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Material Properties

Introduction

Glass manufacturers provide hundreds of different glass types with differing optical transmissibility and mechanical strengths. Melles Griot has simplified the task of selecting the right material for an optical component by offering each of our standard components in a single material, or in a small range of materials best suited to typical applications.

There are, however, two instances in which one might need to know more about optical materials: one might need to determine the performance of a catalog component in a particular application, or one might need specific information to select a material for a custom component. The information given in this chapter is intended to help those in such situations.

The most important material properties to consider in regard to an optical element are as follows:

- Transmission versus wavelength
- Index of refraction
- Thermal characteristics
- Mechanical characteristics
- Chemical characteristics
- Cost

Transmission versus Wavelength

A material must be transmissive at the wavelength of interest if it is to be used for a transmissive component. A transmission curve allows the optical designer to estimate the attenuation of light, at various wavelengths, caused by internal material properties. For mirror substrates, the attenuation may be of no consequence.

Index of Refraction

The index of refraction, as well as the rate of change of index with wavelength (dispersion), might require consideration. High-index materials allow the designer to achieve a given power with less surface curvature, typically resulting in lower aberrations. On the other hand, most high-index flint glasses have higher dispersions, resulting in more chromatic aberration in polychromatic applications. They also typically have poorer chemical characteristics than lower index crown glasses.

Thermal Characteristics

The thermal expansion coefficient can be particularly important in applications in which the part is subjected to high temperatures, such as high-intensity projection systems. This is also of concern when components must undergo large temperature cycles, such as in optical systems used outdoors.

Mechanical Characteristics

The mechanical characteristics of a material are significant in many areas. They can affect how easy it is to fabricate the material into shape, which affects product cost. Scratch resistance is important if

the component will require frequent cleaning. Shock and vibration resistance are important for military, aerospace, or certain industrial applications. Ability to withstand high pressure differentials is important for windows used in vacuum chambers.

Chemical Characteristics

The chemical characteristics of a material, such as acid or stain resistance, can also affect fabrication and durability. As with mechanical characteristics, chemical characteristics should be taken into account for optics used outdoors or in harsh conditions.

Cost

Cost is almost always a factor to consider when specifying materials. Furthermore, the cost of some materials, such as UV-grade synthetic fused silica, increases sharply with larger diameters because of the difficulty in obtaining large pieces of the material.

Overview

The table below shows the general characteristics of the optical glasses used to manufacture most Melles Griot components. Click on the material type for more detailed information.

Material	Usable Transmission Range	Index of Refraction	Features
BK7	350 nm to 2.0 瘵	1.52 @ 550 nm	Excellent all-around lens material combining broad transmission with excellent mechanical characteristics.
LaSFN9	420 nm to 2.3 瘵	1.86 @ 550 nm	High-refractive-index flint glass provides more power with less curvature needed.
SF11	420 nm to 2.3 瘵	1.79 @ 550 nm	High-refractive-index flint glass provides more power with less curvature needed.
F2	350 nm to 1.9 瘵	1.62 @ 550 nm	Material represents a good compromise between higher index and acceptable mechanical characteristics.
BaK1	330 nm to 2.1 瘵	1.57 @ 550 nm	Excellent all-around lens material, but has weaker chemical characteristics than BK7.
Optical Quality Synthetic Fused Silica	260 nm to 2.5 瘵 and 3 瘵 to 3.7 瘵	1.46 @ 550 nm	Material provides good ultraviolet transmission and superior mechanical characteristics..
UV-Grade Synthetic Fused Silica	180 nm to 2.5 瘵 and 3 瘵 to 3.7 瘵	1.46 @ 550 nm	Material provides excellent ultraviolet transmission and superior mechanical characteristics.
Optical Crown Glass	350 nm to 2.5 瘵	1.52 @ 550 nm	This lower tolerance glass can be used as a mirror substrate or in noncritical applications.
Low-Expansion Borosilicate Glass (LEBG)	375 nm to 2.3 瘵	1.48 @ 550 nm	Excellent thermal stability, low cost, and homogeneity makes LEBG useful for high-temperature windows, mirror substrates, and condenser lenses.
Sapphire	180 nm to 5.0 瘵	1.77 @ 550 nm	Excellent mechanical and thermal characteristics make it a superior window material.
Calcium Fluoride	180 nm to 8.0 瘵	1.40 @ 5 瘵	This popular ultraviolet excimer laser material is used for windows, lenses, and mirror substrates.

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