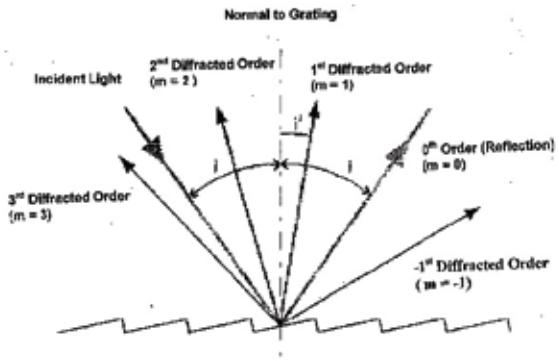
BARR ORDER-SORTING FILTERS

OVERVIEW:

Order-Sorting Filters (step order filters) are often used in optical systems that utilize a diffraction grating as the dispersive element. Diffraction gratings can be transmissive or reflective, and are of different types such as flat-ruled, standard holographic, blazed holographic, echelle, etc.

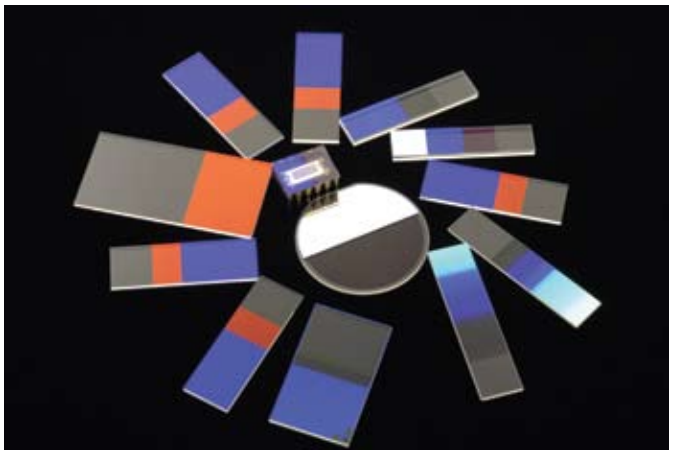


A diffraction grating is an optical component with a regular pattern of elements or grooves. All gratings have intensity maxima at angles θ_m which are given by the grating equation

$$d\left(\sin\theta_m + \sin\theta_i\right) = m\lambda.$$

where θ_i is the angle at which the light is incident, *d* is the separation of grating elements and *m*, the diffraction order, is an integer which can be positive or negative.

If we consider an optical system involving a grating and a detector, where parallel rays of polychromatic light are incident upon the grating, then there will be different values of diffraction angle for each wavelength as well as submultiples of this wavelength, each corresponding to a diffraction order higher than the first. Because overlapping diffracted orders do exist at a given diffraction angle, more than one order will be present at the same point on the detector. A detector cannot discriminate between the desired first order diffraction and the undesired higher order diffraction effects, which are seen as stray light by the detector.



A solution to this problem is afforded by introduction of an Order Sorting Filter (OSF) into the beam, with the filter normally being placed just before the detector to eliminate unwanted diffraction orders.

TYPES OF ORDER SORTING FILTERS:

Order Sorting Filters (OSF's) from Barr are designed to meet individual customer requirements and specifications. Having access to a custom-designed OSF means, for example, that the designer of a grating-based optical system is afforded the filter solution best suited to control higher order diffraction effects in their particular optical system.

We welcome you to contact us at Barr with your specific requirements for order sorting filters. Order Sorting Filters from Barr are offered in two types, Interference-type and Absorption-type.

Interference-type Order Sorting Filters

OSF's made with interference filter coatings are manufactured with durable metal oxide coatings applied to a thin glass or fused silica substrate. Depending upon customer requirements Longpass filter coatings, Bandpass filter coatings, and sometimes Shortpass filter coatings are applied to the filter substrate. Filter coatings are designed to provide high transmission over the spectral region(s) selected for detection in the customer's grating-based system and to provide effective rejection over the wavelength ranges where the undesired diffraction orders exist. The coated substrate is sometimes used as the window for an optical detector such as a CCD. Order Sorting Filters from Barr made with interference filter coatings can be provided in several different forms; as a coated substrate, as a patterned filter, or as a linear variable filter.

