

Active Glass Maps for an Optical Design Program

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ABSTRACT

The shortcomings of the standard glass 'maps' that currently appear in optical design programs are discussed. There is a clear benefit in having a glass map that is interactive, i.e. allows the user to change system glasses directly from the map. This has been implemented in the 'WinLens' software, and the work is reviewed in this paper.

Most aspects of this 'active' map can be customized to suit the requirements for any given lens design task. Standard map, such as n-v, may be generated, but for non-standard wavebands. Unusual variable combinations, such as internal transmission - dispersion, may also be displayed. Finally, glasses in these plots may be colour coded to display one or more extra optical, chemical, mechanical or thermal properties. These simple new tools can reveal significant correlation's between properties and allow the designer to effectively consider a wider range of properties in his glass selection.

1. INTRODUCTION

The informed choice of optical materials is crucial to the good performance & ease of production of most refractive systems. All optical designers are therefore very familiar with the large catalogues and datasheets supplied by the glass manufacturers.

Comparing numerical data from the paper catalogs is not trivial, so over the years a few standard plots or maps have evolved. These plots summarize key information for many glasses and enable quick selection of a few possibilities. The most well known is the 'refractive index' v 'V-value' [n-v] plot, at the d, C, F or the e, C', F' wavelengths. The 'relative partial dispersion' v 'V-value' plot [P-v maps], at the standard visible waveband wavelengths, are usually also found in the large catalogs. Both plot types are very useful for obtaining good colour correction.

However, such plots are not provided for 'non-standard' wavebands. Such 'non-standard' bands are actually in very widespread usage, and might almost be considered as standard! Moreover, simple consideration of index related data is just not enough to ensure optical quality and simple manufacture. Transmission and other properties may all need to be taken into account, depending upon the application. Unfortunately, these properties are generally unrelated and not indicated on the maps, so the designer is left to make a time consuming datasheet comparison.

It might have been expected that the glass manufacturers would take advantage of the coming of the PC to offer software-based catalogs. This has indeed happened, but to date, such programs are, at best, a copy of the paper catalog, with an added rudimentary search capability. The opportunities offered by computerization have been missed. Of course, such programs are further limited in that they offer data for one supplier.

By contrast, optical design programs do have data for many suppliers. However, even the most widely available only offers such simple items as n-v plots – there is very little available in the way of customisation. Furthermore such plots are 'read only' - there is no way to update materials in the current design by some interaction with the map, although this is the obvious human centered location for such a tool. Of course, glass choice can be undertaken by some forms of global optimization, but the skilled designer will often wish to changes glasses manually; to date this has involved typing in the name directly – a slow & error prone procedure.

In this paper we describe a new development, in the WinLens & Glass Manager programs, which addresses these issues.

2. ACTIVE GLASS MAP IN WINLENS

WinLens contains data for nearly 1400 catalog glasses, from Corning, Hoya, Hikari, Ohara, Pilkington, Schott & Sumita. Data for other materials can be created or imported. All these materials can be displayed in a simple table, with limited search and sort capabilities.

