Bandpass Filters

General Specifications

Bandpass filters are characterized spectrally by a defined pass-band with blocking ranges on either side. Nowadays, defining the passband and stopband is the most precise way of describing a bandpass. Traditionally, the specification was done using CWL and FWHM.

- **CWL** (central wavelength) of bandpass
  Defines the central wavelength of the bandpass.
- **Maximum transmission** T [%]
  T defines the percentage of light being transmitted at the filter peak.
- **Blocking** (optical density) in the blocking range
  Blocking is the filter's ability to block undesired spectral ranges.
  The following applies to all filter types:
  Example: OD 4 means transmission of 10^{-4}, or 0.01 %.
- **Cut-on wavelength**
  The wavelength at which a long pass filter transmits 50 %.
- **Cut-off wavelength**
  The wavelength at which a short pass filter transmits 50 %.
- **FWHM** (full width at half maximum) for bandpass
  This indicates the spectral width at which the signal has fallen to 50 % of the peak value.
- **Operating temperature**
  Bandpass filters are specified at room temperature. However, they have a positive temperature coefficient (i.e. with increasing temperature, the CWL shifts to longer wavelengths).
  For example:

  CWL = λo = 500 nm
  temperature coefficient [$\Delta\lambda o$/°C] = 0.01 nm/°C

  Thus, a change in temperature from 22° to 50 °C results in a wavelength shift of +0.28 nm.

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- **Angle of incidence: Formula**
  The following formula shows the relationship between the angle of incidence and the wavelength drift; however, it can only be used up to an angle of incidence of 15°.
  The following applies:

$$\frac{\lambda_\Phi}{\lambda_0} = \frac{\sqrt{(N^2 - \sin^2 \Phi)}}{N}$$

  where

  λo = CWL @ AOI = 0°
  λ_θ = CWL @ AOI = θ°
  N = index of refraction derived from the thin films and the substrate material

- **Angle of Incidence: Spectral effects**
  The passband shifts to blue and becomes wider when a filter is illuminated either perpendicularly by a ocussed beam or at an angle by a collimated beam. The blue shift is caused by the reduction of the difference in path length between the transmitted and reflected beams. As the beam passes through the coating, different refraction indices occur depending on the direction of polarization.
  Abnormal incidence always causes a blue shift and if the light is randomly polarized, the band will widen. For angles up to about 20° the effect is typically moderate and the CWL is transmitted efficiently. With a greater tilt fan angle, the effects can be quite serious; so serious, in fact, that parts tilted at too great an angle can no longer be transmitted.

- **Angle of incidence: Tuning**
  There are cases in which the CWL tolerance needed by the customer exceeds manufacturing tolerances. Example: A filter with a 2-nm bandwidth has a CWL tolerance of +/- 0.4 nm, but the customer needs a tolerance of –0/+0.4 nm. In such a case a 0.4-nm red shift in the CWL specification is recommended. Thus, the filter can always be adjusted to the desired spectral position by slight tilting and its associated blue shift.

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