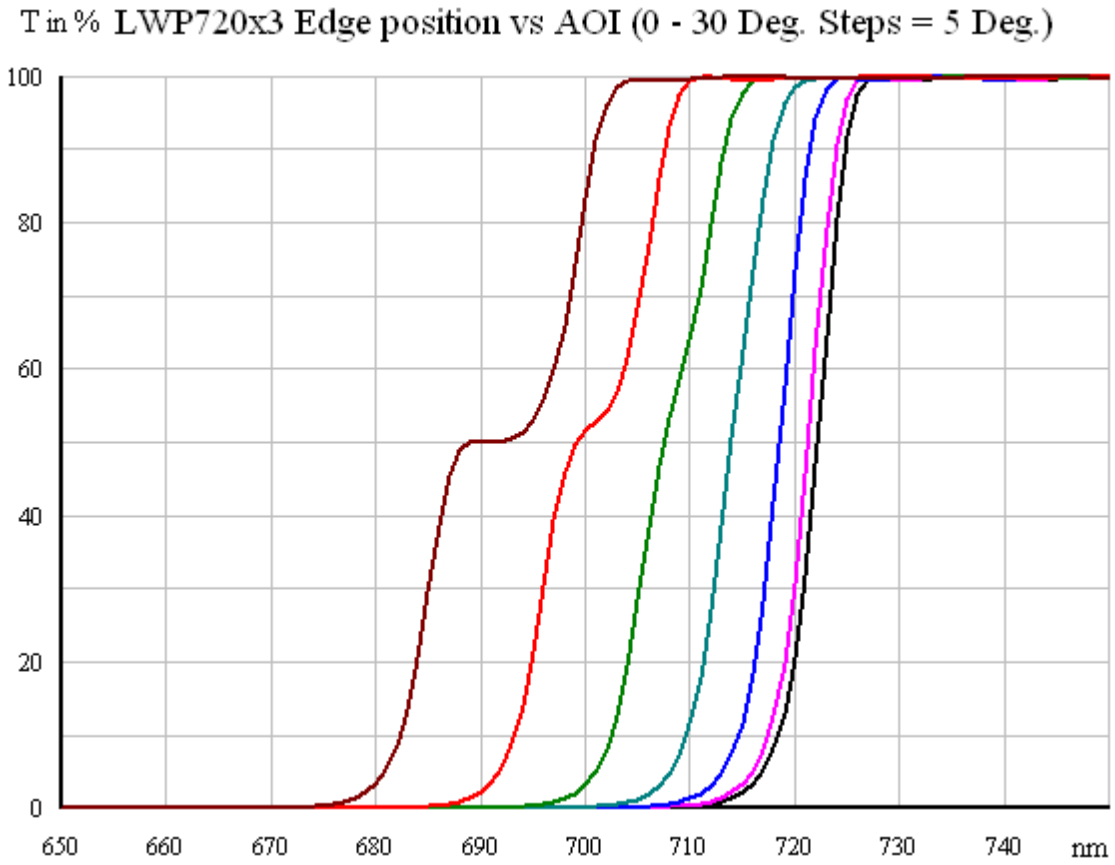
Angling of linear variable filters

It is common to tilt the filter slightly to avoid inter-reflections between filters put in a row, and to avoid reflection directly back into a laser.

The following figure shows a typical example of the angular dependence of a linear variable edge filter.



The phase thickness of the layers in the multi layered coating is described by

$$\emptyset = \frac{2\pi}{\lambda} n(\lambda) d\ Cos\theta$$

Where

λ is the wavelength of light
n is the refractive index of the layer
d is the physical thickness of the layer
θ is the angle of light propagating in the layer

The angle of light in the layer is linked to the angle of incidence in air, V, by Snells law.

$$n \cdot Sin\theta = SinV$$

Hence

$$Cos\theta = \sqrt{1 - (\frac{SinV}{n})^2}$$

The coating mostly consists of a large number of layers and every second has a higher refractive index than the other. However, it is acceptable to introduce some sort of an effective refractive index, representing the whole multilayer

$$n_{effective} \approx \sqrt{n_H * n_L}$$

The coating treated in the figure is made of Ta_2O_5 and SiO_2. At a wavelength of 720nm those materials have refractive indices of around 2.1085 and 1.4771 giving an effective refractive index of 1.7648.

Assuming a wavelength of 721.5nm at normal incidence (the black curve and the T=50% point), we may calculate the following values for the rest of the angles shown in the figure with the formula

$$\lambda_\theta = \lambda_0 \frac{\sqrt{n^2 - \sin^2\theta}}{n}$$

AOI= 5 Degrees => 720.6nm
AOI = 10 Degrees => 718.0nm
AOI = 15 Degrees => 713.7nm
AOI = 20 Degrees => 707.8nm
AOI = 25 Degrees => 700.5nm
AOI = 30 Degrees => 691.9nm

The values actually fit the curves quite well – however, polarisation effects clearly course a severe distortion of the edge at angles of incidence of more than 20 Degrees. We normally recommend keeping angles of incidence lower than 15 degrees. The curves shown in the figure tell why.

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Delta Optical Thin Film A/S