Optical Interference

- Wave nature of light results in optical interference
- Consider two plane wave sources of same wavelength
- Where wave crests/troughs add get constructive interfrence
- e.g. Waves A & B below
- Where crests/troughs opposite get destructive interference
- e.g. Waves A & C below

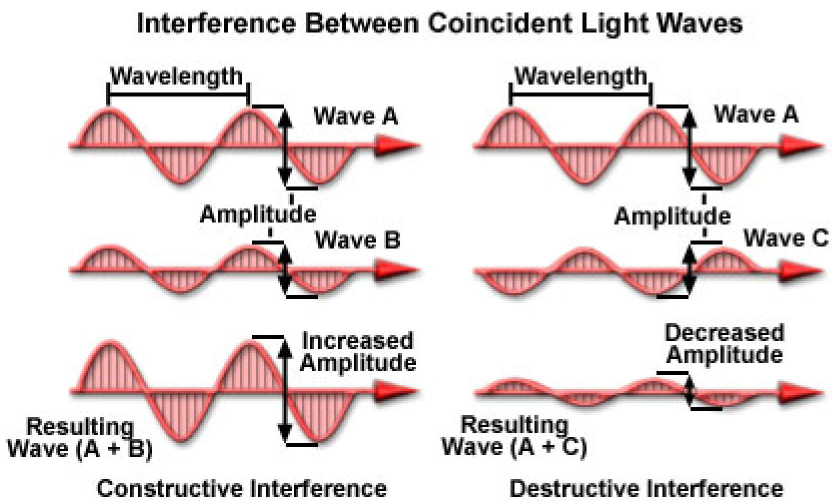
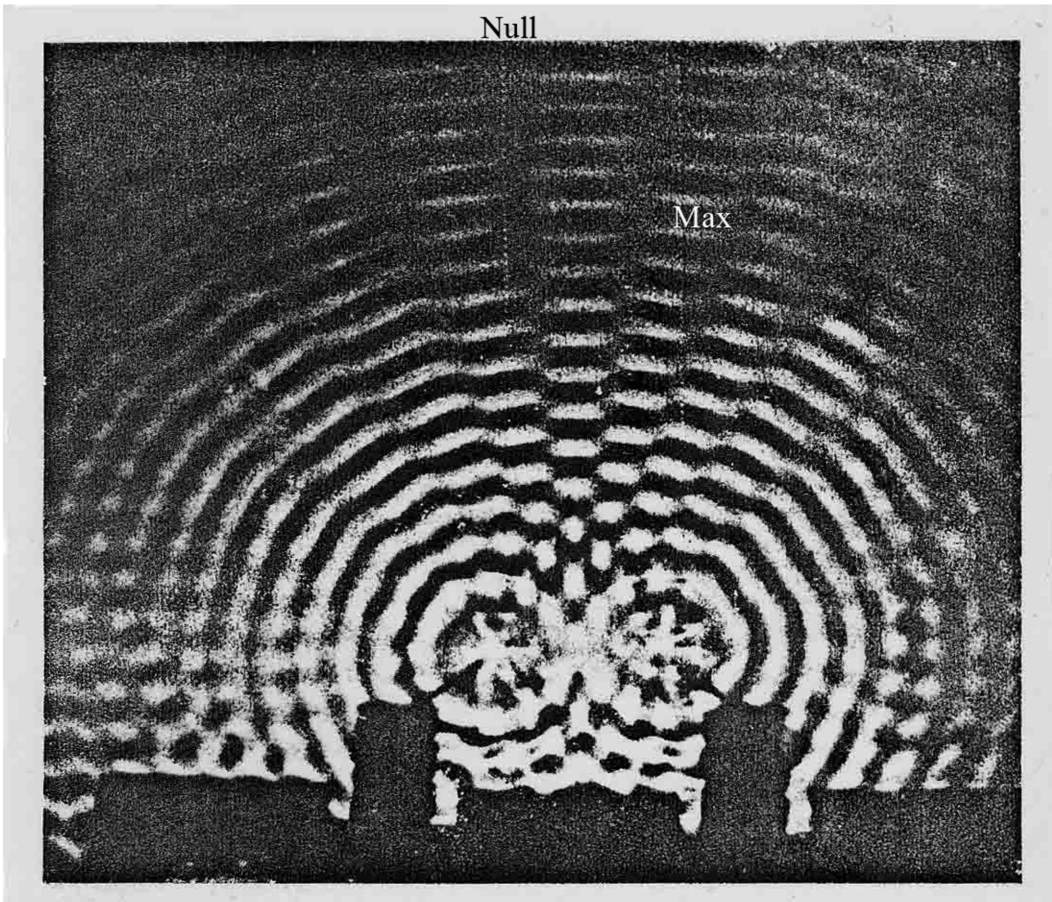


