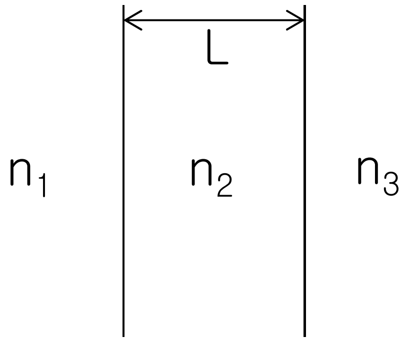
Lect. 8: Multiple Dielectric Interface

– Anti Reflection

– High Reflection

Lect. 8: Multiple Dielectric Interface

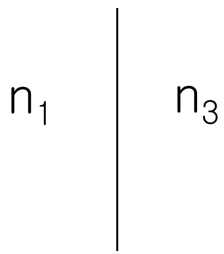


Complex Problem:

Requires more advanced technique

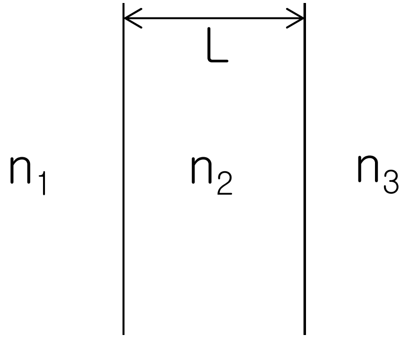
Consider two special cases:

1) $L = m\dfrac{\lambda}{2n_2}$ (Half Wavelength) ➔ The influence of n_2 layer can be ignored



$$\therefore\ r = \frac{n_1 - n_3}{n_1 + n_3},\quad t = \frac{2n_1}{n_1 + n_3}$$

Lect. 8: Multiple Dielectric Interface



Complex Problem:

Requires more advanced technique

$$2)\ L = (m + \frac{1}{2})\frac{\lambda}{2n_2} \quad \text{(Quarter Wavelength)}$$

➔ Normalized reflective index is inversed

n_1 | $\dfrac{n_2^{\,2}}{n_3}$

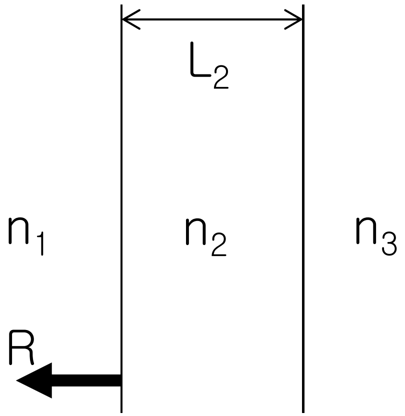
$$\frac{n_3}{n_2} \Rightarrow \frac{n_2}{n_3} \Rightarrow \frac{n_2^{\,2}}{n_3}$$

$$r = \frac{n_1 - n_2^{\,2}/n_3}{n_1 + n_2^{\,2}/n_3} = \frac{n_1 n_3 - n_2^{\,2}}{n_1 n_3 + n_2^{\,2}}$$

$$t = \frac{2n_1}{n_1 + n_2^{\,2}/n_3} = \frac{2n_1 n_3}{n_1 n_3 + n_2^{\,2}}$$

Lect. 8: Multiple Dielectric Interface

Anti-Reflection coating: Determine L_2 and n_2 so that R=0



$$R = |r|^2$$

With $L_2 = \dfrac{\lambda}{4n_2}$

n_1 | $n = \dfrac{n_2^{\ 2}}{n_3}$

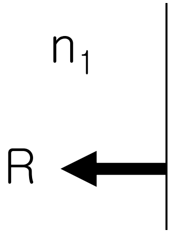
Since $r = \dfrac{n_1 n_3 - n_2^{\ 2}}{n_1 n_3 + n_2^{\ 2}}$,

