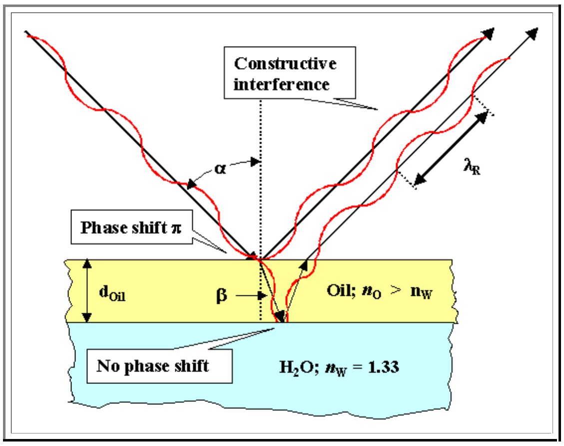
Interference Colors

Basics

Here is a quicky about interference colors from oil films (or any other transparent thin film). You may also want to look at

- "Interferenz und Beugung"
- "Wellen und Phasen"
- "Eigenschaften von Wellen und Teilchen"
- "Basic Optics"



- We have an oil film with thickness d_{Oil} and an index of refraction n_{Oil} that is larger than that of water (**n_W = 1.33**). An incoming wave with wavelength λ_R hits the liquids at an angle α and is reflected at the same angle and diffracted with an angle β.
- The phase of the wave reflected at the surface of the oil film "jumps" **180°** or by π - just believe it, it you don't know the reason for that.
- The diffracted wave propagates with a wavelength λ_{oil} given by $\lambda_{oil} = \lambda_R / n_{Oil}$ and is reflected without a phase jump at the oil - water boundary. At the oil - air boundary it is refracted and runs "parallel" to the wave that was directly reflected at the oil surface.

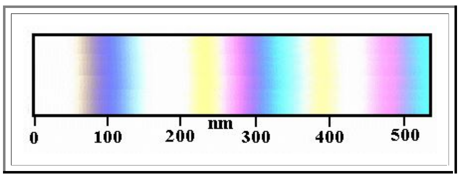
The total light reflected consists of whatever is left over after the waves reflected at both surfaces / interfaces interfered with each other.

- Only for constructive interference as drawn above, a sizeable reflection will be noticed. The equation for constructive interference of the **m**-th order is

$$2n_{Oil} \cdot d_{Oil} \cdot \cos\beta = (m - \tfrac{1}{2}) \cdot \lambda_R$$

- If you think about that for a bit, you will realize that you can measure the thickness of arbitrarily thin oil films by making β large, i.e. for "glancing" incidence. However, if you think a tiny bit harder, you will realize that there are all kinds of problems coming up in real life if you make β too large.
- Nevertheless, by doing experiments along the line drawn above, we should be able to measure the thickness of thin (transparent) films down to a fraction - **1/10th...1/20th** - of the wavelength used in the experiment, i.e. down to **10 nm - 30 nm** without much problems. Accepting problems (meaning paying much money for more sophisticated equipment) we can measure thicknesses in the **1 nm** region with optical means.

If we look at a **Si** wafer with a thin layer of **SiO_2** on it, the color we will see correlates to the thickness roughly like that:



- With a little bit of experience you can make an educated guess at the thickness; but you must be sure you get the order right.
- More important than guessing a the thickness (a simple optical instrument can do that much better than you) is that you see if the thickness of the layer is uniform, because small changes of the thickness changes the color, and the eye is quite sensitive to that.