Figure 1

Nulls & Crests

- Where waves cancel get nulls – areas with no waves
- Where add get crests
- Many optical effects created by this.



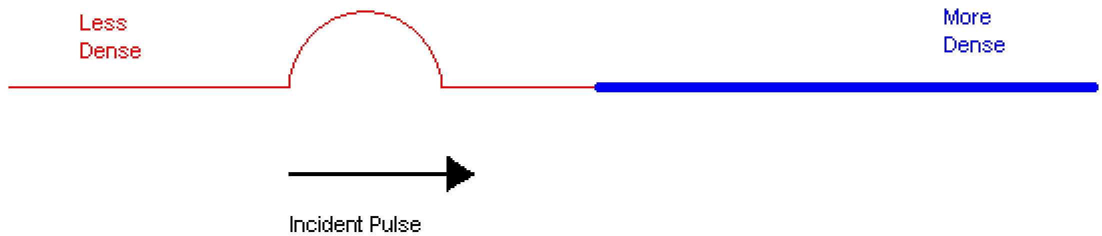
Wavelength and Coatings

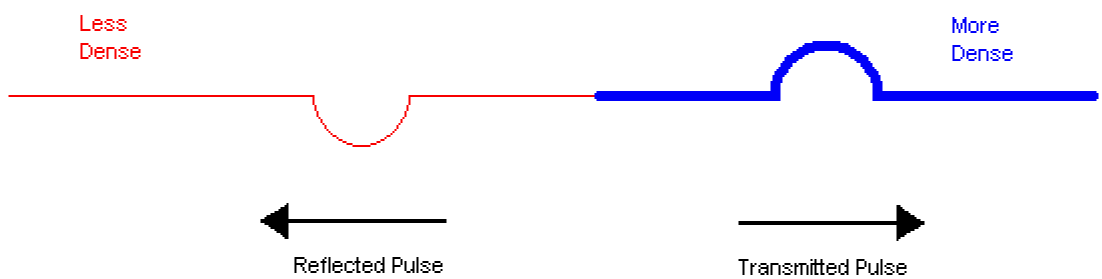
Consider a thin dielectric film $n_o << n_c$

