Active glass selection and chromatic correction using individual glass maps

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Enhanced glass maps in a glass database and in an optical design program help the optical designer to select optical glass types in a more efficient way. 'Active' glass maps can be used to compare glasses for special properties and to change glasses in the optical design process. Besides discussing the various types of diagrams, the usage and flexibility of this design tool is shown by an example of a high-performance, high-aperture apo-chromatic repro-lens 2.0/85.

1 Introduction

Standard glass diagrams let the user compare a few selected optical properties, such as 'refractive index' - 'ν value' [n-ν] and 'relative partial dispersion' - 'ν value' [P-ν], but only at the standard visible wavelengths. These plots cannot be customised and are strictly non-interactive.

Normally such maps only show data from a single glass supplier. However, in the glass database program, Glass Manager, and in the WinLens optical design program, glass data from all the main suppliers are displayed and can be compared. A powerful search facility allows for precise location of glasses with suitable properties.

Further enhancements allow the user to change wavelengths for the actual application and select the parameters shown in individual glass maps. In WinLens, system glasses can be changed directly from the map.

2 Wavelength selection

For all glass spectral parameters the wavelength can be changed. The user can select between special wavebands or user defined wavelengths. In this way especially graphs for individual partial dispersions can be created which are more appropriate for the actual application.

3 Colour coding

In these glass maps each glass can be colour coded, as a 'third' dimension, for example by status or by make. Of most interest is the option to colour code by a glass

property value. For example, a standard n-ν plot can be coded by internal transmission at a particular wavelength, [resulting in an n-ν-T-diagram]. Other options might include total transmission, density etc.

4 Individual parameter axis

Both horizontal and vertical axes can be defined by selection from a list of options such as refractive index [n or 1/n], dispersion [$\Delta n = n_1 - n_2$], Abbe value [ν or $1/\nu$], relative partial dispersion [P], density, internal and total transmission, and other chemical, mechanical ot thermal properties. This allows the optical designer to create custom glass maps specific to the needs of the design.

In Fig. 1 an example is shown for a n-Δn-diagram using wavelengths of 550, 380 and 800 nm. With colour coding for Knoop hardness).
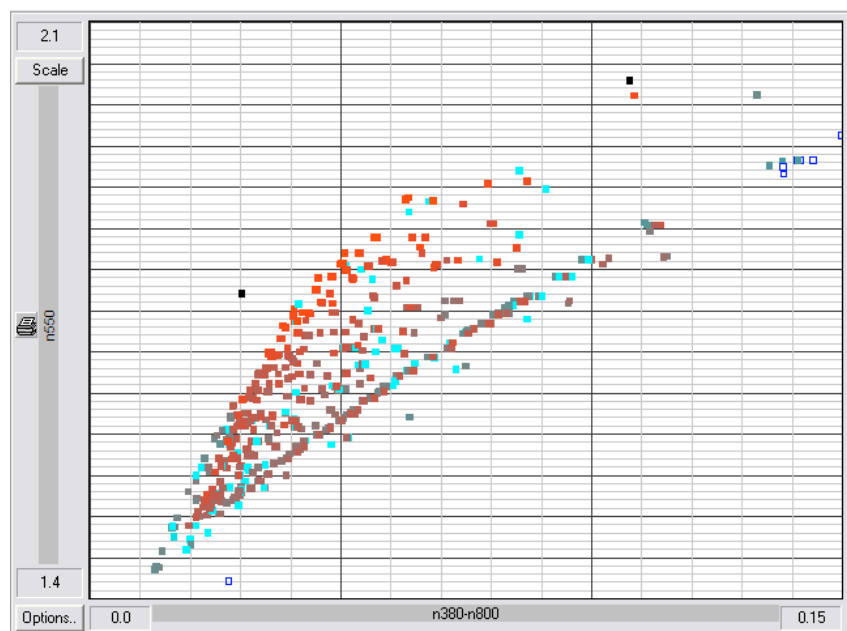

Fig. 1 *Individual glass map: n-Δn-Knoop / 550, 380, 800 nm*

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5 Design example

To demonstrate the new glass map features the design of a high-performance, high-aperture apo-chromatic repro-lens 2.0/85 is used. The lens is used for 1:1 imaging onto a CCD camera, therefore a holosymmetric lay-out is used. The system consists of 8 elements in 4 groups. Unusually, the inner groups are cemented triplets.
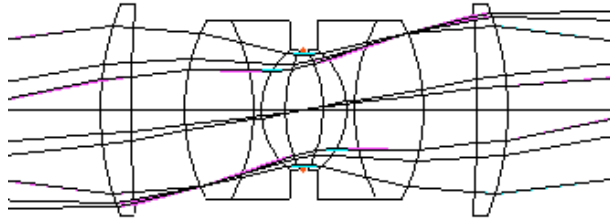

Fig. 2 *Apo-chromatic repro-lens 2.0/85*

The design process results in a choice of special glasses for these inner groups shown in Fig. 2. In the glass map P[(g-e)/(F'-C')] vs. $1/\nu_e$ the locations of N-KzFS11 (Schott) and S-FPL53 (Ohara) are clearly well away from the main concentrations.

