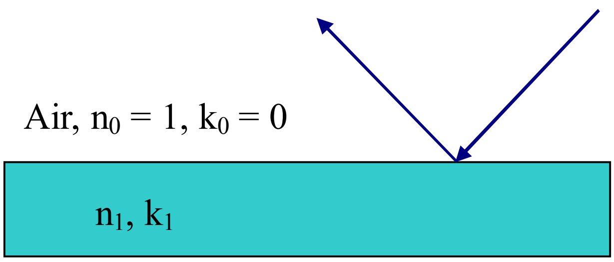
Principle of Operation

FilmSmart measuring software uses the refractive index or transmission spectrum of sample to predict the optical characteristics of film, including film thickness, refractive index and light eliminating index. Because this optical measurement technique possesses non-destructive and high precision property, this device becomes a very important tool for the measurement of film characteristics.

Because the transmission of light has wave characteristics, we can use plane wave concept to demonstrate how to apply optical interference on the measurement of optical characteristics of film. When the light passes through the interface of different mediums, a part of light is reflected by one medium of them, it is because the light passes through discontinuous refractive index and light eliminating index. The light reflected in the air can be shown as the following equation:

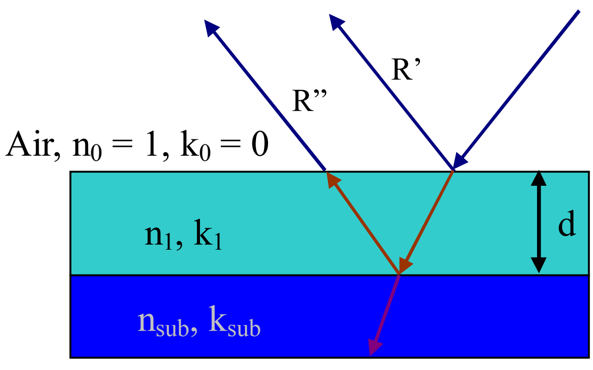


$$R^2 = ((n_1 - n_0)^2 + k_1^2)/((n_1 + n_0)^2 + k_1^2)$$

Why the reflective spectrum can be used to calculate refractive index? If a simple condition is assumed that the light is reflected by a single layer of substance which does not absorb light (the light eliminating index=0), the refractive index of this substance can be shown as the following equation:

$$R^2 = (n_1 - n_0)^2/(n_1 + n_0)^2$$

Under the actual condition, the refractive index is changing with wavelength (it means color dispersion phenomenon will be occurred under actual condition). While



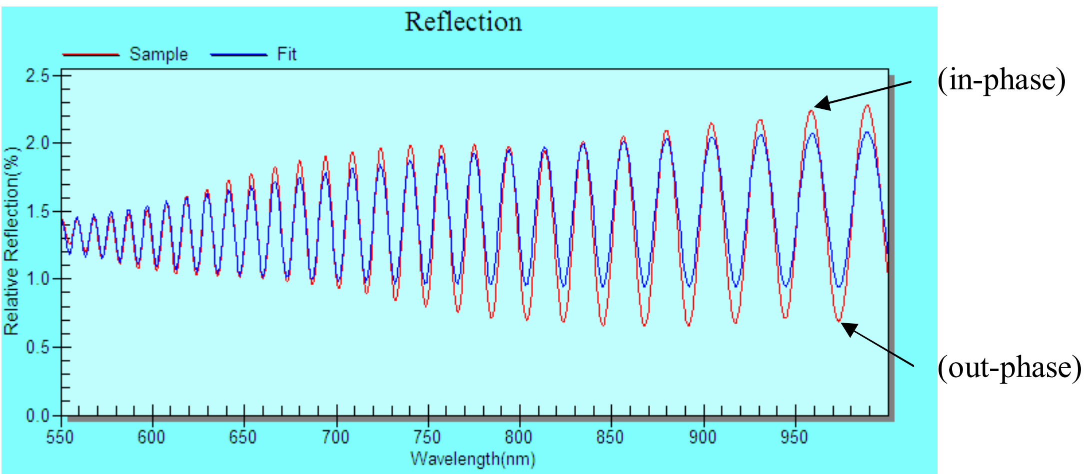
we can get the refractive ratio of each wavelength, thus we can calculate the refractive index for different wavelength.

