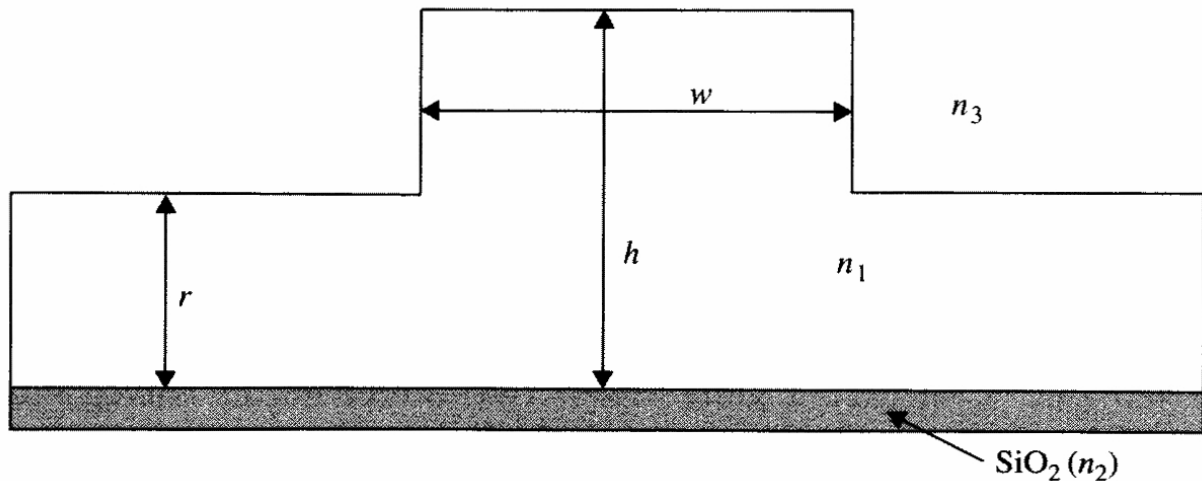# Silicon Photonics Homework #4

HW 4-1.

Find the effective index, N_{wg}, of the fundamental TE mode of the rib waveguide for $w = 2\ \mu\text{m}$, $h = 3\ \mu\text{m}$, $r = 2\ \mu\text{m}$, $n_1 = 3.5$, $n_2 = 1.5$, $n_3 = 1.0$ at the operating wavelength of 1.55 μm by using the effective index method.

HW 4-2.

Consider a planar waveguide: $n_1 = 3.5$, $n_2 = 1.5$, $n_3 = 1.0$, $h = 0.2\ \mu\text{m}$, and the operating wavelength $\lambda_0 = 1.55\ \mu\text{m}$. If the surface roughness of the upper and lower claddings σ_u and σ_l are both 2 nm, calculate the scattering loss α_s of the TE_0 mode.

HW 4-3.

If the variations of the concentration of electron and hole concentration in silicon are $\Delta N_e = 2\times10^{18}$ and $\Delta N_h = 2\times10^{18}$. For a light wave at $\lambda_0 = 1.55\ \mu\text{m}$, please calculate

(a) the variation of the refractive index Δn

(b) the variation of the absorption coefficient $\Delta \alpha$

HW 4-4.

The propagation loss of an SOI channel waveguide is measured by the Fabry-Perot resonance method with two endfaces to the air ($n_{air} = 1$). The spectrum is shown as the following figure. The measurement is taken around the center wavelength $\lambda_0 = 1550$ nm. It is known that the effective index of the waveguide is $N = 2.8$. From the measured spectrum, the maximum and the minimum of the transmittance curve are $I_{max} = 0.62$ and $I_{min} = 0.28$, and the free spectral range is $\Delta\lambda = 0.07$ nm.

Please calculate

(a) the reflectance R at each endface.

(b) the length of the waveguide L

(c) the propagation loss α (in dB/cm) of the channel waveguide.
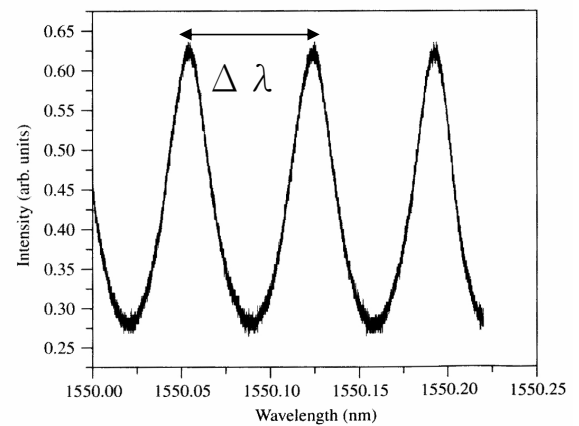
Hint: $R = \left| \dfrac{N - n_{air}}{N + n_{air}} \right|^2$ $\Delta l = \dfrac{l_0^2}{2NL}$

HW 4-5.

Consider a planar waveguide: $n_1 = 3.5$, $n_2 = n_3 = 1.5$, $h = 0.24$ μm, and the operating wavelength $\lambda_0 = 1.55$ μm. If the light is coupled into the waveguide mode (TE$_0$) by the grating on the core surface with the diffraction order $p = -1$.

Please calculate

(a) the effective index N of the TE$_0$ Mode (see Chap 2)
(b) the grating period Λ, if the incidence angle of the light $\theta_a = 0°$ (normal incidence) in the upper cladding.
(c) the grating period Λ, if the incidence angle of the light $\theta_a = 45°$ in the upper cladding.