Inverting reflection from low index n_o to a high n_c

Non-Inverting reflection from high index n_c to low

Thus interference is going to depend on what you reflect from





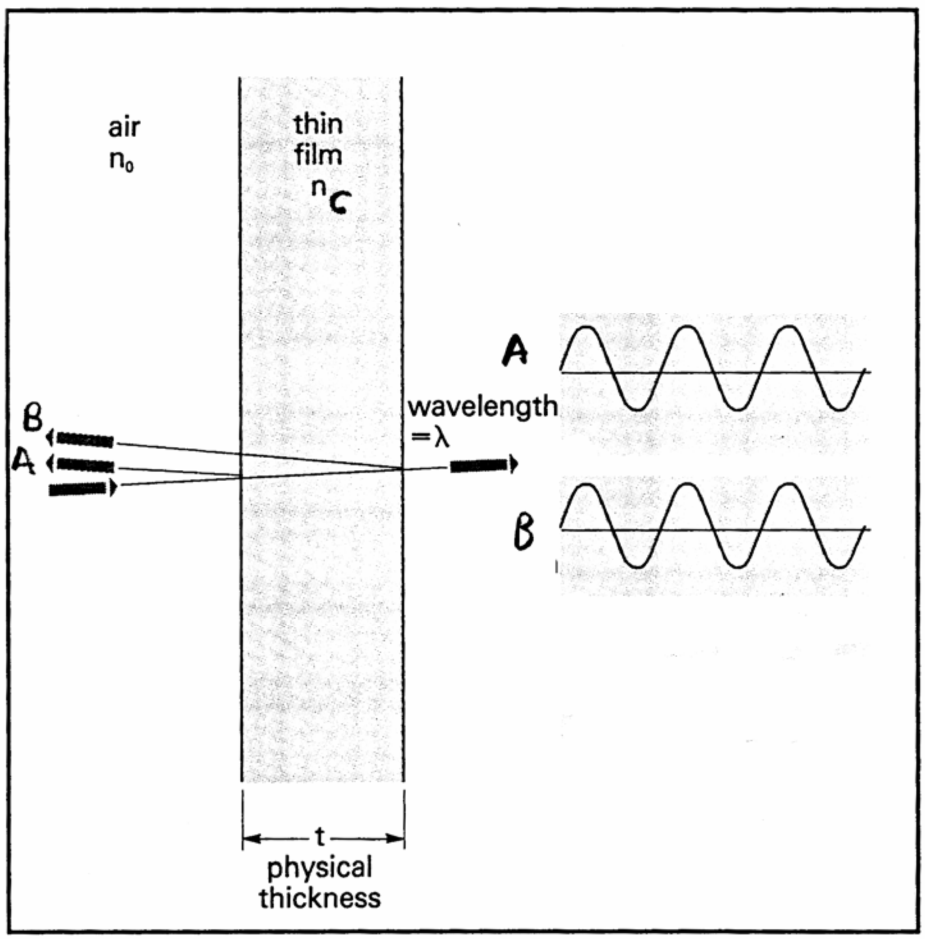
Inference in Thin Films

- Consider film of thickness

$$n_c t = \frac{\lambda}{4}$$

where t is the film thickness

- Result is a ½ wavelength path
- First surface: inverting reflection from low index n_o to a high n_c
- Back surface: Non-Inverting reflection from high index n_c to low
- Result is constructive interference



Wedge Interference

- Consider a wedge of 2 glass slides with space in between
- Thickness few wavelengths
- Illuminate with a monochromatic light source (e.g. laser)
- Bottom surface: inverting reflection from low index n_o to a high n_c
- Front surface: Non-Inverting reflection from high index n_c to low
- Goes through destructive interference when

$$t = \frac{(2j+1)\lambda}{4}$$

- Where j is an integer >=0
- Creates parallel lines of bright and nulls space by $\lambda/2$
- If measure horizontal distance between nulls get slope

