Application Note: Optimal Cut Point Selection

For simplicity's sake, let's say we're trying to make a single layer AR coating optimized at 500nm, and we have good control of when we can make our cuts but don't have precise control over our thin film index, n_1. Let's assume our bare glass has an index of refraction of $n_{glass} = 1.8$. The amplitude of the reflection off the bare glass is

$$R = \left| \frac{n_{glass} - n_{air}}{n_{glass} + n_{air}} \right|^2 = \left| \frac{1.8 - 1}{1.8 + 1} \right| = 0.28571.$$

The intensity of the transmitted light is $T = 1 - R$ (ignoring absorption), which would be 91.8% for the bare glass (ignoring the back surface of the glass).

We'd like to do better than that, so we deposit an optical quarter wave of our thin film. The physical thickness of the quarter wave will be $500nm/4/n1$. Our net reflection amplitude will be the reflection from the air-to-coating interface, r_1, minus the coating-to-glass interface, r_2. The air-to-coating reflection amplitude is

$$r_1 = \frac{n_1 - n_{air}}{n_1 + n_{air}}.$$

The coating-to-glass reflection amplitude is

$$r_2 = \frac{n_{glass} - n_1}{n_{glass} + n_1}.$$

The transmitted light is $T = 1 - (r_{net})^2 = 1 - (r_1 - r_2)^2$. However, if the value of our thin film index isn't precisely known, we can run into the problem you've seen with an absolute cut-point.

More generally, we can find the reflectance for a thin film of thickness t by

$$r(t) = \frac{r_2 + r_1 e^{i2kt}}{1 + r_1 r_2 e^{i2kt}},$$

where $k = \frac{2\pi n_1}{\lambda}$. We can see this reduces to $e^{i\pi} = -1$ when t is a QWOT, producing a minima in the reflectance.

In the figure below I've plotted the optical transmission as a function of thin film thickness for two different index values, 1.4 and 1.5. If we were to set our cutoff at an absolute value of 99%, we're not doing great in either case. If our index of refraction is 1.5, we'll never reach our cut-point. If our index of refraction is 1.4 we'll cut off our deposition before we get to a full quarter-wave optical thickness, meaning we could have made a better AR coating but we stopped too soon.

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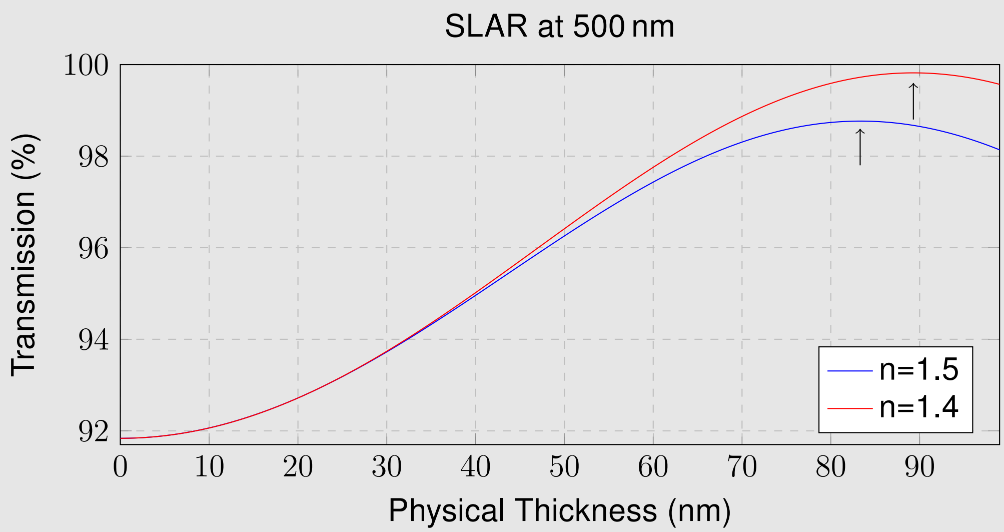
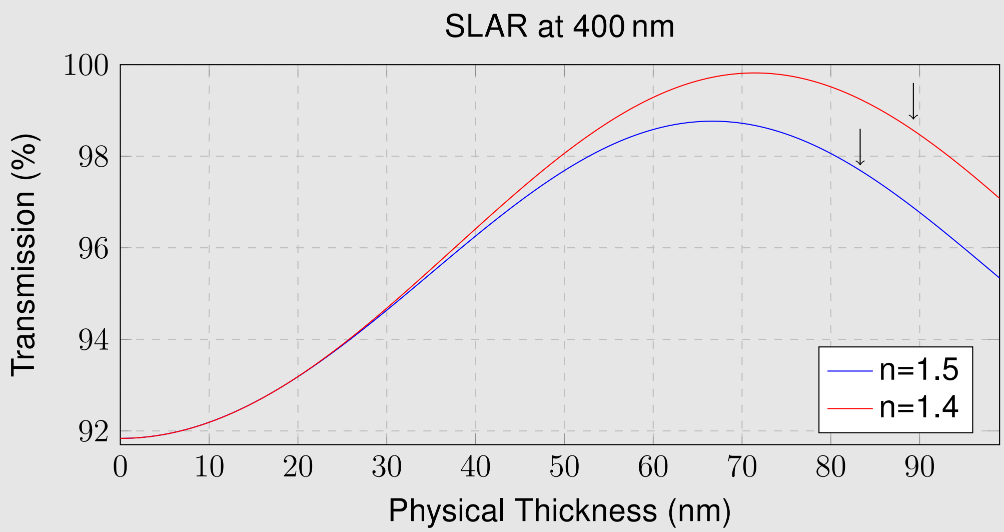

SLAR at 500 nm
Transmission (%)
100
98
96
94
92
0
10
20
30
40
50
60
70
80
90
Physical Thickness (nm)
n=1.5
n=1.4


SLAR at 400 nm
Transmission (%)
100
98
96
94
92
0
10
20
30
40
50
60
70
80
90
Physical Thickness (nm)
n=1.5
n=1.4