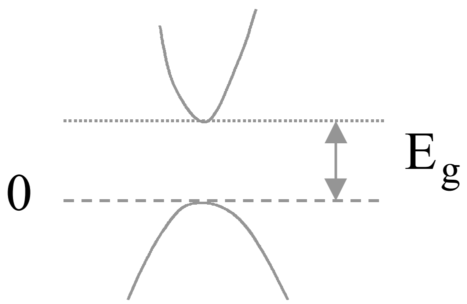
광전자 Test 3. 2000년 6월 1일.

Prob.1 (65)

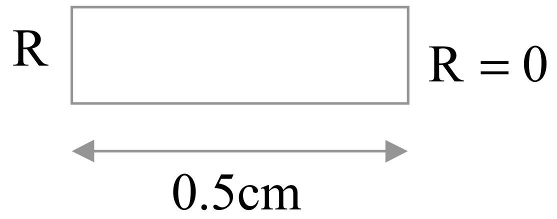
Consider a semiconductor whose band structure is shown below. The bandgap is E_g and the conduction band effective mass, m_e^*, and the valence band effective mass, m_h^*, are constant and $m_h^* = 2m_e^*$.



(a) (10) Carriers are injected into the semiconductor until the semiconductor is transparent for photons whose energy is $E + \Delta E$. What is the separation of quasi-Fermi energies in this semiconductor? Assume the bandgap does not change with the injected carriers.

(b)(15) What is the conduction-band quasi-Fermi energy for the situation given in (a)? The electron density of states is given as $g_0 (m_e^*)^{3/2} (E - E_g)^{1/2}$ and the semiconductor is at 0K.

(c)(10) An optical amplifier is mode with the semiconductor having length of $0.5cm$. In order to make the amplifier have 20dB power gain at $\lambda = 1\mu m$. What is the required injected carrier densities? Assume the amplifier has end facets with zero reflectivities, g the gain coefficient at $\lambda = 1\,\mu m$ is given as $a(N - N_0)$ for where $a = 10^{-17}\,cm^2$, N_0 is $10^{18}\,cm^{-3}$, and $\Gamma = 0.1$.



(d)(10) The above amplifier is converted into a laser by making both end facets to have non-zero reflectivity R. If the lasing threshold carrier density is $2N_0$, What is the mirror reflectivity? Assume there is no internal loss.

(e)(10) The laser is observed to have ten lasing modes at around $\lambda = 1\mu m$. What is an estimate in nm for the range in which the semiconductor has optical gain? Assume all refractive index of the semiconductor is 3.5.

(f)(10) We want to make a single mode laser by reducing the cavity length of the laser in (e). Determine the maximum cavity length so that the laser has a single mode. Assume all other conditions are the same as in (e).

Prob. 2 (35)

(a)(10) An intrinsic semiconductor has the electron and hole consentration of 10^{10} cm^{-3} and the recombination time of $10\mu s$. A photoconductor is made of this semiconductor. If $1 mW/cm^3$ photon power density at $\lambda = 1\mu m$ is incident at the photoconductor, how many carriers are produced at the steady-state? Assume the photoconductor has the internal quantum efficiency of 0.5.

(b)(10) How many times does the resistence of the photoconductor increase (or decrease)? Assume the electron and hole mobilities are identical.

(c)(15) An APD has separate absorption and gain regions and the gain region has $K(\alpha_h / \alpha_e)$ of 1 and length W. Drive the APD gain.