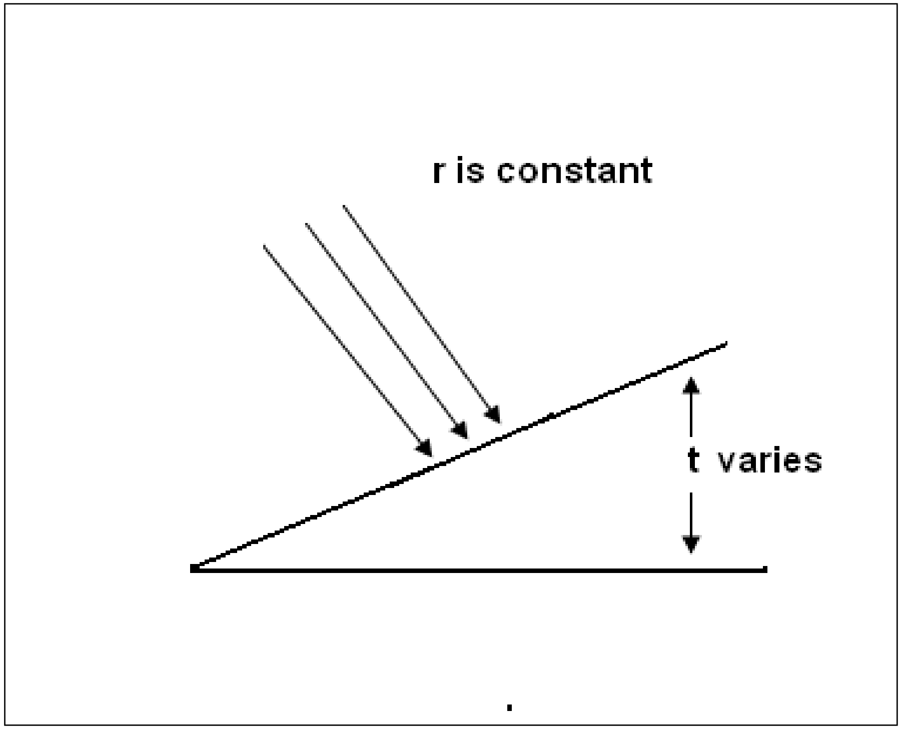
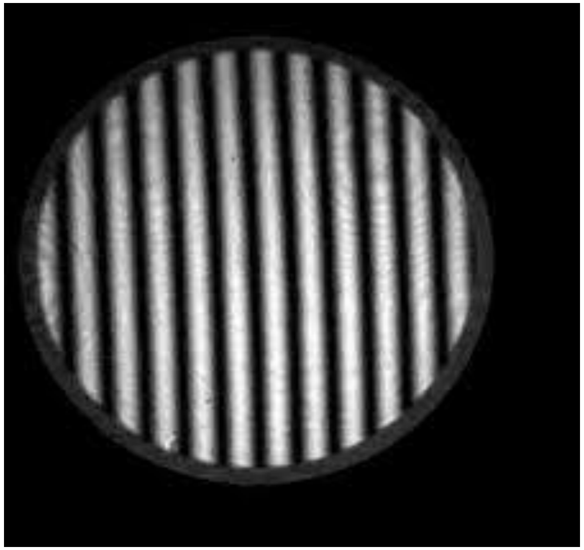
# Interference of
# Light Wave Optics