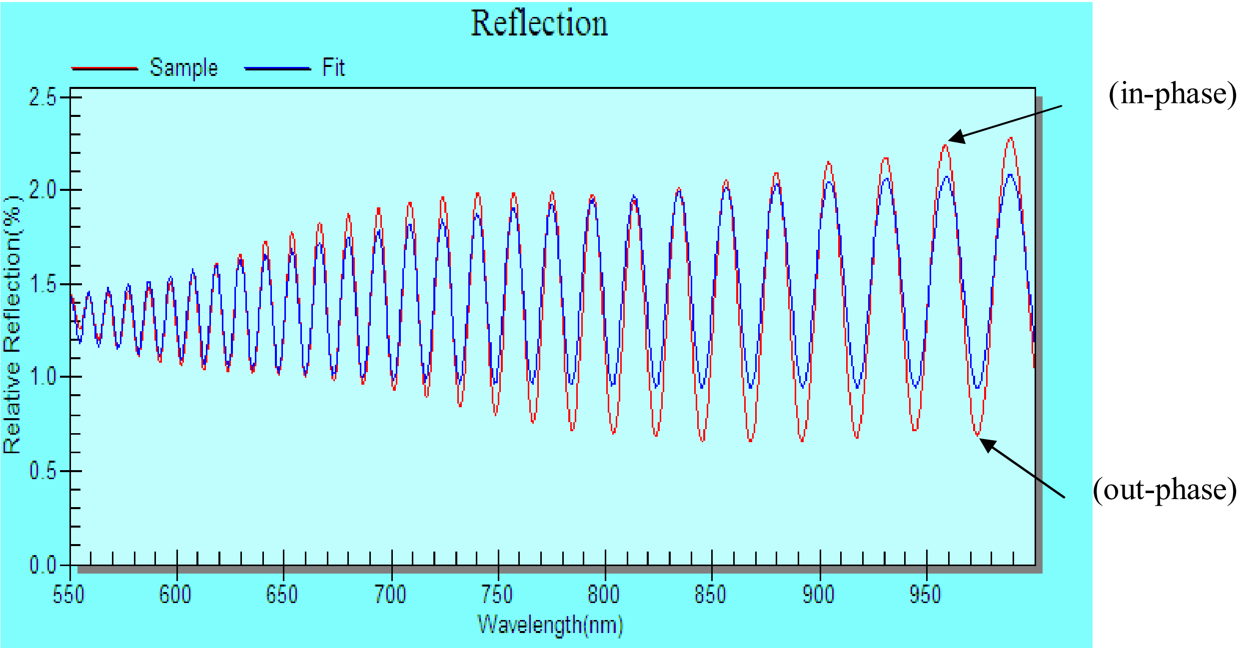
Now, if there is a layer of film covered on the surface of substance, the reflective light will be generated on the surface and bottom of said film, and the total amount of reflective light is the sum of these two up and bottom reflective lights. Because the light has wave property, the addition of up and bottom reflective lights will generate in-phase and out-phase waves due to the difference of light transmission distance. The frequency and valley these waves can be used to calculate film thickness and optical coefficients. The following two equations demonstrate the cause for the generation of constructive (in-phase) and destructive (out-phase) wave. Where the incident angle of light is 0 degree, d is film thickness, i is an integer, λ is wavelength, and the constant term is 2 because the light wave passes the film two times.

$$2nd = (i + \frac{1}{2})\lambda$$ out-phase (the destruction to form wave valley)