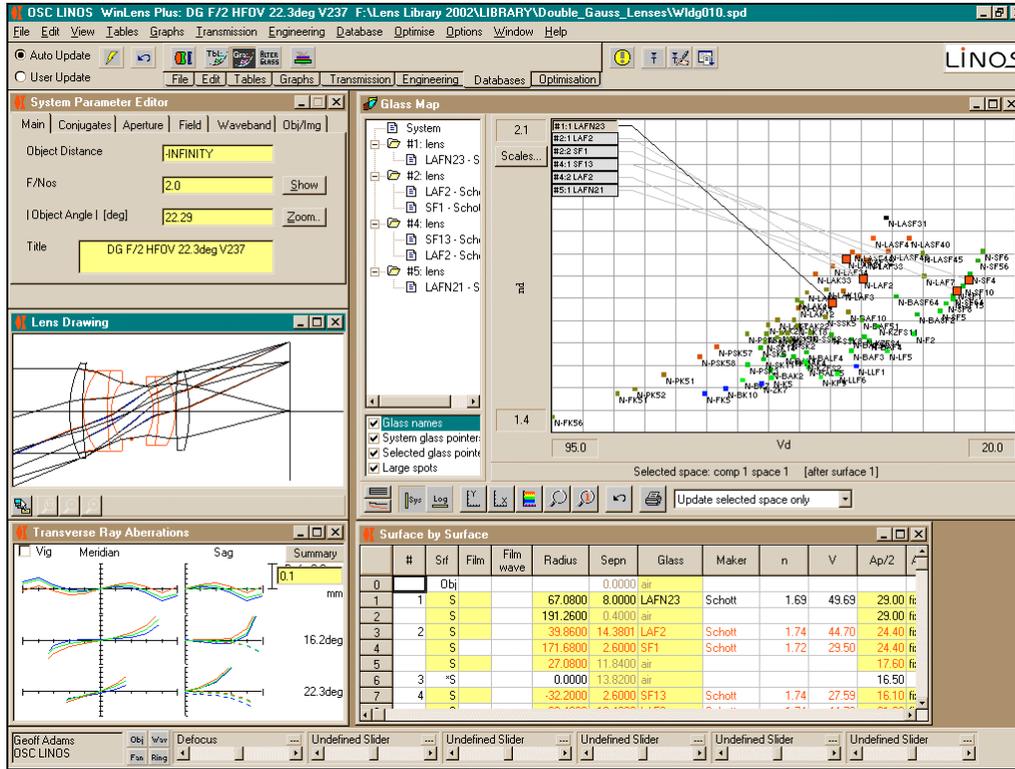


Fig 1: the new glass map in WinLens Plus

tree structure to the left of the map, and also highlighted in sequence on the map itself. Click on one of these names and that will become the 'current' space.

This in itself is informative, but another level of interaction has been added. If the designer clicks on the map, then the glass in the current space is replaced with the nearest glass to the mouse pointer. All other graphs and tables are then updated. This makes it very easy to test the impact of different materials.

As can be seen above, some portions of the map can get quite crowded. Therefore, the designer can zoom into the map in any desired area, before making his choice.

The update action is optional. By default, only the current space is updated, but the user may elect to choose 'no update' or 'update all spaces with same original glass'.

One obvious use of the active map is after glass optimisation. The damped least squares process generates fictitious glasses. These must be replaced with real equivalents. When the location of such glasses is clearly indicated on the map, it is a trivial matter to zoom into the area of interest and try out real alternatives until the best is found.

To change glasses in a system the user could either type the name directly into the appropriate cell of the surface data editor, or drag and drop the glass from the table mentioned above.

Recently, to provide a more visually satisfying means of displaying the data, a glass map has been added to WinLens.

Most properties of the map, such as axis definition, colour coding etc, may be customised, but these features are dealt with in following sections.

Perhaps the most important aspect of the glass map is that it is linked directly to the optical system, which is being designed now.

First, and as can be seen in Fig1, the glasses for the current system are listed in a

tree structure to the left of the map, and also highlighted in sequence on the map itself. Click on one of these names and that will become the 'current' space.

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3. GLASS MAPS FOR NON STANDARD WAVEBANDS

Fig 2a shows the core part of the WinLens version of the n-v glass map, with index data calculated for the standard d, C, F wavelengths. This will be immediately familiar to all optical designers. For this example, so that the names are not completely confused, only eco-friendly glasses from Schott are displayed.

Both vertical & horizontal scales may be altered and the user can zoom into any area.

Most optical design programs only provide this plot for the d, C & F wavelengths [or may be the e, C' & F' wavelengths].

In WinLens, the map is generated to display data for the current waveband. The wavelengths may be defined manually or by simple selection from extensive & precise lists of standard and laser wavelengths.