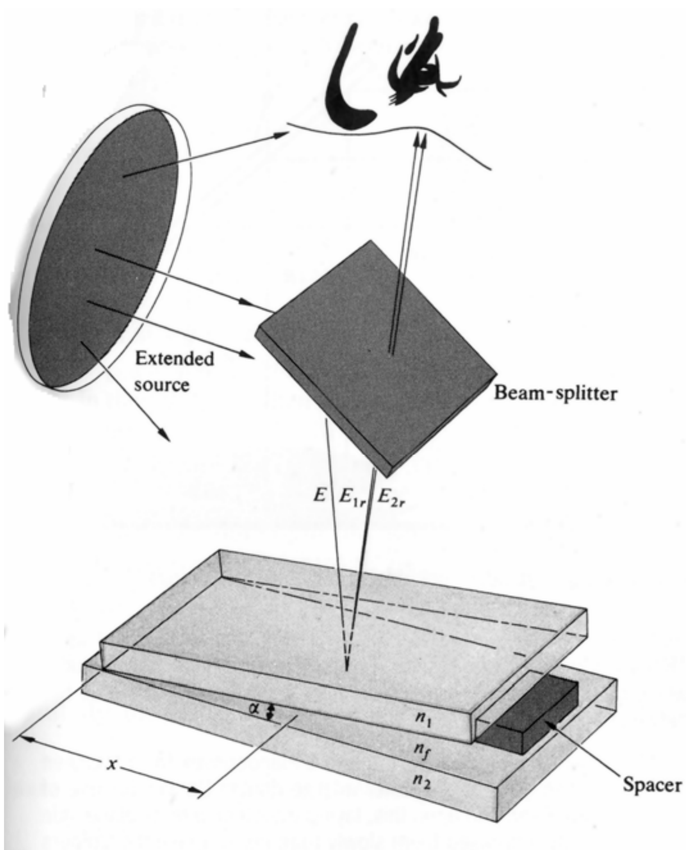


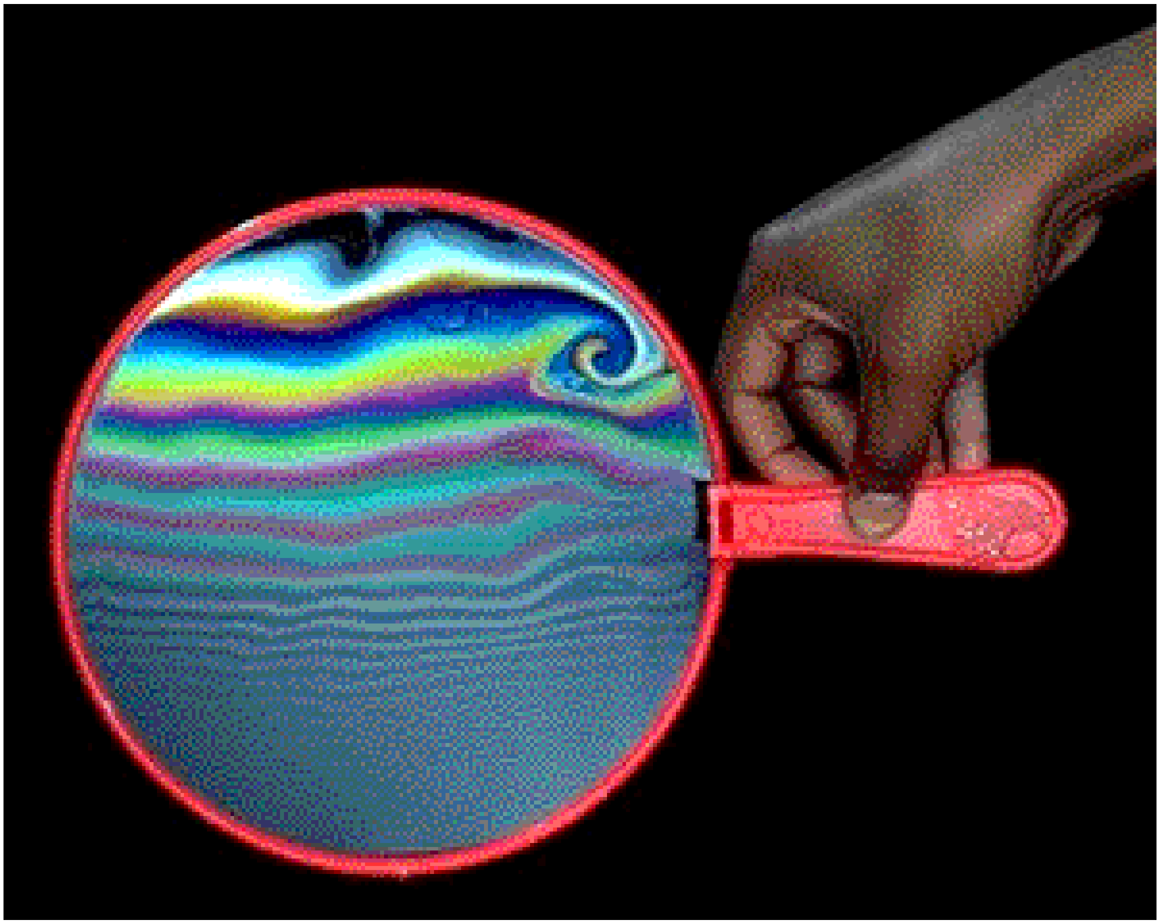
Figure 9.22 Fringes from a wedge-shaped film.