Interference Filter Coating on Substrate as Order Sorting Filter

Suppression of higher diffraction orders in a grating-based instrument is often achieved by use of an Order Sorting Filter comprised of a longpass or bandpass filter coating on a thin glass substrate. The blocking band of the interference filter coating affords rejection of undesired diffraction orders.

While absorption filters (such as color filter glass) can also be used as OSF's, advantages for use of interference filter coatings as OSF's over use of absorption-type filters include:

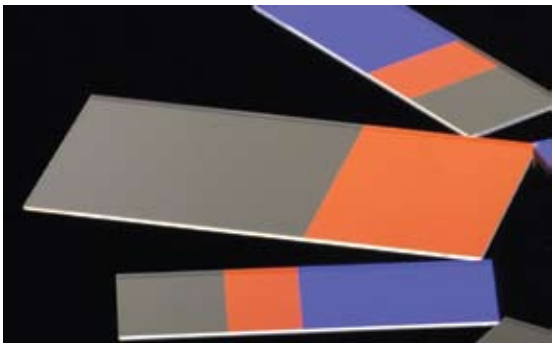
- greater flexibility in selecting spectral positioning of the filter's transmission band and blocking band
- availability of a wider spectral range for filter design
- ability to achieve a thin thickness profile for the filter, a desirable feature when mounting the Order Sorting Filter to an optical detector.

Barr offers custom-designed OSF's made with interference filter coatings within a very broad range of wavelength (195nm to 40 microns), however, the operational wavelength range for any particular OSF is narrower and typically selected to be compatible with the responsivity range of the detector with which it would be used.

In a typical application involving order sorting for a monochromator, a longpass-type OSF would be located at the input side of the monochromator. The cut-on wavelength of the OSF would be selected to result in rejection of higher diffraction orders at wavelengths shorter than the cut-on wavelength and to provide transmission over a wavelength range for the first diffracted order. To accommodate the need to provide effective order sorting while scanning a broad wavelength range with the monochromator a filter wheel is often used to allow use of order sorting filters having different cut-on wavelengths and transmission ranges.

Barr offers OSF's made with interference filter coatings in a wide variety of sizes, shapes, and thicknesses to suit customer requirements.

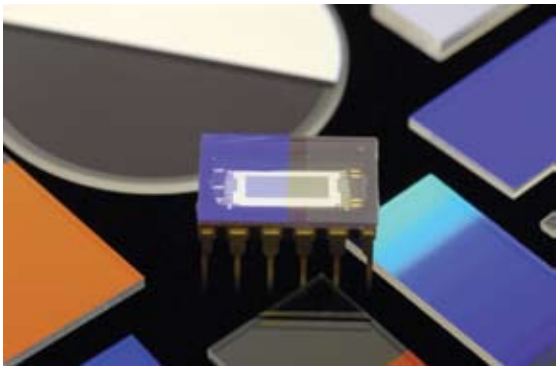
Patterned Interference Filter Coatings as Order Sorting Filter



Some types of miniature spectrometers are designed using a fixed diffraction grating and CCD detector and require some form of optical filtering to eliminate higher order diffraction effects. Effective order sorting for the detector is accomplished by dividing the detector area into different zones, and then optically filtering each of the different zones with a portion of the total wavelength range for which order sorting is required. Optical filtering in the different zones is typically accomplished by use of longpass filters with different spectral cut-on wavelength values, although in some order sorting applications bandpass filter coatings are used.

