Changing Glass Catalogs

Optical design requires accurate knowledge of glass properties and availability.

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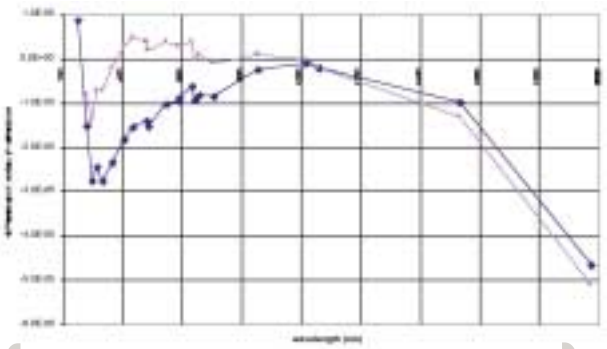
Today's optical designers face new challenges when designing and modeling refractive systems. Glass catalogs and glass availability are shrinking. The Schott Glass (Duryea, PA) catalog published in 1984 had 244 glass types, for example; now, the Schott catalog has about 101 glass types. Ohara (Rancho Santa Margarita, CA) offered around 240 glass types in the mid-1980s; today, they provide a total of 112 recommended glass types plus two leaded materials and 13 *i*-line glasses. At its peak, Pilkington Special Glass (PSG; Clwyd, UK) offered 64 optical glass types; several years ago, PSG pared that offering down to 29 "standard" and 16 "enquiry" glasses.



Calculated index of refraction for certain materials may vary from the reported numbers; curves show the difference in calculated versus reported index of refraction for calcium fluoride as shown in ZEMAX (blue) and Code V (purple).

In an effort to be complete, the ray trace programs continue to include the outdated glasses. This can present a serious pitfall for the indiscriminant optical designer. Often, the first step in fabricating a new optical design is to eliminate the glasses that are no longer manufactured.

Out with the Old, In with the New

Simply swapping in new glasses and materials is not nearly as simple as it might seem at first blush. Switching to environmentally friendly lead- and arsenic-free glasses is a worthy goal, but can have pitfalls. Consider a projection lens that includes two SF5 lenses that are each 12.5-mm thick for a total of 25-mm glass thickness. If the designer switches to the new Schott designation (N-SF5), the optical properties are largely the same and the image quality looks acceptable in the ray trace program; however, the transmission analysis and Schott glass data sheets confirm the projection lens loses 12% transmittance at 405 nm due to the increased internal absorption of N-SF5.

The thermal properties of eco-friendly glass are also different from the corresponding leaded glasses. At the principal neodymium-doped yttrium aluminum garnet wavelength of 1064 nm, Schott SF10 shows an increase in refractive index with increasing temperature (positive relative dn/dT value). In contrast, the new designation N-SF10 has a negative relative dn/dT value—the index of refraction *decreases* over the same temperature range.

Switching between manufacturers can also cause problems. On paper, Chinese glass ZF52(847238) looks like a low-cost alternative to Ohara S-TIH53. The glass data sheet indicates that it has higher transmittance through 10 mm at 440 nm (0.965) than the Ohara material (0.927). Transmission measurements suggest that the catalog data may be questionable, however.

Indeed, index data on materials like calcium fluoride and fused silica vary from manufacturer to manufacturer, or between theoretical and experimental values (see figure). Assuming that the manufacturer has the best knowledge of their own materials, the optical design codes should allow you to choose from different manufacturers in the glass catalog to ensure accurate performance modeling.

Extending the Range

A final problem area is using glass data over extended spectral ranges. The only way to be safe using optical glasses outside the visible spectrum is to pay to have the melt tested near your operational wavelength. Even knowing the refractive index near 1550 nm, for example, may not be enough over large temperature ranges because the dn/dT at 1550 nm is not the same as the dn/dT near the visible spectral region.

The burden of knowing glass properties and making correct choices lies with the designer. "Because some of the new glasses have the same names as the old glasses, optical designers need to be especially vigilant," says the manual for Zemax (Focus Software Inc.; Tucson, AZ). Data fitting, bad ray trace program data, bad source data, and unreasonable use of data outside normal operating conditions all add up to pitfalls for designers who want their designs to work in practice, not just on paper. **oe**

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