Optics 302 HW 9 Solution

April 23, 2009

9.43 Solution:
When the incident light is perpendicular to the plane, the reflectivity is 
\[ r_{\theta_i=0} = \frac{n_t-n_i}{n_t+n_i} \]
For the bare substrate case, we have 
\[ r_{\text{bare}} = \frac{n_s-1}{n_s+1}, \]
while for the substrate with film,
\[ r'_{\text{trt}} = t_{0-f}r_{f-s}t_{f-o}. \]
For the transmission \( t_{\theta_i=0} = \frac{2n_i}{n_t+n_i} \). Thus the reflectivity for the substrate with film,
\[ r'_{\text{trt}} = \frac{4n_f(n_s-n_f)}{(1+n_f)(n_s+n_f)(n_f+1)}. \]
Here \( n_f = n \). Note that \( n_s > n_f > 1 \), thus both \( r \) and \( r' \) are positive. With the film thickness \( \lambda/4 \), a \( \pi \) (round trip, \( \pi/2 \times 2 = \pi \)) phase shift occurs on due to the OPD in the \( r' \) beam, so \( r_{\text{net}} = r - r'_{\text{trt}} \). Thus the \( r' \) beam partially cancels the \( r \) beam. When the amplitudes of the two beams equal to each other, they totally cancel each other.

9.47 Solution:
It is easy to find that
\[ d\cos\theta_t = (2m+1)\frac{\lambda}{4} \]
. Let \( \theta_t = 0 \) and \( m = 0 \), thus the minimum thickness is 
\[ d = \frac{\lambda_0}{4n} = 9.62 \times 10^{-8}m = 96.2nm \]
We should divide the refraction index of the film rather than that of glass.

10.8 Solution:
With \( bsin\theta_m = m\lambda_0 \), we can get that 
\[ b = m\lambda/sin\theta_m = 1.07 \times 10^{-4}m \]
In the water, the wavelength of the light is \( \lambda = \frac{n_{\text{air}} \lambda_0}{n_{\text{water}}} \), thus

\[
\sin \theta_m = m \lambda_{\text{water}} / b.
\]

Taking numbers into the formula, we can get \( \theta_m = 4.7 \text{degree} \).