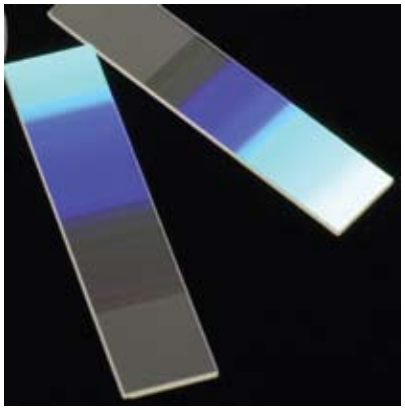
A typical filter of this type is comprised of a pattern of different interference filter coatings deposited in distinct zones on a thin, glass or fused silica substrate. Filter shape is often rectangular although other shapes are available as well. Typically there is a region or zone on the substrate devoid of optical coating and one or more regions or zones coated with different longpass optical filter coatings. The transition region between zones can be controlled to dimensions of 20 microns or less. Optionally the rear surface of the Patterned OSF can be coated with an anti-reflective coating. Barr produces these interference filters using stable and durable, hard metal-oxide coatings.

Barr offers Patterned Order Sorting Filters, designed to customer specifications, which can be used as a window on an optical detector such as a CCD.

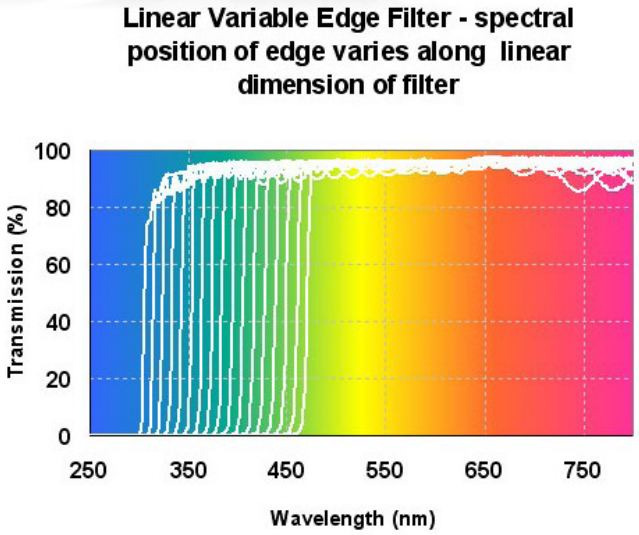


The wavelength range within which OSF's can be manufactured by Barr with Patterned Interference Filter Coatings is 195nm to 40 microns, the same as is offered for OSF's made with interference filter coatings which are not patterned. The most common wavelength range within which Barr Patterned OSF's would be produced includes 195nm to about 3 microns.

Linear Variable Filter Coating as Order Sorting Filter



A Linear Variable Filter (LVF) is comprised of an interference filter coating on a glass or fused silica substrate deposited in such a way that the spectral properties of the filter vary continuously and linearly along one of the linear dimensions of the filter.



Barr designs and manufactures both edge-type and bandpass-type LVF's to customer specifications, and both types of LVF's are sometimes used as Order Sorting Filters in grating-based systems. For example, a Linear Variable Filter can be used in an imaging spectrograph to provide order sorting when used with a focal plane detector.

The wavelength range within which Barr offers edge-type LVF's used as OSF's is typically 195nm to 2 microns. However, the wavelength range spanned by an individual LVF OSF would typically be narrower since it would be designed to be compatible with the responsivity range for the optical detector with which it is used.

For example, if one considers a grating-based system involving a silicon-based detector where suppression of 2nd and 3rd diffraction orders is desired, then the edge-type LVF might be designed to provide a linear variation of the wavelength position of the filter edge along the length of the filter from 300nm at one position to approximately 575nm at the opposite end of the filter.

If your requirements call for an edge-type LVF with wavelength characteristics outside of Barr's typical custom design range for LVF's (195nm to 2 microns), or for bandpass-type LVF please call for more information.

Absorption-Glass-Type Order Sorting Filter

Barr can provide simple absorption-glass-type filters for order sorting. Filters of this type are constructed using color filter glass selected to provide transmission over the wavelength range required for sensing of the desired diffractive order while attenuating (by absorption) the shorter wavelengths associated with higher diffraction orders.

Absorption-glass-type OSF's are offered over the wavelength range of 300nm to 850nm and, within this range, Barr can offer filters with selected 50% cut-on wavelength values. Typical filter thickness for absorption-glass-type OSF's is 3mm.

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