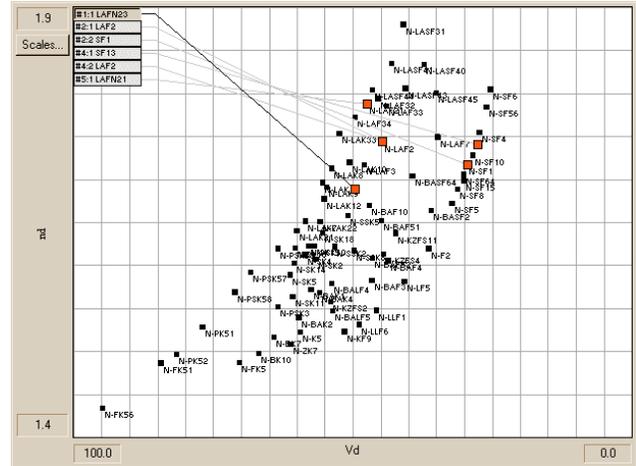


Fig 2.a: n-v plot for the visible waveband [d, C, F]

Two further examples are shown below using the same set of glasses. One waveband is in the near UV and the other in the near IR. As can be clearly seen, there are obvious and significant differences between the plots for the different wavebands. Therefore using the plot for d, C, F wavelengths can easily lead to sub-optimal choice of glasses in non-standard wavebands.

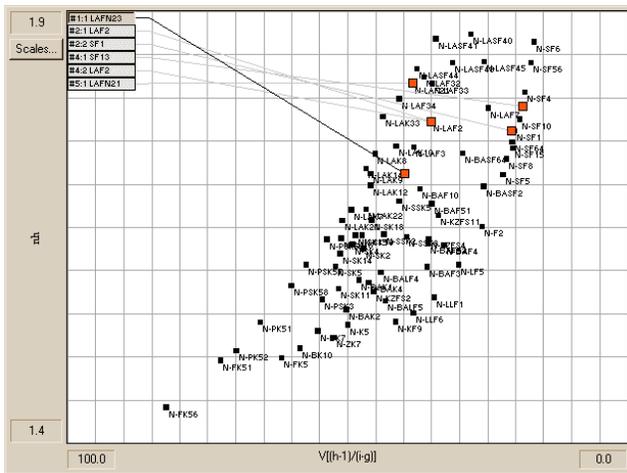


Fig 2.b: n-v plot for a UV waveband

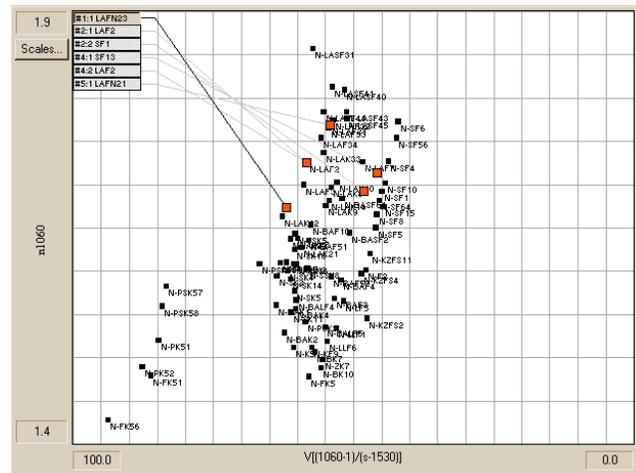


Fig 2.c: n-v plot for an IR waveband

4. GLASS MAPS WITH CUSTOM VARIABLES

Beside the standard n-v & P-v plots, most full catalogues offer one or two more specialised plots, such as the n-ρ [density] plot. These vary from manufacturer to manufacturer, but given the large range of properties, the many interesting plots are not available.

By contrast, WinLens Plus allows the designer to view a custom plot with user selectable axes. Either axis may be defined using an item from a list. This list includes:

- Refractive Index: n
- Refractive Index: 1/n
- V-Value: v
- V-Value:1/v
- Dispersion
- Relative partial dispersions
- Transmission: [internal]
- Transmission [total]
- Density

Both internal and total transmission values are calculated at a user-specified wavelength for a user specified block thickness.

Further properties may be added in the future.

Two examples are shown here, each of which could be of significance in different circumstances.

A high quality printout option is available which uses the full printer paper size & resolution.