# Fizau's and Haindinger's fringes:

**The systematic and gradual variation of path difference requires to produce an interference pattern.**

**Either $t$ should vary by keeping $r$ same or vice versa.**



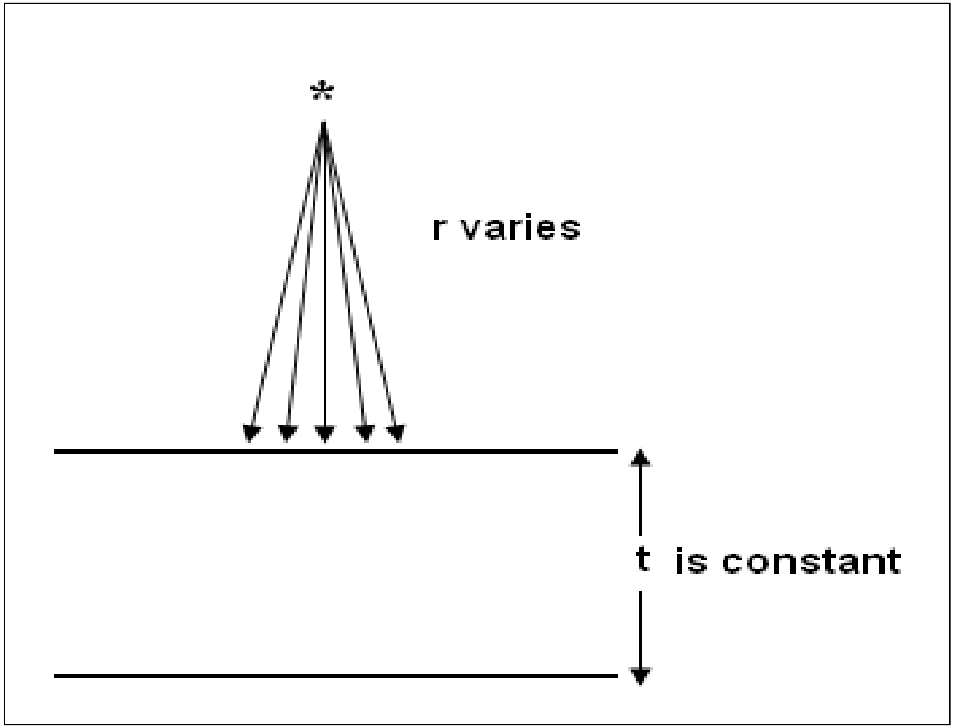



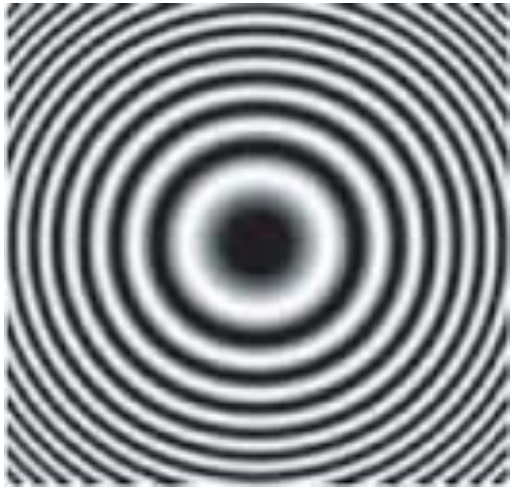
***t* increases gradually *r* remains the same and the wavefront is parallel**.

P.D. and the change in the intensity of the fringe occurs in horizontal $(X)$ direction.

As the thickness gradually increases, the p.d. gradually acquires the values starting from $\frac{\lambda}{2}$ and then $\lambda$, $3\frac{\lambda}{2}$, $2\lambda, 5\frac{\lambda}{2}$, $3\lambda, 7\frac{\lambda}{2}$ and so forth.

Dark and bright fringes occur alternatively. **These fringes, which are parallel to the edge of the film, equidistant, and in the horizontal plane, are referred as Fizau's fringes.**