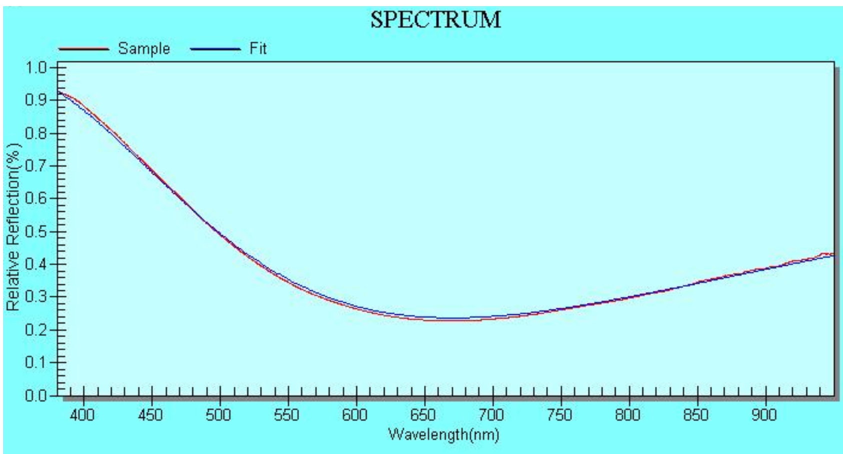
$$2nd = (i)\lambda$$ in-phase (the construction to form wave peak)

When the difference of light transmission distance equals to the integral times of wavelength, these two sets of reflective light have the same phase position, the constructive wave will be generated to form wave peak. On the contrary, when the difference of light transmission distance equals to the integral times plus 1/2 times of wavelength, these two sets of reflective light have different phase position, the destructive wave will be generated to form wave valley.

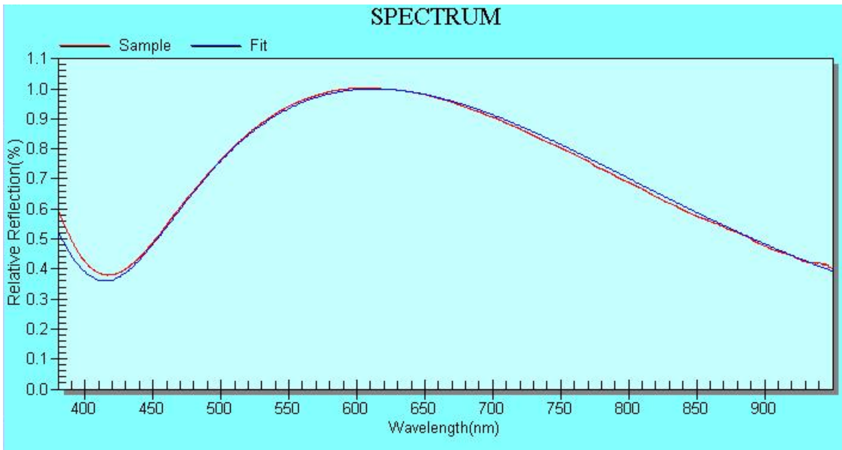




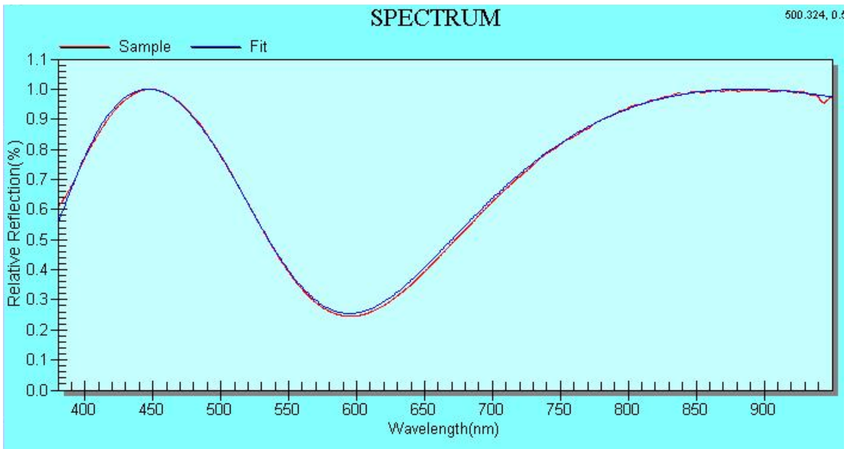
It shows that the refractive ratio of film will be changed periodically with respect to 1/wavelength. The thicker film will generate the amplitude change with higher frequency within fixed wavelength range. the refractive ratio of film will be changed periodically with respect to 1/wavelength. The thinner film will generate the amplitude change with lower frequency within the same wavelength range.



SiO_2 in 1000 Å



SiO_2 in 2000 Å



SiO_2 in 3000 Å