CAS PY 106

InClass Note 33

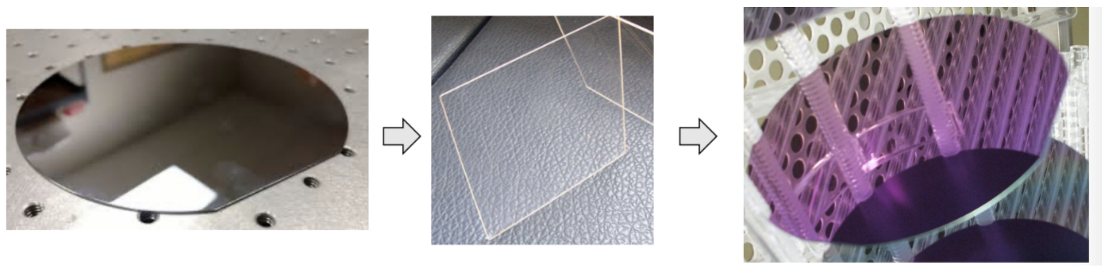
1. Light as an electro (E) magnetic (B) wave
    a. Electromagnetic waves do not require a medium in which to travel (unlike sound waves)
    b. Light has no mass but has momentum in the form of energy
    c. Energy can be measured by its intensity (power per unit area)
    d. Light from the sun, e.g., is unpolarized and can be polarized
    e. EM waves can change direction when they hit matter (scattering or specular reflection)
    f. We see a green tree because the energy of blue wavelengths in the visible spectrum is absorbed by chlorophyl, green wavelengths reflect back to our eyes; we exploit reflection with mirrors to create images
    g. Light can be transmitted through dense material, refracting; it slows down and wavelength decreases; if we change the angle in which light hits the medium we can bend its direction; lenses exploit this bending, focusing light to create images
    h. Smaller wavelengths have larger refractive indices, so smaller wavelengths (blues, 450 nm) bend more than larger wavelengths (reds, 650 nm); dispersion allows us to see, for example, rainbows!
    i. Like reflecting mechanical waves in 1D lead to constructive and destructive interference, i.e., standing waves, waves can interfere in 2D, including light creating interference and diffraction patterns

2. Thin Films

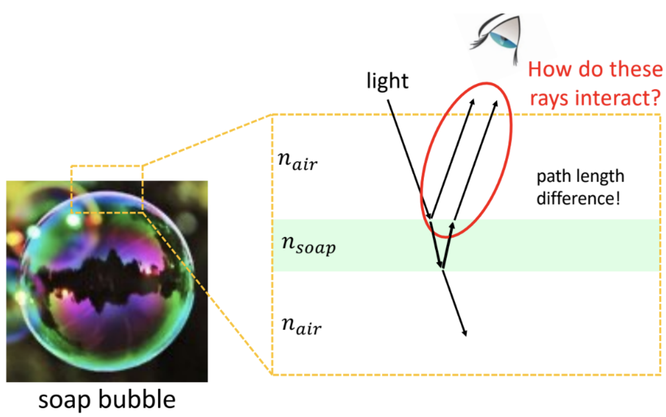
    a. Polished silicon is gray

    b. Coat with a thin player of colorless glass

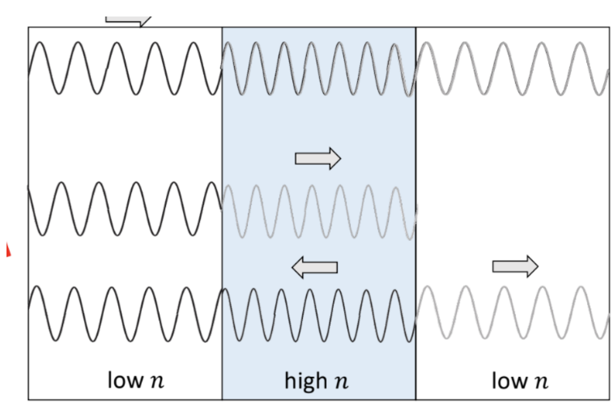
    c. It becomes purple?

    d. 

3. Light hits an interface of refractive indices

    a. 

