Photonics in Semiconductors, Spring 2017

Exercise 2, 2.2.2017

1. Reflectance of polarized light

Linearly polarized plane wave is incident at an interface between two linear, homogeneous non-magnetic dielectric media. The angle between the plane of incidence and direction of polarization is γ_i. The reflectance components of p- and s-polarized components are$R_{\parallel}$ and $R_{\perp}$, respectively. Write an expression for the total reflectance R. Hint: start by writing: $R = I_r/I_i$, where I_r is the total incident intensity.

2. Reflectance of natural light

Natural, or unpolarized light, is such that the angle γ_i of problem 1 changes rapidly and randomly. Derive an expression for the reflectance of natural light, R_n, in terms of $I_{\parallel}$ and $I_{\perp}$. Hint: problem 1 should give something proportional to γ_i. Take the time average of that result.

3. Reflection and transmission at a semiconductor-semiconductor interface

A light wave with a free space wavelength of 890 nm (free space wavelength) that is propagating in GaAs becomes incident on AlGaAs. The refractive index of GaAs is 3.60, that of AlGaAs is 3.30.
(a) Consider normal incidence. What are the reflection and transmission coefficients and the reflectance and transmittance? (From GaAs into AlGaAs)
(b) What is the Brewster angle (the polarization angle θ_p) and the critical angle (θ_c) for total internal reflection for the wave in (a); the wave that is traveling in GaAs and incident on the GaAs/AlGaAs interface.
(c) What is the reflection coefficient and the phase change in the reflected wave when the angle of incidence is $\theta_i = 79°$?
(d) What is the penetration depth of the evanescent wave into medium 2 when $\theta_i = 79°$ and when $\theta_i = 89$? What is your conclusion?

4. Evanescent wave

Total internal reflection (TIR) of a plane wave from a boundary between a more dense medium (1) n_1 and a less dense medium (2) n_2 is accompanied by an evanescent wave propagating in medium 2 near the boundary. Find the functional form of this wave and discuss how its magnitude varies with the distance into medium 2.

5. Goos-Hänchen shift

A ray of light which is travelling in a glass medium (1) of refractive index 1.460 becomes incident to another glass medium (2) of refractive index 1.430. The free-space wavelength of the light ray is 850 nm and the angle of incidence is 85°. Estimate the lateral Goos-Hänchen shift in the reflected wave for the parallel and perpendicular field component. What is your conclusion and would there be some applications for this effect?