Soap Bubbles

- In soap bubbles film changes thickness from thin (top)
- to thick bottom
- Thickness few wavelengths
- As wavelengths go through constructive interference see that colour

$$n_c t = \frac{(2j+1)\lambda}{4}$$

- Where j is an integer >=0
- Get a spectrum as each colour hits max



Newton's Rings

- Now put lens on flat plat and illuminate with monochromatic light
- Get Newton's Rings: circles of light
- Consider a lens of Radius of Curvature R
- Let x = distance from center
- Let d = distance between lens surface and plate
- Now relationship between these is

$$x^2 = R^2 - (R-d)^2 \approx 2Rd$$

- Since R>>d
- Thus the mth order maximum occurs when

$$2d_m = \left(m + \frac{1}{2}\right)\lambda$$

- And the position of the mth bright ring is

$$x_m = \sqrt{\left(m + \frac{1}{2}\right)\lambda R}$$

- And the dark ring is at $x_m = \sqrt{m\lambda R}$

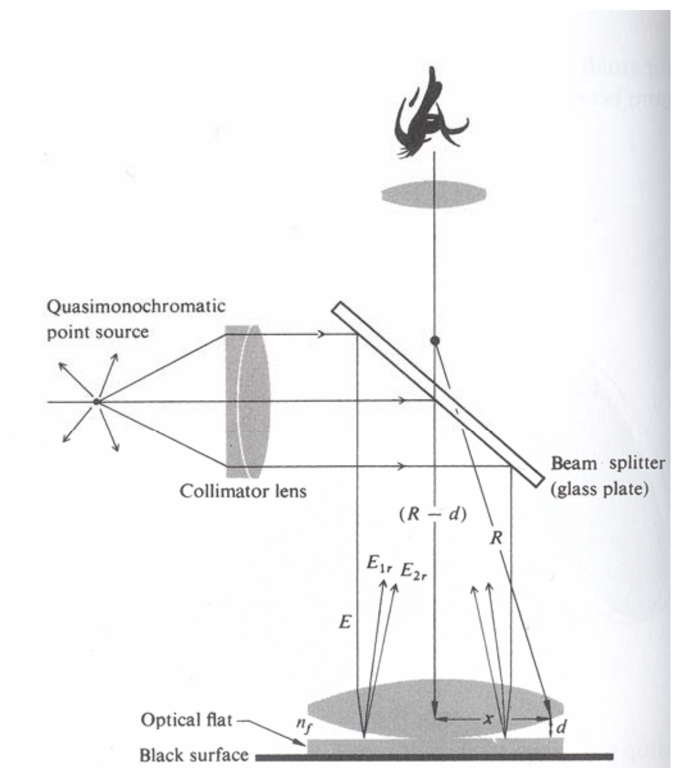
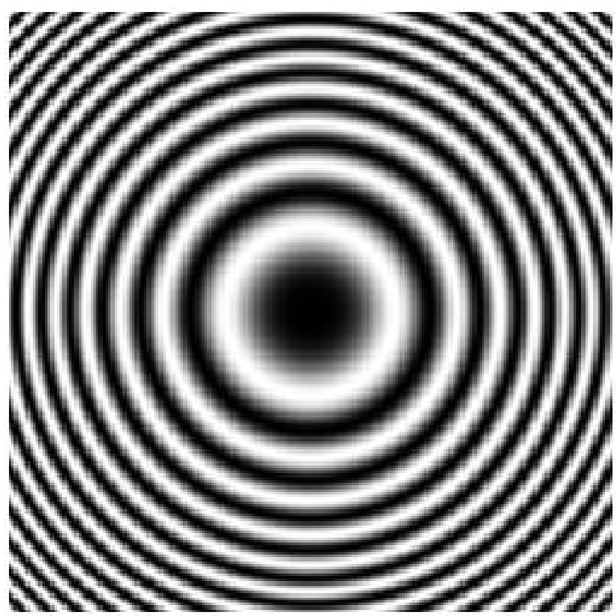