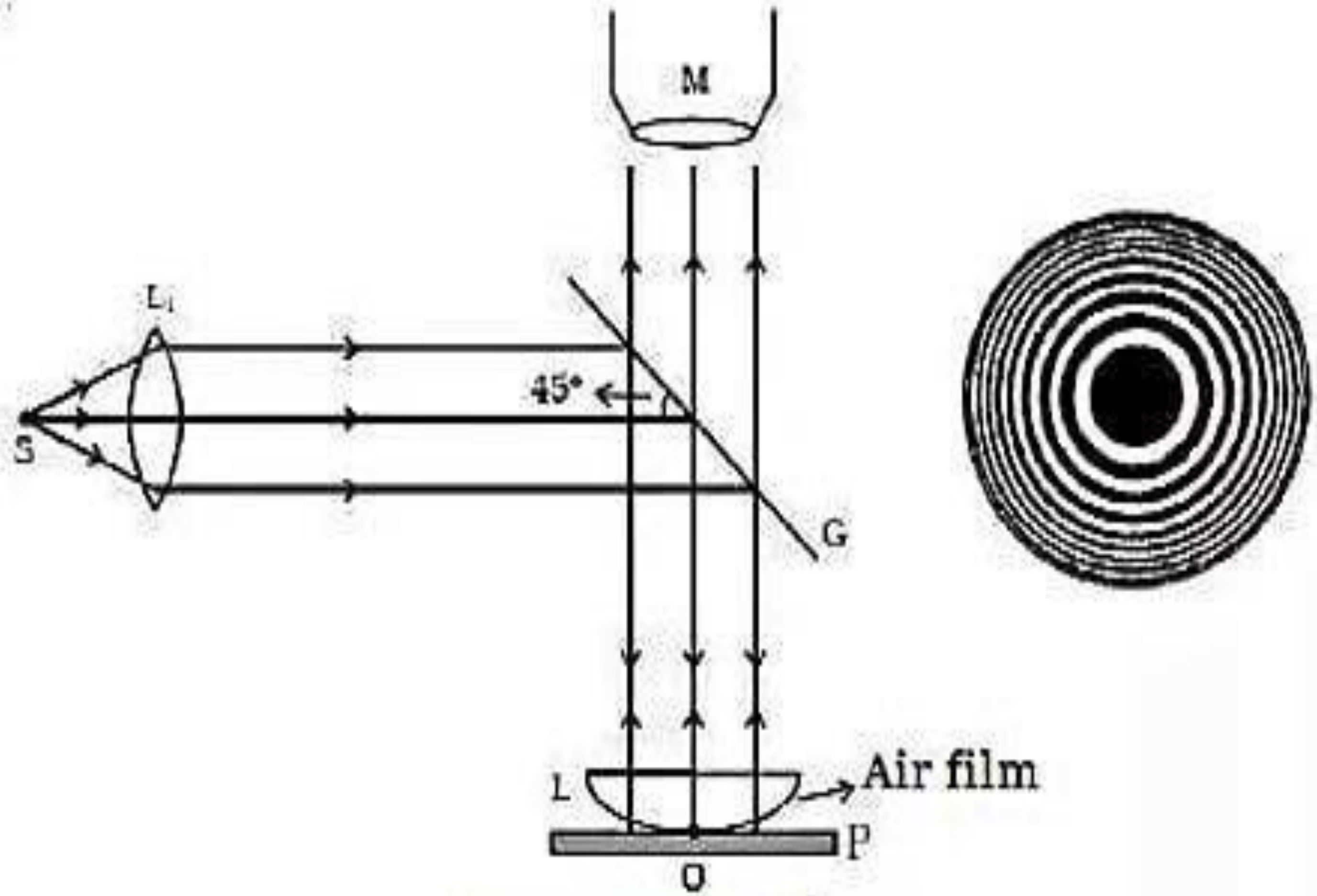
The source emits a spherical wavefront and thus the rays are incident on the film along various cones.

For each cone, **r** remains constant over a circle.

PD remains constant over a circle.

