EE 232
10/6/2010

Midterm Examination-1
EE 232 – Lightwave Devices

Fall 2010
Prof. Ming Wu

- If you need additional conditions to solve a problem, please write down your assumptions.
- Answer in the space below the problem. If you need additional space, you can use the overflow pages in the back. Please indicate which page the answer continues in the lower-right corner.
- Please put a square box around your final answers for each problem.

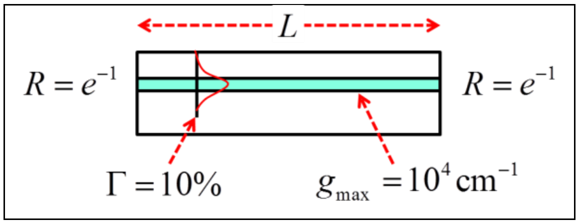
Commonly used constants:

$\hbar = 1.054\times10^{-34}$ J·s	$q = 1.6\times10^{-19}$ C	$m_0 = 9.11\times10^{-31}$ kg
$k_BT = 0.026$ eV at 300K	$k_B = 1.38\times10^{-23}$ J/K	$\varepsilon_0 = 8.854\times10^{-12}$ F/m
1 eV $= 1.6\times10^{-19}$ J		

Your Name	
Student ID #	
Signature	

Problem	Points	Points Earned
1	25	
2	25	
3	20	
4	30	
Total	100	

1. The edge-emitting laser on the right has a cavity length of *L*, a confinement factor of 10%, and a reflectivity of $e^{-1} = 36.8\%$ for both facets. Assume the intrinsic loss is negligible, and the maximum available gain of the active media is 10^4 cm^{-1}. As the laser cavity length decreases, the mirror loss increases and eventually it is not possible to achieve lasing. Find the minimum length of the laser that can still lase.



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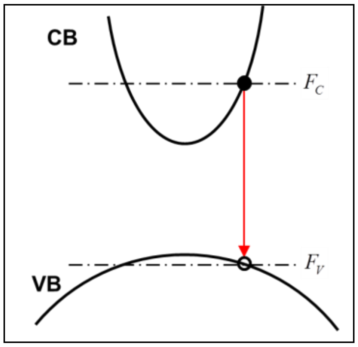
2. In bulk semiconductor laser, the electron concentration can be expressed by the following expression when the electron quasi-Fermi level is above the conduction band edge:

$$n \approx N_C \cdot \frac{4}{3\sqrt{\pi}}\left(\frac{F_n - E_C}{k_B T}\right)^{3/2} \quad \text{where} \quad N_C = 2\left(\frac{\pi m_e^* k_B T}{2\pi^2 \hbar^2}\right)^{3/2}.$$

The expressions for holes are similar.

Prove that when an electron with energy equal to electron-quasi-Fermi level, F_C, recombines *radiatively* with a hole, the hole energy is *always* equal to the hole-quasi-Fermi level, F_V.



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3. To predict the gain of an unknown semiconductor, we performed optical absorption measurement of the semiconductor and found the absorption coefficients are 2×10^3 and 4×10^3 cm^{-1}, respectively, for photon energies of 1.04 and 1.16 eV. What would the gain coefficient of the semiconductor be at photon energy of 1.25 eV when the population is fully inverted? Assume all temperatures are at zero Kevin.

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4. Consider two III-V semiconductors with the same bandgap energy and dipole moments but very different effective masses: 0.1 m_0 for both electron and hole effective masses for Semiconductor A, and 1 m_0 for Semiconductor B.

   a) Find the *ratio* of the peak optical gains for the two semiconductors when they have the same carrier (electron and hole) concentration.

   b) Find the *ratio* of the optical gain bandwidth for the two semiconductors when they have the same carrier (electron and hole) concentration.

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