Figure 9.23 A standard setup to observe Newton's rings



Quarter Wavelength Coatings

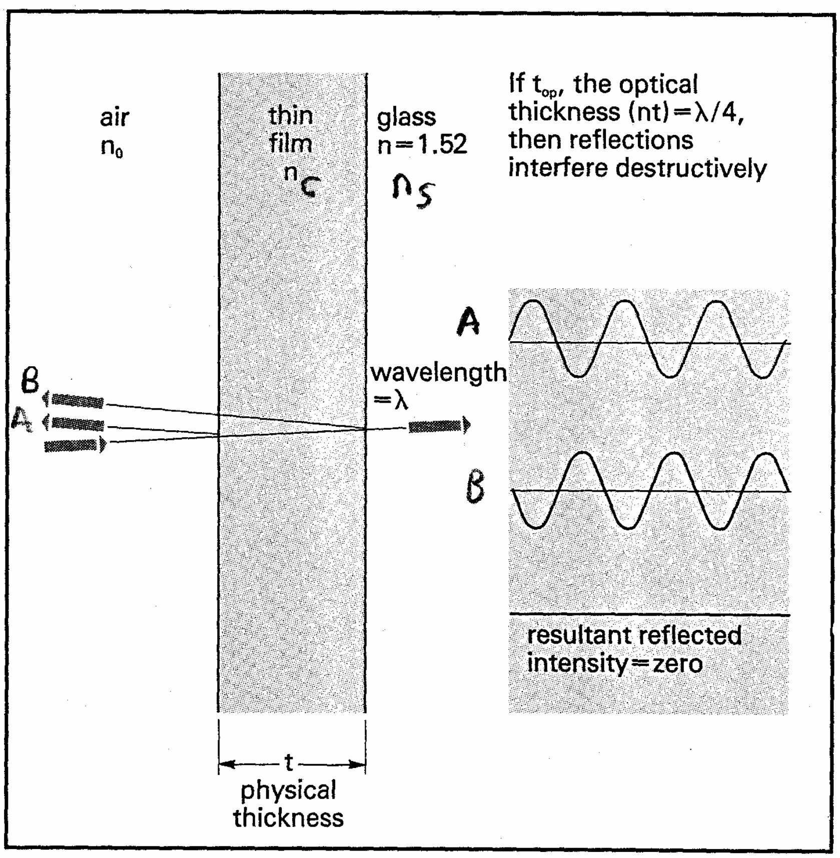
- Thin dielectric layers on substrate
- $n_o << n_c << n_s$
- Inverting reflection from low index n_o to a high n_c
- Non-Inverting reflection from high index n_c to a high n_s
- Destructive interference of waves due to added path when

$$n_c t = \frac{\lambda}{4}$$

where t is the film thickness

- Called Anti-reflection (AR) Coating
- Equal reflections (full compensation) when

$$n_c = \sqrt{n_s}$$



SCHEMATIC REPRESENTATION of a single layer anti-reflection coating.

Enhanced Dielectric Mirrors

- If have multiple layers of alternating high/low index
- Enhanced Reflectance (ER) Coating