Owing to this circular symmetry, if observed from the top, the fringes will appear concentric and circular. This are referred as **Haidenger's fringes.**

# NEWTON'S RINGS (NEWTON'S INTERFEROMETER)




*Newton's Rings*

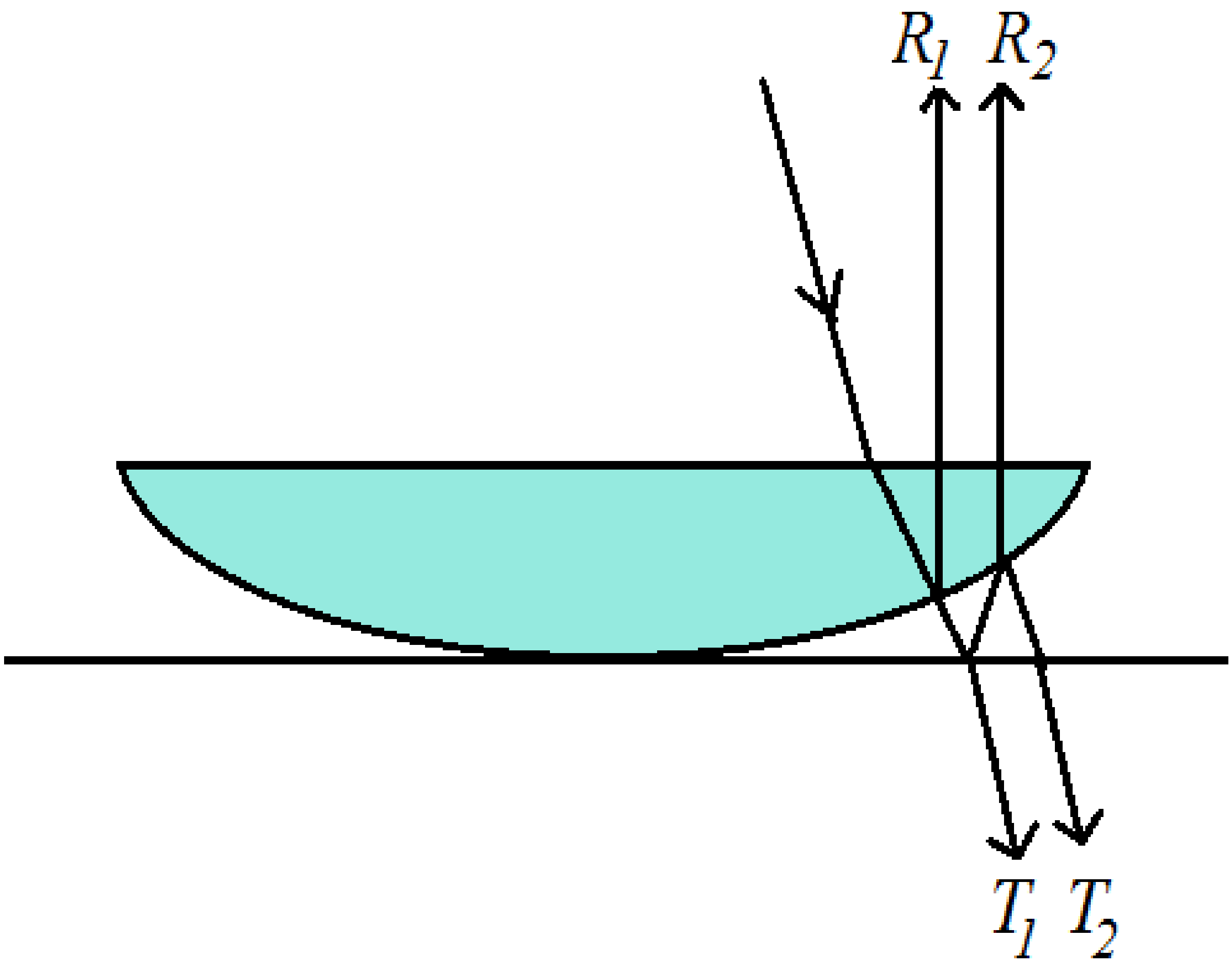


*fig.* Transmitted rays and reflected rays in Newton's rings

**The film involved here is a special case of wedge shaped films**

**Thus,**

$$P.D._{I,II} = 2\mu t\cos(r+\alpha) \pm \frac{\lambda}{2}$$

**By the above equation, it is possible to derive the relations between -**

**The radius of curvature of the plano-convex lens,**

**The wavelength of source,**

**The refractive index of the medium**

**Diameter of the Newton's rings.**

**Diameter of the Newton's rings**

$$\boxed{D_n^2 = \frac{4Rn\lambda}{\mu}}$$

$$\boxed{D_n = \sqrt{\frac{4Rn\lambda}{\mu}} = \sqrt{\frac{2R\lambda}{\mu}}\sqrt{2n}}$$

