THEORY OF MULTILAYER FILM

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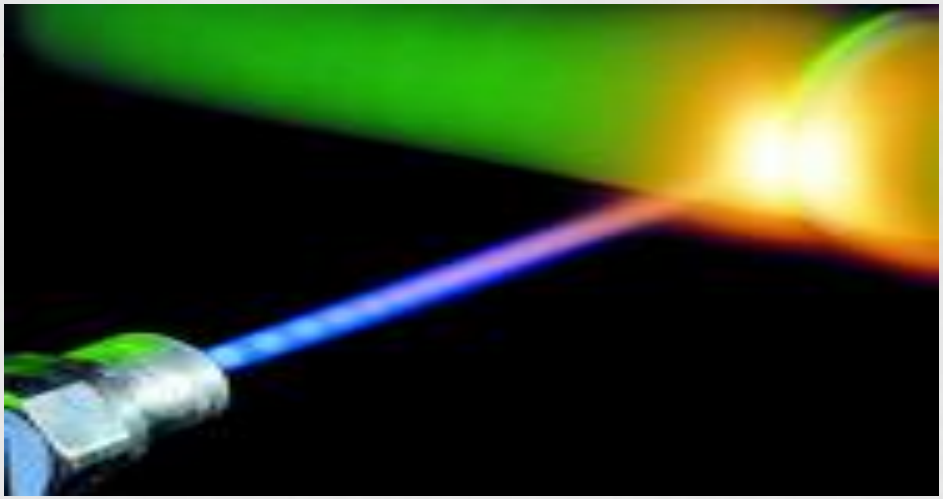
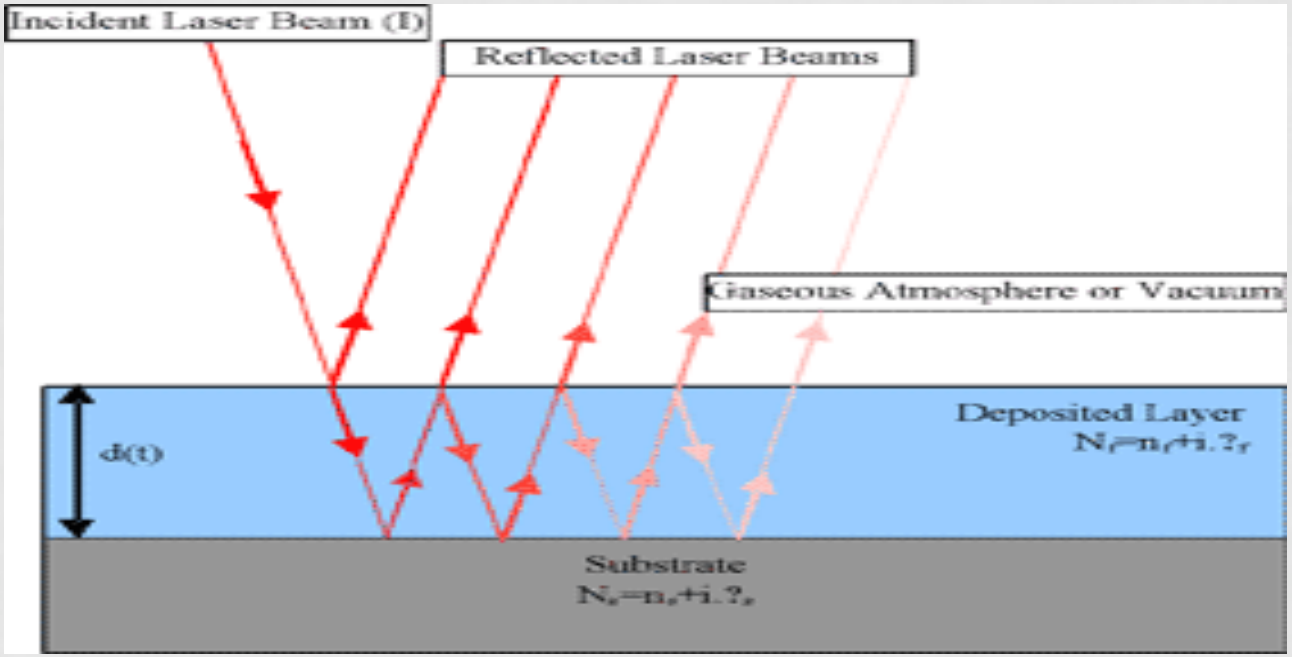
THE DESIGN



Nd (neodymium-doped): YAG

λ = 1.064 μm

THIN FILM AND INTERFERENCE



Constructive interference: $\Delta = m\lambda = 2nt$

Destructive interference: $\Delta = (m + \frac{1}{2})\lambda = 2nt$

TRANSFER MATRIX

$$\begin{bmatrix} E_a \\ B_a \end{bmatrix} = \begin{bmatrix} \cos\delta & (i \sin\delta / \gamma_i) \\ (i \gamma_i \sin\delta) & \cos\delta \end{bmatrix} \begin{bmatrix} E_b \\ B_b \end{bmatrix}$$

$$\begin{bmatrix} E_a \\ B_a \end{bmatrix} = M_T \begin{bmatrix} E_n \\ B_n \end{bmatrix} \quad \text{where } M_T = M_1 M_2 M_3 \ldots M_N$$

TRANSFER MATRIX AND REFLECTION COEFFICIENT

$$M_T = \begin{bmatrix} m_{11} & m_{12} \\ m_{21} & m_{22} \end{bmatrix}$$

$$(1)\quad r = \frac{(\gamma_o m_{11} + \gamma_o \gamma_s m_{12} - m_{21} - \gamma_s m_{22})}{(\gamma_o m_{11} + \gamma_o \gamma_s m_{12} + m_{21} + \gamma_s m_{22})}$$

KEY TASK

Assumptions: i) Laser beam is incident normally.
ii) Film thickness must be $\lambda/4$.

1) Determine the refractive indices we need.

2) Determine the corresponding thickness.

NAME OF THE GAME

$$R = \frac{(n_o n_2^2 - n_s n_1^2)^2}{(n_o n_2^2 + n_s n_1^2)^2}$$

(normal incidence)

(quarter-wave thickness)

(2) $n_2 / n_1 = \sqrt{(n_s / n_o)}$

CHOOSE COATING MATERIAL

- $\sqrt{(n_s / n_o)} = 1.233$
- [Ge] $n_2 = 4$
- [Si] $n_1 = 3.3$
- $(n_2 / n_1) = 1.212$

DETERMINE FILM THICKNESS

- $\lambda_f = \lambda_o / n_f$ $\lambda_o = 1.064\ \mu m$
- $n_1 = 3.3$ $n_2 = 4$
- $\lambda_1 = 322.4\ nm$ $\lambda_2 = 266\ nm$
- $\mathbf{t_1} = 80.6\ nm$ $\mathbf{t_2} = 66.5\ nm$

REFLECTANCE COMPARISON

R% (double-layer)

- **[Ge / Si] = .029%**
- [ThO_2 / Al_2O_3] = .038%
- [CeF_3 / MgF_2] = .209%
- [Nd_2O_3 / Al_2O_3] = .041%

R% (mono-layer)

[SiO] = 5.06%

[Cryolite] = .28%

[CeF_3] = 8.03%