4. Reflection off of a thin refractive interface

    a. 

b. The kind of interference depends on the path length difference of the two reflected waves

5. Back to soap bubble

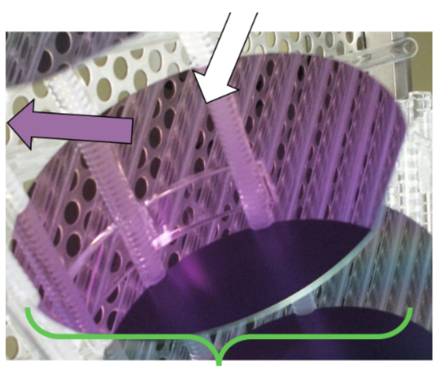
a. 

b. White light shines on the bubble

c. Certain wavelengths destructively interfere, leading to reflected light having distinct colors

d. Thickness variations in the soap layer lead to different colors

6. The silicon water

a. 

b. White light comes in

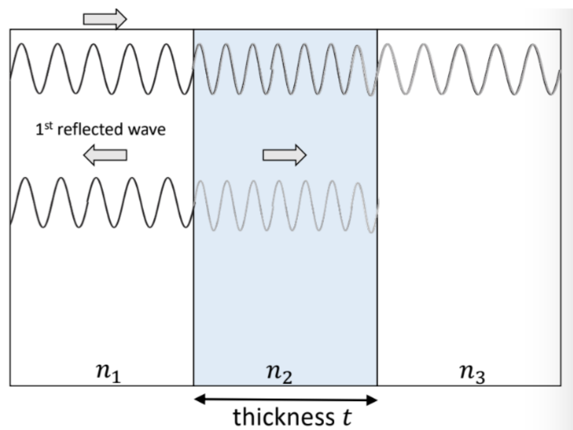
c. Destructive interference occurs for certain wavelengths reflecting off the thin glass film

d. Uniformity in thickness leads to a single color, unlike the soap bubble

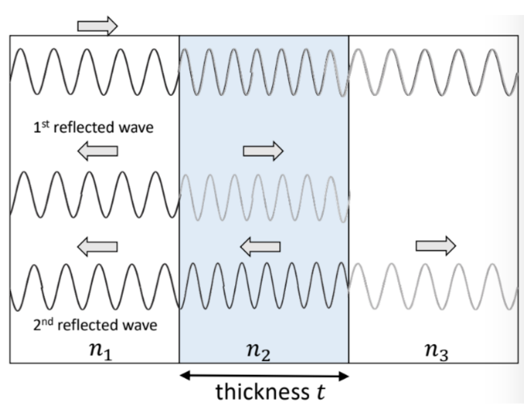
e. This is why, even though glass is transparent, if you make a very thin layer of it, thin film interference will create colors!

7. Thin films - the five-step method

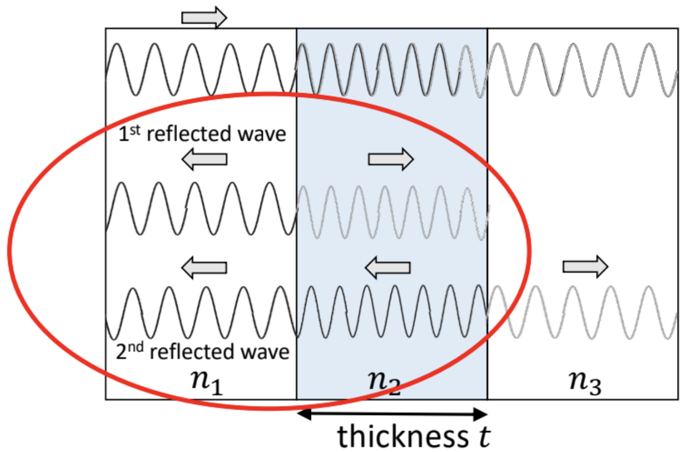
   a. Step 1 - Determine delta t, the shift for the wave reflecting from the top surface of the film

      - If n2 > n1, delta t = wavelength /2, 180 degrees phase shift
      - If n2 < n1, delta t = 0, no phase shift
      - 

   b. Step 2 - Determine delta b, the shift for the wave reflecting from the bottom surface of the film. We have at least 2t, from the extra distance traveled

      - If n3 > n2, delta b = 2t + wavelength/2, 180 degrees phase shift
      - If n3 < n2, delta b = 2t, no phase shift
      - 

c. Step 3 - find the effective path-length difference, delta L



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d. Step 4 - Bring in the appropriate interference condition, depending on the situation:

- Constructive interference: $$\Delta L = m\lambda_{film}$$
- Destructive interference: $$\Delta L = \left(m + \frac{1}{2}\right)\lambda_{film}$$

e. Step 5 - Solve the resulting equation

- The solution generally connects the thickness, t, of the film to the wavelength of the light in the film, such that: $$\lambda_{film} = \frac{\lambda_{vacuum}}{n_{film}}$$