$$\Rightarrow D_n \propto \sqrt{2n}$$

## Similar derivation for the m^th Bright Ring

$$\boxed{D_m = \sqrt{\frac{2R\lambda}{\mu}}\sqrt{(2m \pm 1)}}$$

$$\Rightarrow D_m \propto \sqrt{(2m \pm 1)}$$

**Radius of curvature of the plano-convex lens**

$$\boxed{R = \frac{\mu\left(D_m^2 - D_n^2\right)}{4(m-n)\lambda}}$$

$$\boxed{\mu = \frac{D_m^2 - D_n^2}{D_m^{2'} - D_n^{2'}}}$$

**Refractive index of the medium**

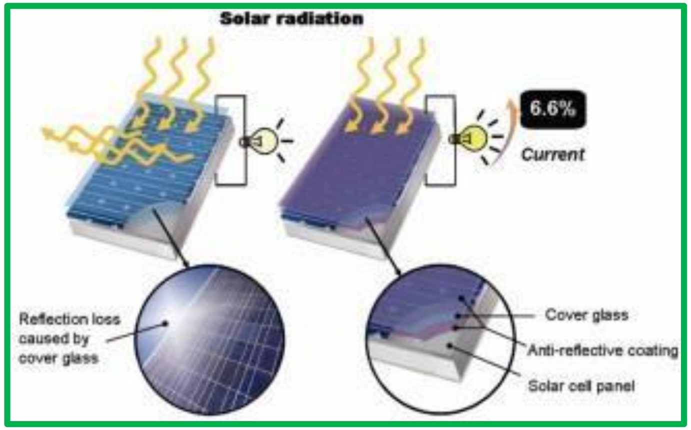
**Optical coatings** are used **to enhance the transmission, reflection, or polarization properties of an optical component.**

Due to Fresnel reflection, as light passes from air through an uncoated glass substrate approximately 4% of the light will be reflected at each interface. This results in a total transmission of only 92% of the incident light.

An anti-reflection coating could be applied to reduce the reflection at each surface to less than 0.1% and a highly reflective dielectric coating could also be applied to increase reflectivity to more than 99.99%.

An optical coating is composed of a combination of thin layers of materials such as **oxides, metals, or rare earth materials**. The performance of an optical coating is dependent on the number of layers, their thickness, and the refractive index difference between them.

