Physics II

Anti-Reflex Coatings

Problem 1.- Calculate the minimum thickness of an antireflective coating that doesn't reflect any green light (533nm) if its index of refraction is 1.38 and covers a lens with n=1.52
Draw a diagram and explain the rationale of your answer.

Solution: If we want to reduce the light reflected, we need the two reflected waves to interfere destructively and this is accomplished if they are shifted half a wavelength with respect to each other. In other words, we want the extra path of the light to be half a wavelength:

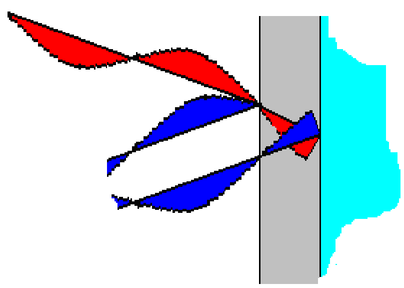
$$2t = \frac{\lambda}{2}$$ where t is the thickness of the coating.

Notice that the two shifts at the air-coating and coating-lens interface are unimportant in this case as they cancel each other out. Also, notice that the wavelength in this equation is the wavelength *inside* the coating, which is shorter than in air:

$$\lambda_{coating} = \frac{\lambda_{air}}{n_{coating}} = \frac{533\text{nm}}{1.38}$$

So the thickness we need is:

$$t = \frac{\lambda}{4} = \frac{533\text{nm}}{4(1.38)} = \mathbf{96.5\ nm}$$



Problem 1a.- Calculate the minimum thickness of an antireflective coating that doesn't reflect green light (533nm) if its index of refraction is 1.42 and covers a lens with n=1.52

Solution: Light inside the coating will have shorter wavelength, in this case:

$$\lambda_{in-coating} = \frac{533nm}{1.42} = 375nm$$

To eliminate glare, we want the two reflections, the one from the air-coating interface and the one from the coating-lens interface to interfere destructively. To do this the extra path will have to be $\lambda_{in-coating}/2$, and since the extra path is 2 times the thickness, the necessary thickness is:

$$th = \frac{\lambda_{in-coating}}{4} = \frac{533nm}{4\times 1.42} = \mathbf{94\ nm}$$

Problem 2.- Why is that lenses that have an anti-reflecting coating look purple?

Solution: The antireflection property will work well for one wavelength, and not so well away from that designed value. So, in lenses the chosen wavelength is in the middle of the visible spectrum, meaning that some light at the extreme ends will be reflected (blue and red), which make the purple color that you see.

Problem 3.- What is the minimum possible thickness of a thin oil film floating on water that looks blue (main intensity at a wavelength=450nm) when illuminated with white light at an angle of incidence of 0º?
Index of refraction of oil = 1.47, index of refraction of water=1.33

Solution: The interface air-oil will reflect light shifted $\lambda/2$ in phase, but the oil water interface will not shift the phase of the reflected light. The maximum intensity will happen when the two reflections are in phase, so the extra distance covered should be $\lambda/2$, then:

$$2\times thickness = \lambda/2 \rightarrow thickness = \frac{\lambda}{4},$$

But be careful that the wavelength is inside the oil, so it will be shorter than in air:

$$thickness = \frac{\lambda_{air}}{4n_{oil}},$$

For blue light: $thickness = \dfrac{450nm}{4\times 1.47} = \mathbf{77\ nm}$