For r=0, $n_1 n_3 - n_2^{\ 2} = 0$

$$n_2 = \sqrt{n_1 n_3}$$

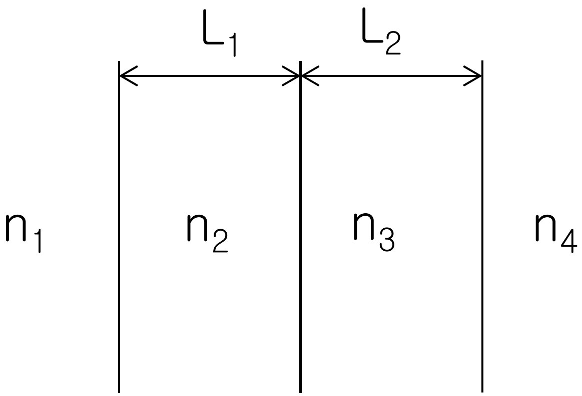
Lect. 8: Multiple Dielectric Interface

High-Reflection Coating

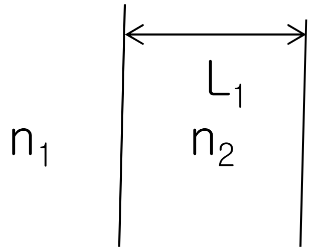


$$R = \left(\frac{n_1 - n_2}{n_1 + n_2}\right)^2 \qquad R \to 1 \text{ if } n_1 >> n_2 \text{ or } n_1 << n_2$$

Use quarter-wavelength layers

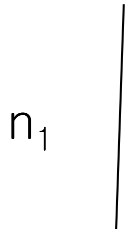


With $L_2 = \dfrac{\lambda}{4n_3}$



$$n = \frac{n_3^{\ 2}}{n_4}$$

With $L_1 = \dfrac{\lambda}{4n_2}$



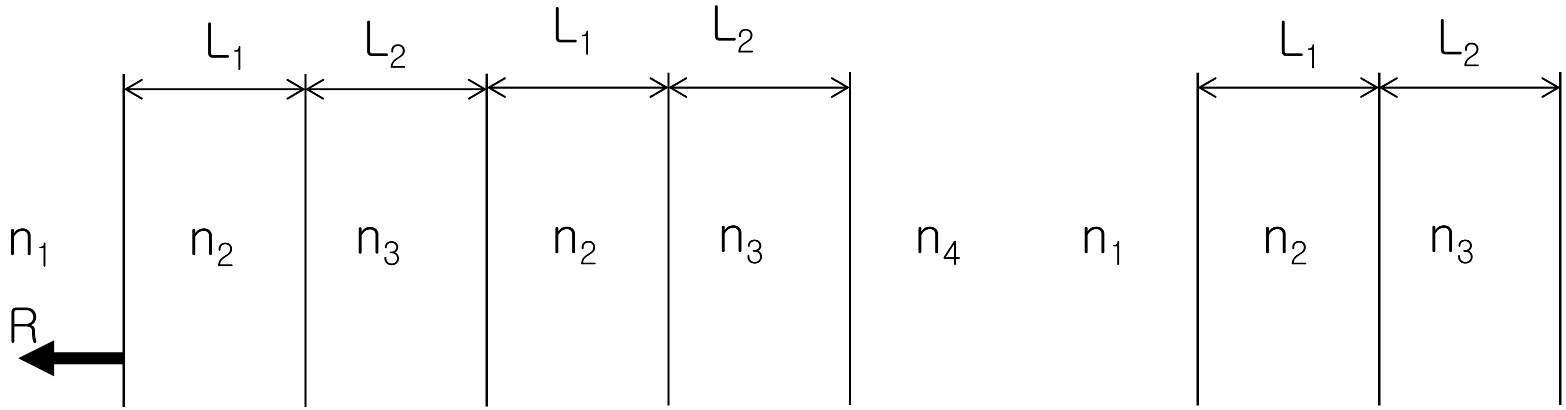
$$\frac{n_2^{\ 2}}{n_3^{\ 2}/n_4}$$

$$R = \left(\frac{n_1 - \left(\frac{n_2}{n_3}\right)^2 n_4}{n_1 + \left(\frac{n_2}{n_3}\right)^2 n_4} \right)^2$$