# INTERFERENCE COATINGS (ARC)



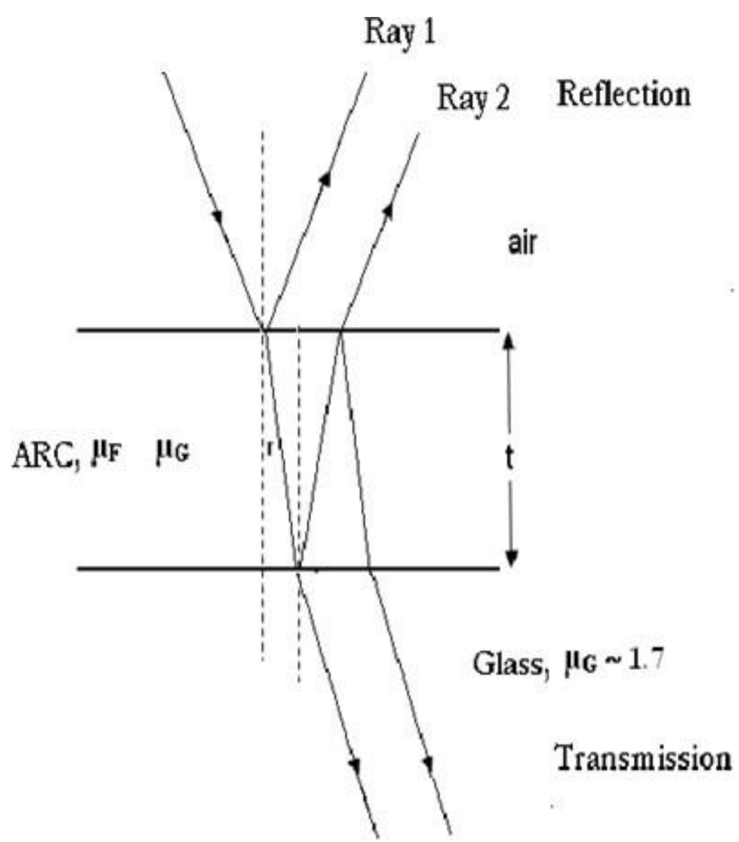

# Anti-Reflection Coatings (ARC)

$$PD_{R,I,II} = 2\mu t\cos r \pm \frac{\lambda}{2}$$

$$PD_{I,II} = 2\mu t\cos r = (2n \pm 1)\frac{\lambda}{2}$$

**If the film is thin enough, we can safely assume $n \approx 0$ and r $\rightarrow$ 0**

$$\boxed{t_{ARC} = \frac{\lambda}{4\mu}}$$



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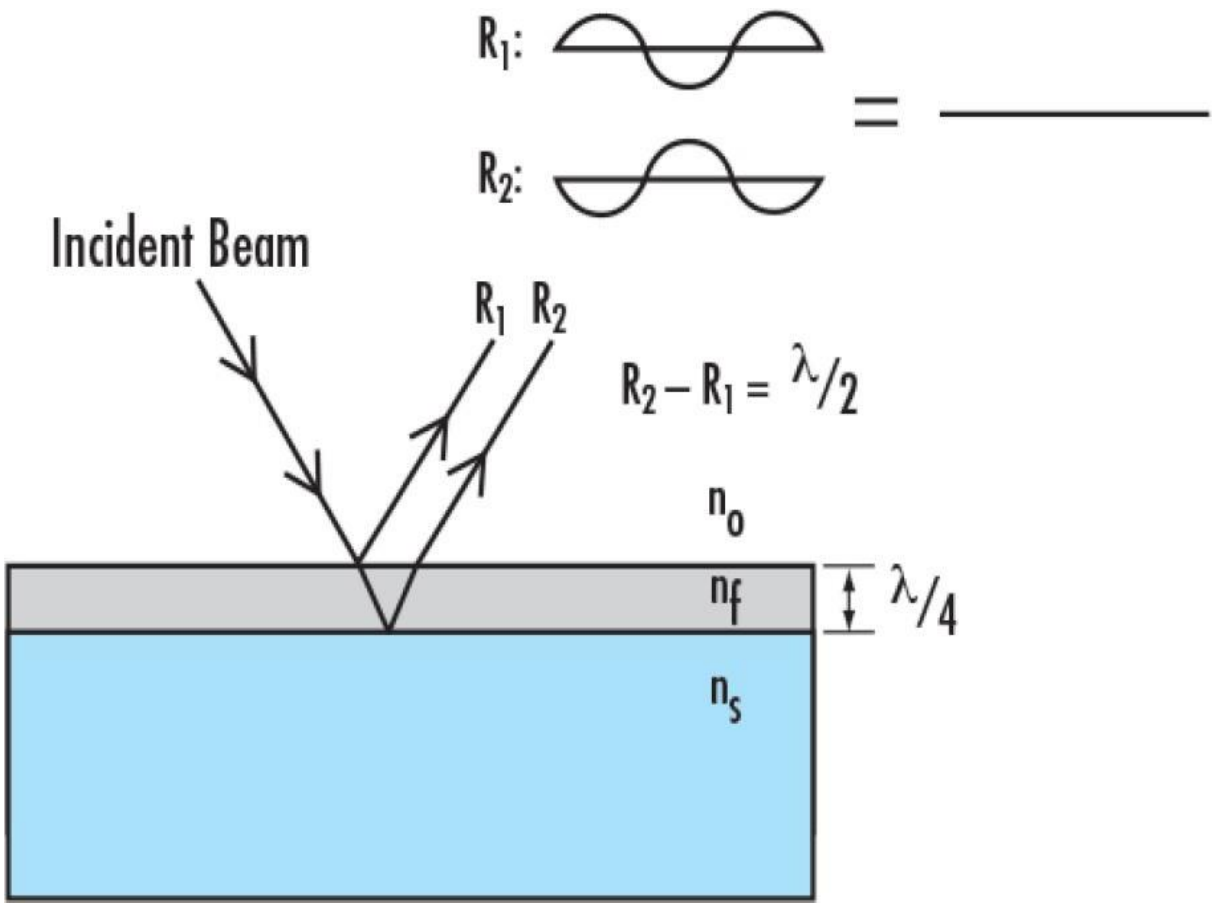