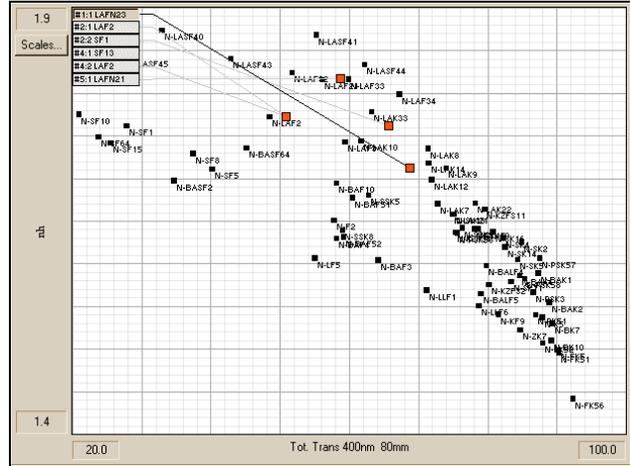


Fig 3a: index v total transmission [400nm /80mm block]

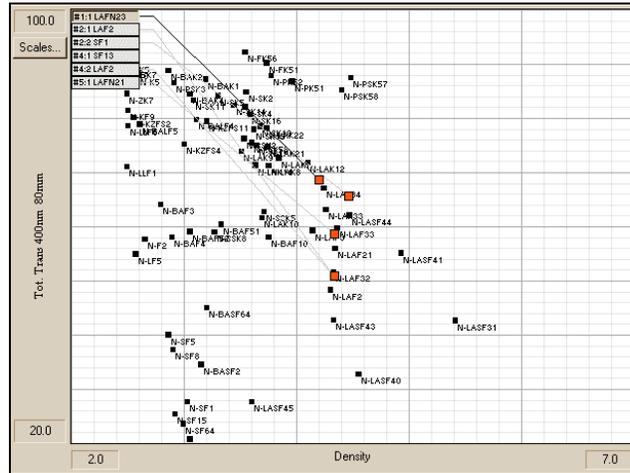


Fig 3b: total transmission v density

5. GLASS MAPS WITH CUSTOM COLOUR CODING

Glass maps are two-dimensional, i.e. show the correlation's between two material properties. Clearly it would be helpful to display other properties on the same map. A true three-dimensional map would however be very cluttered, and probably hide information rather than reveal it.

However colour coding the glass icons on the plot has been found to be an effective way of conveying further information. In WinLens, the user may choose a method to colour code all glasses. This might be a simple manufacturer coding, or a glass status coding [eco-friendly, recommended, available & obsolete].

However the most interesting method is to select a glass property. The user selects two points, which are within the 'spectrum' of values of that property. For example, if density were chosen, then the values range from 2 to 7g/cc, and the user might chose 3 & 5g/cc as end points. A colour is then assigned to the two end points. This establishes a colour gradient. Then the colour chosen for a given glass is picked from the colour gradient by the value of its property relative to the end points. Property values below and above the end points are indicated with one of two other colours, which can also be chosen by the user.

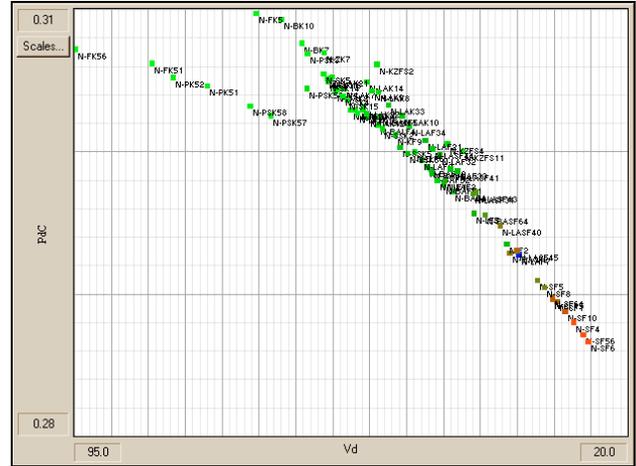


Fig 4: PCs-v map - colour coded for transmission

Fig 4 illustrates this well. A conventional P-v plot has been chosen, as the base map. Imposed on this is colour coding based upon internal transmission at 400nm for a 20mm glass block. Bright green denotes 100% transmission, while bright red denotes 60% transmission. Anything between is indicated by a colour in that gradient. Blue is chosen to show anything less than 60%. All colours and key points are user selected.