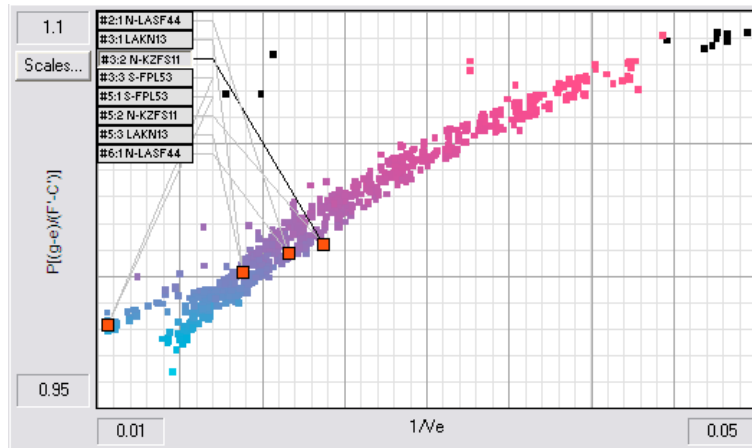Any search for alternatives must bear this in mind.

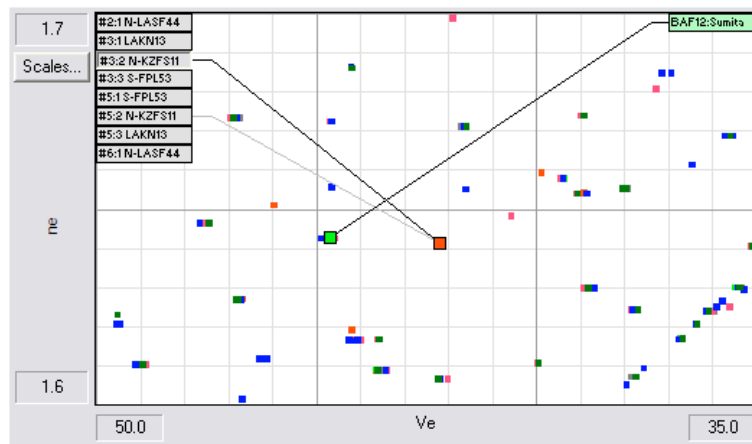**Fig. 3** *P-$1/\nu_e$-diagram: glass types for repro-lens 2.0/85*

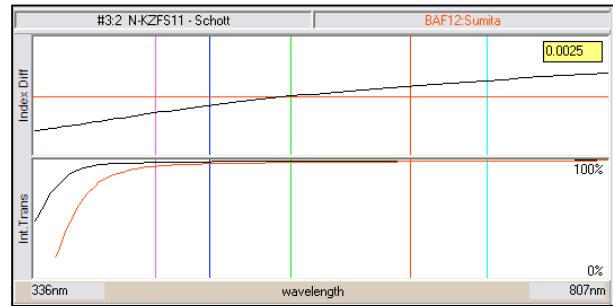**Fig. 4** *n_e-ν_e-diagram: active glass type variation*

Fig. 5 *Refractive index and transmission difference*

For example, zooming into a n_e-ν_e plot around N-KzFS11, the user can select a 'close' alternative [such as BaF12] by clicking on the map. Doing this ensures that the n_e and ν_e are not changed significantly, and therefore should maintain performance. Indeed a first glance at the child graph [fig 5] suggests that this might be a suitable alternative, though with reduced transmission. However all performance graphs are immediately updated, and these show a dramatic increase in longitudinal chromatic aberration. This is confirmed by inspection of the P: ν graph. Alternatively colour coding of the n_e-ν_e plot with P as the third dimension would have revealed the problem and eliminated BaF12.

6 Summary

By simply clicking on an active glass map within the optical design program the designer can vary glasses in a lens and immediately see how the system performance changes. Different custom glass maps can be created by defining the parameters for both diagram axes. Colour coding of the glasses acts as a 'third dimension' to these plots.

The new tools provide much more information than standard glass maps. Unexpected correlations between the properties of different glasses may be found. The user can inspect data from all suppliers, or search for a sub set with particular properties and/or origins.

References

[1] R. Schuhmann, G. Adams: "Enhancements to the optimisation process in lens design (I)", Proc. SPIE 4441 (2001)

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