glasses

You can also find additional information and resources on infrared materials by visiting our website:
schott.com/products/infrared-glasses-and-materials