# INTERFERENCE COATINGS (HRC/ATC)


Dielectric HR coatings reflect light based on constructive interference during Fresnel reflections and have the complete opposite purpose of AR coatings and utilize constructive interference to maximize Fresnel reflections instead of utilizing destructive interference to minimize them.

The constructive interference is caused by alternating

layers of a high and low refractive index materials

with thicknesses specifically chosen to maximize reflectivity

at a given wavelength range.

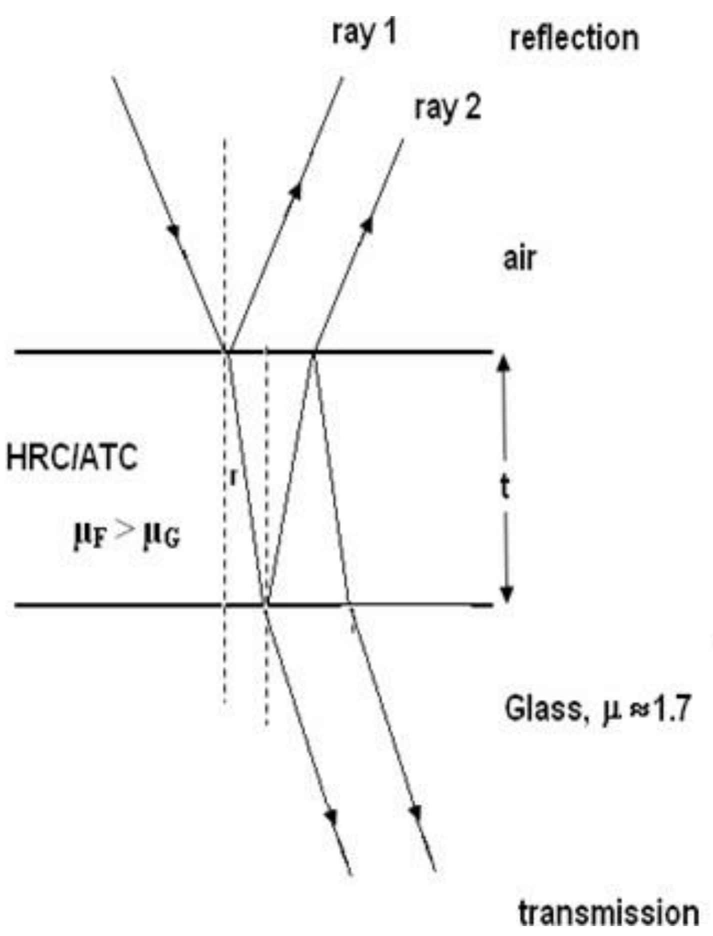
# High Reflection Coatings/Anti Transmission coatings (HRC/ATC)