$$R = \frac{(1-p)}{(1+p)}$$

$$p = \left(\frac{n_h}{n_l}\right)^{N-1}\left(\frac{n_h^2}{n_s}\right)$$

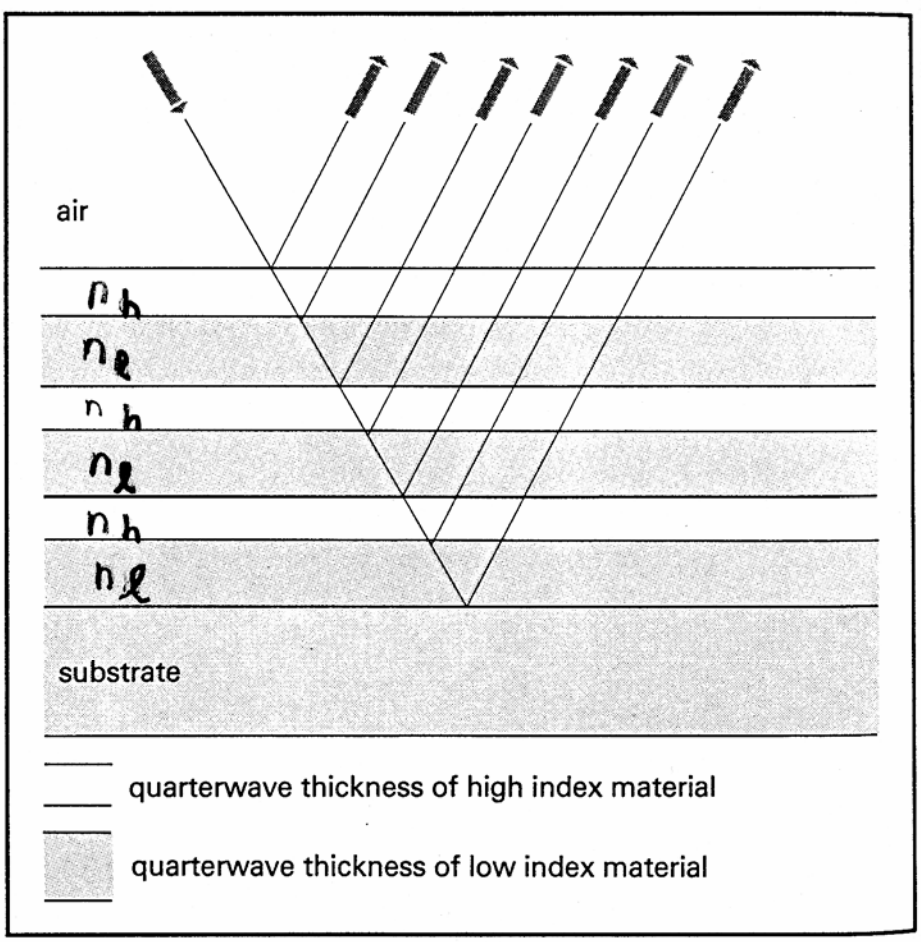
where n_s = substrate index

n_h = high index layer

n_l = low index layer ($n_o >> n_l << n_s << n_h$)

N = number of layers

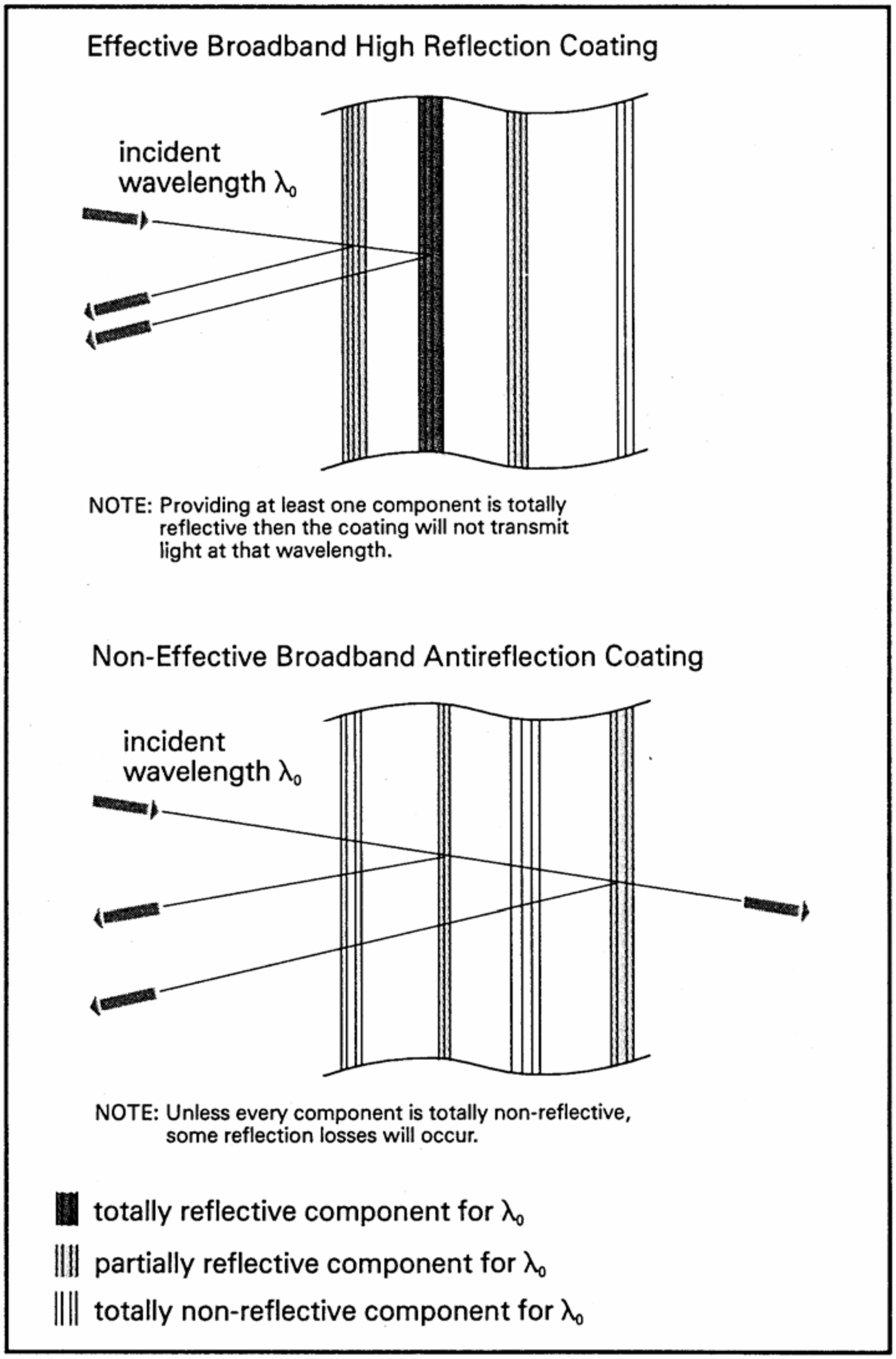
- Much higher power 1000 W/cm^2 CW, 0.5 J/cm^2 10 nsec pulse