By simple inspection, it is clear that there is a very strong correlation between PdC & internal transmission, namely that the glasses with low PdC have low internal transmission and vice versa. Such a correlation is just not obvious in other methods of data display, such as a table.

6. GLASS MAP TOOLS

The aim of this work has been to create a human friendly design aid. The active nature of the glass map and the ability to customise it has been covered, but there are several other features which should be mentioned.

While colour coding can display an extra dimension of information about all glasses, it is often necessary to have a more detailed comparison for the original glass in a space and a possible replacement. Therefore, a popup child graph can be displayed showing index and transmission data versus wavelength, for the original glass in the current space and the most recently selected material. This child graph is updated when the designer changes glass in the main map.

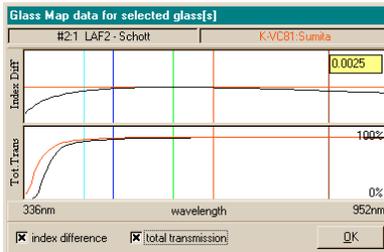


Fig 5: child graph

In this child map, the designer can display the absolute index values of the two glasses, or the change in the difference of index between the two. He may also display the internal or the total transmission curves.

Clearly, it would be confusing to display all glasses simultaneously. Therefore, a powerful search capability has been added to enable the designer to find those glasses meeting selected criteria. These can include glass name, maker, status, density, index, v-value, relative partial dispersion, internal and total transmission [user selected wavelength and glass thickness]. String criteria can include wild cards.

Although it is quite easy changing axis definitions, colour codes and search criteria, it can be a distraction, when the designer wishes to rapidly compare the data under different conditions. For example he may wish to view the materials colour coded by density and then by internal transmission.

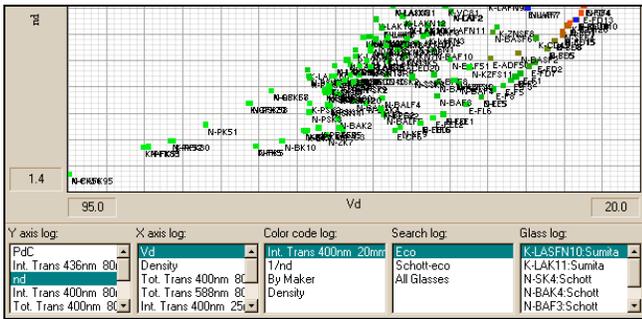


Fig 5b: history logs

Therefore, whenever any of these conditions are changed in WinLens Plus, the new definition is logged. These history logs can be displayed in a set of lists under the map. By clicking on an item in one of the lists, that definition is restored.

In this way, it is very easy for the designer to set up informative displays and then recall them as required.

Finally, it must be recognized that monitors have a limited resolution, and that some designers like having a paper version of the map. Therefore, a high-resolution printout has been included in WinLens Plus. This printout will use the full paper size, so that A3 or even A2 maps can be generated given the appropriate printer.

7. GLASS MAP IN GLASS MANAGER

The Glass Manager program is a full glass database program, with powerful search/sort facilities. This already offers many standard glass maps, with colour coding and for standard or user defined wavebands. However, we have also added the custom glass map to Glass Manager. Since Glass Manager is not a design program, it is not necessary to have the active update feature. However the custom glass map within Glass Manager can be customised, in axis definition and colour coding, to a much wider range of properties than possible in WinLens. The high resolution printout is again available.

8. SUMMARY

This paper reports on a human centered glass map to an optical design program. This glass map is 'active'.

- Can highlight some/all glasses in the current system
- Can be used to update the material in a selected space, by the simple act of clicking on the map

Most aspects of the glass map can be customised:

- Search criteria can be set up to limit range of displayed glasses
- Standard glass map types at non standard wavelengths
- Specialised glass maps with user defined variables
- User defined colour coding in glass maps to display extra properties

There are various ancillary tools designed to provide more information on specific glasses and to allow the user to rapidly switch between various custom settings.

These enhancements allow the designer to prepare glass maps that are appropriate to the task, and may reveal hitherto unexpected correlations between the properties of different glasses. For the first time, the active elements allow the designer to use the glass map as an integrated part of the design process.