$$PD_{I',II'} = 2\mu t\cos r \pm \frac{\lambda}{2} = n\lambda$$

$$2\mu t\cos r = (2n \pm 1)\frac{\lambda}{2}$$

For thin films, it is safe to assume **n ≈ 0**. Generally, the incident ray passes close to normal. Thus $r \to 0$

$$\boxed{t_{HRC/ATC} = \frac{\lambda}{4\mu}}$$



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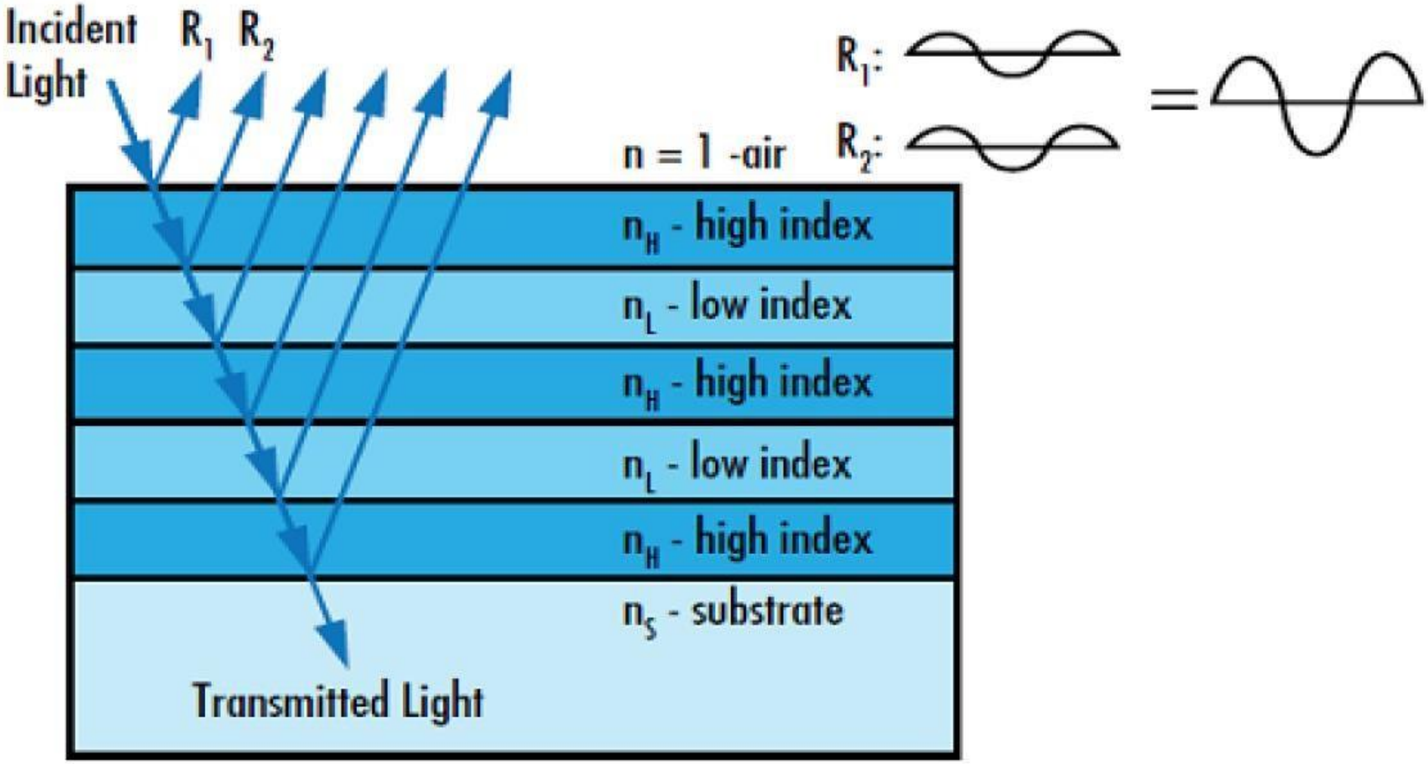

# Thank you