A SIMPLE QUARTERWAVE STACK.

Broadband ER Mirrors

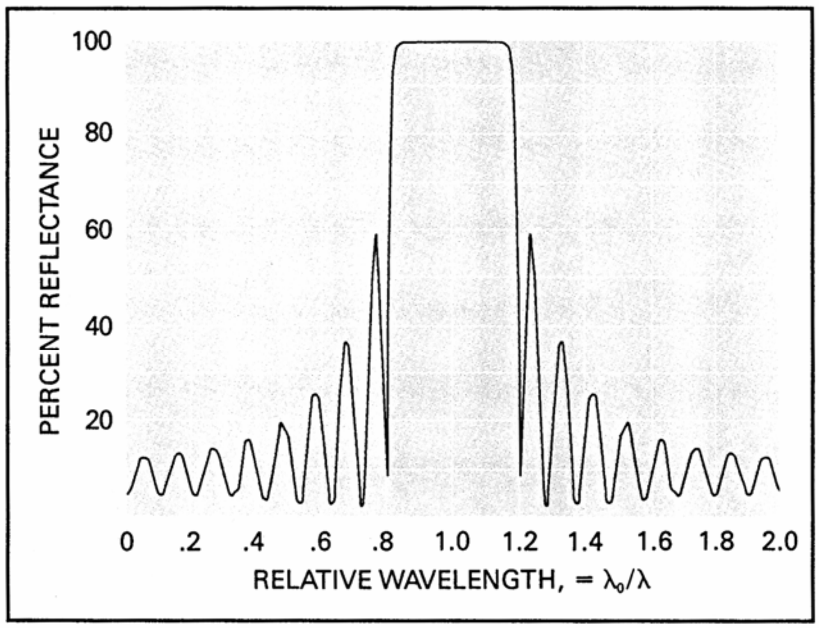
- Can broaden width of reflectance stack
- Make two stacks tuned to different wavelengths
- Alternately modify layer thicknesses to tune



SCHEMATIC MULTICOMPONENT COATINGS with only one component exactly matched to the incident wavelength, λ_0.

Broadband Dielectric Mirrors

- Important for lasers that emit many wavelengths eg Argon from 514 nm to 400 nm
- Note: different coatings for 45^o or perpendicular
- Mirrors Degrade with organic coats
- Must be cleaned with solvent eg acetone



TYPICAL REFLECTANCE CURVE of an unmodified quarter-wave stack.