Properties of Optical Materials

Homogeneity and Striae

During the manufacturing process of optical substrate materials great care is taken by the manufacturer to ensure an equal cooling of the melt to avoid variations in the refractive index of the material. Any such variations are unwanted as they will negatively influence the transmitted wavefront of an optical component manufactured out of the material.

Extreme examples of variations in the refractive index of a material can often be found in Georgian and Victorian window panes which are made of sheet glass. The variations in the window panes are generally visible by the naked eye, causing objects viewed through the window to appear clearly distorted.

A variation in the refractive index is called an inhomogeneity and represents the difference between the highest and lowest refractive index found in the material sample. The application usually dictates the homogeneity requirement of the optical material, but great care must be taken when specifying the homogeneity as it also has an influence on the cost - the more homogenous the refractive index has to be and the larger the substrate, the more expensive the raw material becomes. If a material is not used in transmission, but, for example, as a mirror, the homogeneity is of little importance.

ISO 10110 Part 4 specifies six different inhomogeneity classes as listed in table 2014-02a below:

Inhomogeneity Class	Max. variation of the refractive index within a part of 10^{-6}
0	+/-50
1	+/-20
2	+/-5
3	+/-2
4	+/-1
5	+/-0.5

Table 2014-02a: Inhomogeneity classes in optical materials as per ISO 10110 Part 4

In practice, a large ingot of material is manufactured and then cut up according to areas of lower and higher homogeneity. When investigating the material, one also commonly finds bands up to a size of a few mm running through the material where the refractive index varies. These are called striae and are also classified in ISO 10110 Part 4. The definition of striae refers to the finished optical component and there are four different classes (see Table 2014-02b), with only striae causing an optical path difference ('OPD') of at least 30nm being considered in most cases.

Striae Class	Density of Striae causing an OPD of at least 30nm in %
1	<=10
2	<=5
3	<=2
4	<=1
5	Striae free, 30nm OPD rule does NOT apply

Table 2014-02b: Striae classes in optical materials as per ISO 10110 Part 4

In ISO-compliant drawings, inhomogeneity and striae are referred to by code number 2 followed by a forward slash and the homogeneity and striae classes, for example:

2/A;B with A being the Inhomogeneity class and B the Striae class

Especially when specifying larger pieces of material with high homogeneity and low striae (2/5;5, for example) it is advisable to contact potential material suppliers beforehand to ensure the manufacturability of the material and get an indication of potential delivery times. Where budget constraints are present, a cost indication will also be helpful as costs of high grade materials can rise exponentially with the required size of the raw material.

References:

BS ISO 10110-4:1997: Optics and optical instruments. Preparation of drawings for optical elements and systems. Material imperfections. Inhomogeneity and striae, ISBN 0 580 28769 6

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