Lect. 8: Multiple Dielectric Interface

High-Reflection Coating

Repeat the quarter-wavelength pair



$$\frac{n_2^{\,2}}{n_3^{\,2}/n_4}$$

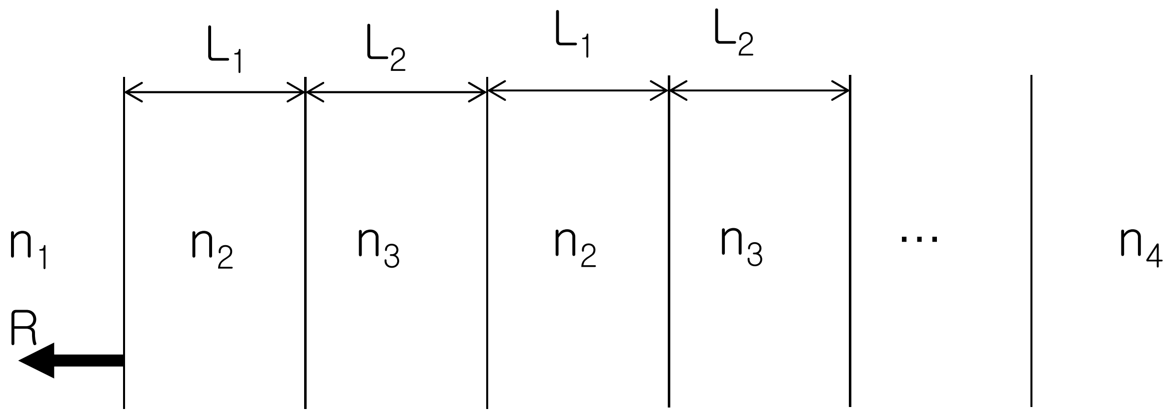
Substitute $\dfrac{n_2^{\,2}}{n_3^{\,2}/n_4}$ for n_4 in $R = \left(\dfrac{n_1 - \left(\dfrac{n_2}{n_3}\right)^2 n_4}{n_1 + \left(\dfrac{n_2}{n_3}\right)^2 n_4} \right)^2$

Then, $R = \left(\dfrac{n_1 - \left(\dfrac{n_2}{n_3}\right)^4 n_4}{n_1 + \left(\dfrac{n_2}{n_3}\right)^4 n_4} \right)^2$

Lect. 8: Multiple Dielectric Interface

High-Reflection Coating

Repeat the quarter-wavelength pair m times.



$$R = \left(\frac{n_1 - \left(\frac{n_2}{n_3}\right)^{2m} n_4}{n_1 + \left(\frac{n_2}{n_3}\right)^{2m} n_4} \right)^2$$

When m is sufficiently large,

For $n_2 > n_3$, $R \sim \left(\frac{-(n_2/n_3)^{2m} n_4}{+(n_2/n_3)^{2m} n_4} \right)^2 = 1$

For $n_2 < n_3$, $R \sim \left(\frac{n_1}{n_1} \right)^2 = 1$

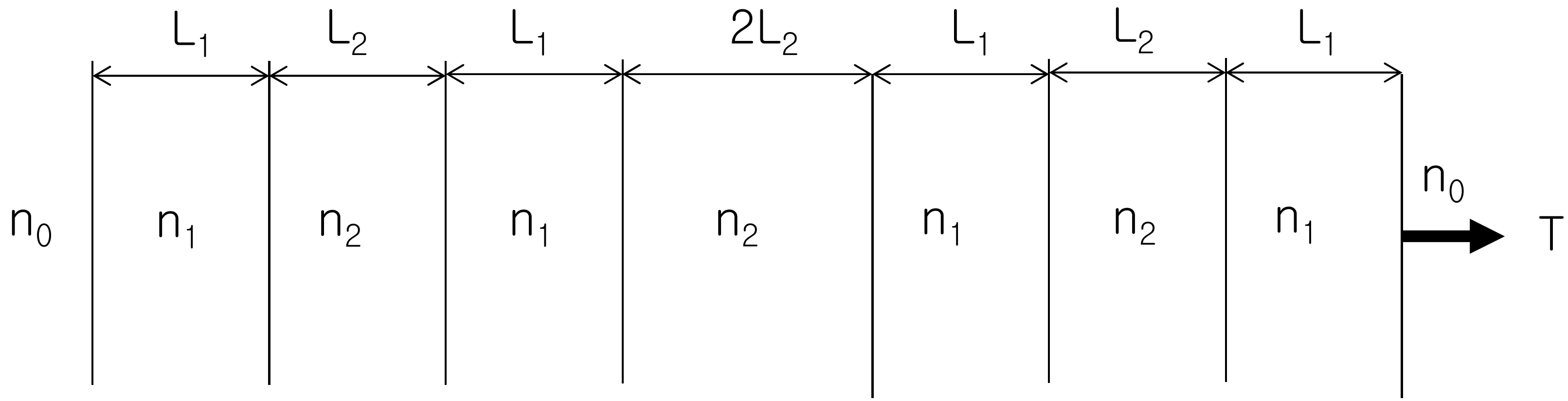
Multiple quarter-wavelength layers of two different materials

➔ Dielectric mirror with $r = 1$ or -1

Lect. 8: Multiple Dielectric Interface

Homework:

Determine T for the following multiple dielectric layers.



$$n_1 = 1.35,\ n_2 = 2.3,\ L_{1,2} = \frac{\lambda}{4n_{1,2}}$$