LED and Laser Diode Characteristics

1. Semiconductor LED Properties

Consult the datasheet for the Lite On LTST-C190CKT AlGaAs red light emitting diode (linked on the webpage).

a) What is the radiant intensity R, in [W sr^{-1}] , at the test current of I_f=10 mA? Use the relationship that $R = I_v/\eta_v$ where I_v is the luminous intensity in candelas (lumens per steradian) and η_v is the luminous efficacy in lumens per watt (at λ = 660 nm η_v = 41.5 [lm W^{-1}].

b) Assuming Lambertian illumination into the forward hemisphere, what is the total optical output power, in watts, if R is the radiant intensity along a direction normal to the surface of the chip?

c) What is the wall plug efficiency, defined as "optical output power"/"electrical input power", at I_f=10 mA?

d) What is the external efficiency η_{ex}, defined as "photons out"/"electrons in" ?

2. Semiconductor Laser Diode Properties

Consult the data sheet for the Sanyo DL3149 AlGaInP single mode 660 nm laser diode (linked on the webpage). Assume case temperature $T_c = 25^oC$.

a) What is the threshold current, I_{th} ?

b) Estimate the slope quantum efficiency η. The slope quantum efficiency is defined to be the incremental number of photons per incremental number of electrons, well above threshold. In other words, $\eta = \dfrac{\Delta P/h\nu}{\Delta I/e}$ where e is the charge per electron, or 1.6×10^{-19} Coulombs. How does this compare to the external efficiency of the LED in problem 1?

c) At P_o = 5 mW, what is the wall plug efficiency? How does this compare to the wall plug efficiency of the LED in problem 1?

d) From the lasing wavelength vs. temperature curve, estimate the mode spacing $\Delta\nu$ [Hz], and also $\Delta\lambda$ [nm]. What is the approximate length of the laser cavity? Assume the index of refraction for this material is n=3.5.

e) From the divergence angles $\theta_\perp$ and $\theta_\parallel$ (note that these angles are specified **as full width half maximum**, not the divergence half angle to the 1/e beam width that we defined for the Gaussian beams), calculate the size of the beam waist 1/e radius, specified by $w_{o\perp}$ and $w_{o\parallel}$. The waist is located approximately at the output facet of the laser diode.