EECS 523 Homework # 8

Note: For all problems, assume no iteration is necessary for finding ΔL unless otherwise stated. $v_{SAT} = 10^7$ cm/s.

1. The ratio (I_{SUB}/I_D) at hot-carrier induced breakdown usually falls within the range of 0.05 to 0.2. For this problem, assume that it is equal to 0.05 and is device independent. A 1μm CMOS technology has the following NMOS device and process parameters: t_{OX} = 20nm, x_j = 0.3μm, α=0, V_T = 0.7V.
   (a) Derive an expression for the hot-electron induced breakdown voltage V_{BD} ($V_{BD} = V_{Ds}$) of the NMOS devices as a function of L_{eff} and V_g'.
   (b) Plot log (V_{BD}) as a function of log (L_{eff}) for L_{eff} = 0.1μm to 100μm for V_g' = 2V.

2. Use the following parameters for an n-channel MOSFET: t_{OX}=20nm, x_j = 0.3μm, α=0, V_T = 0.7 and L_{eff} = 1um. Based on device degradation results, it is recommended that this n-channel MOSFET should not be operated with $E_M > 2 \times 10^5$ V/cm.

a) What is the ratio of I_{SUB}/I_D at this value of E_M? Determine the recommended maximum supply voltage V_{DD}. Assume V_g = 3V and that this value of V_g produces the maximum I_{SUB}.
b) What is the breakdown voltage of the device with V_g = 3V, assuming that the device breaks down at $E_M = 4 \times 10^5$ V/cm.

3. a) Calculate E_M and I_{SUB} in a non-LDD MOSFET described by the following parameters: t_{OX} = 20nm, x_j = 0.2μm, α=0, V_{th} = 0.7V, L_{eff} = 0.5μm and W = 0.5μm when the source is grounded, the gate voltage V_g = 2V, and the drain voltage V_d = 4V.
   b) How much are the maximum E_M and I_{SUB} reduced by adding a 0.1μm LDD region having an optimum doping profile? Also, what is the improvement in the device lifetime τ_{DC} from the LDD structure? Assume I_d is unchanged with the addition of the LDD region.

4. An NMOS device has the following parameters: W = 1μm, t_{OX} = 2nm, x_j = 0.06μm, α=0, V_{th} = 0.3V, L_{eff} = 0.08um, $v_{SAT} = 10^7$ cm/s, V_{DD} = 1.2V.
   Find I_d for $V_{ds} = V_{gs} = V_{DD}$ = 1.2V (iterate to find ΔL in this problem).