Fundamental of Opto-Electronics 方法论

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Chapter 1

Introduction

1.1 Maxwell

$$\begin{aligned}
\nabla \times \mathrm{E} &= -\frac{\partial \mathrm{B}}{\partial t} && (1.1)\\
\nabla \times \mathrm{H} &= \mathrm{J} + \frac{\partial \mathrm{D}}{\partial t} && (1.2)\\
\nabla \cdot \mathrm{B} &= 0 && (1.3)\\
\nabla \cdot \mathrm{D} &= \rho && (1.4)
\end{aligned}$$

$$\begin{aligned}
\oint_{loop} \mathrm{E} \cdot d\mathrm{l} &= -\frac{\partial}{\partial t} \int_{area} \mathrm{B} \cdot d\mathrm{S} && (1.5)\\
\oint \mathrm{H} \cdot d\mathrm{l} &= \int \mathrm{J} \cdot d\mathrm{S} + \frac{\partial}{\partial t} \int_{area} \mathrm{D} \cdot d\mathrm{S} && (1.6)\\
\oint_{surf} \mathrm{B} \cdot d\mathrm{S} &= 0 && (1.7)\\
\oint_{surf} \mathrm{D} \cdot d\mathrm{S} &= Q_{enclosed} && (1.8)
\end{aligned}$$

$$F = q(\mathrm{e} + \mathrm{v} \times \mathrm{B}) \qquad (1.9)$$

E:electric field strength;V/M
D:electric flux density; C/m^2
H:magnetic field strength; A/m
B:magnetic flux density; $Webers/m^2$
J:electric current density; A/m^2
I_0;$I_{incident}, I_{reflection}, I_{transmission}, I_{absorption}, I_{lumin}, I_{scattering}, I_{interference}$

$R = \dfrac{|E_R|^2}{|E_0|^2}$:reflectivity, or reflectance $\quad T = \dfrac{|E_T|^2}{|E_0|^2}$:transmitivity, or transmitance
$r = \dfrac{|E_R|}{|E_0|}$:reflection coefficiency $\quad t = \dfrac{|E_T|}{|E_0|}$:transmit coefficiency
$\lambda = c/f = 2\pi c/\omega$; $\dfrac{v}{c} = \dfrac{\lambda_1 f_1}{\lambda_0 f_0} = \dfrac{1}{n_1}$, so $f_0 = f_1$
When $l \gg l_c$,

$$T = \frac{(1-R_1)(1-R_2)e^{-\alpha l}}{1-R_1R_2e^{-2\alpha l}} = (1-R_1)(1-R_2)e^{-\alpha l} \cdot \sum_0^{\infty}(R_1R_2e^{-2\alpha l})^i \tag{1.10}$$

$I = \langle s \rangle \propto \langle \mathrm{E} \times \mathrm{H} \rangle = \frac{c}{4\pi}\sqrt{\frac{\varepsilon}{\mu}}\langle E^2 \rangle$
for $\mathrm{E}(\mathrm{r}, t) = \frac{1}{2}[A(\mathrm{r})e^{-i\omega t} + A^*(\mathrm{r})e^{i\omega t}]$,$E = E_1 + E_2$

$$I = \langle E^2 \rangle = \langle E_1^2 \rangle + \langle E_2^2 \rangle + 2 \cdot \langle E_1 \cdot E_2 \rangle \tag{1.11}$$

if $\omega_1 = \omega_2$,

$$\langle E_1 \cdot E_2 \rangle = \frac{1}{4}\langle A_1A_2^* + A_1^*A_2 \rangle$$

if $A_1 = a_1e^{i\phi_1}$, $A_2 = a_2e^{i\phi_2}$

$$\langle E_1E_2 \rangle = \frac{1}{4}[a_1a_2cos(\phi_1 - \phi_2) + a_1a_2cos(\phi_2 - \phi_1)]$$

that is to say ,for $\delta = \phi_1 - \phi_2 = 2\pi/\lambda L_c$, $L_c = \dfrac{\lambda \cdot \delta}{2\pi}$

Absorption coefficiency:α, according to Lamb-Beer Law:$I = I_0e^{-\alpha l}$. Absorb ratio: $A = |\dfrac{I_\alpha}{I_0}| = |\dfrac{E_\alpha}{E_0}|$

1.2 Polarization

$$\mathrm{H} = (-\mathrm{x}\frac{b}{\eta}e^{j\phi_b}e^{-jkz} + \mathrm{y}\frac{a}{\eta}e^{j\phi_a}e^{-jkz})e^{j\omega t}$$

for $z = 0$

$$\mathrm{H} = (-\mathrm{x}\frac{b}{\eta}e^{j\phi_b} + \mathrm{y}\frac{a}{\eta}e^{j\phi_a})e^{j\omega t}$$

$$\mathrm{E} = (\mathrm{x}ae^{j\phi_a} + \mathrm{y}be^{j\phi_b})e^{j\omega t} \tag{1.12}$$
$$real(\mathrm{E}) = \mathrm{x}a\cos(\omega t + \phi_a) + \mathrm{y}b\cos(\omega t + \phi_b) \tag{1.13}$$

for $a = b, \phi_a = \phi_b$, linear-polarization
for$a = b, \phi_a - \phi_b = \pi/2$, circle-polarization

1.3 Material

with a ϵ and μ, the material is called isotropic;

with 9ϵ and 9μ, anisotropic;

with 18ϵ and 18μ, bianisotropic;

with ϵ, μ, χ, κ, baisotropic;

homogeneous: independent on r. $\epsilon(\mathrm{r}) = \epsilon_0$;

linear material: $\epsilon \mathrm{E} = \epsilon_0 = \epsilon(\mathrm{r}, t)$

Chapter 2

Classical Propagation

Chapter 3

Interband absorption

Chapter 4

Excitons

Chapter 5

Luminescence

Chapter 6

Free Electrons

Chapter 7

Phonons