

Test 01-EE 5342/051 (print last name) _____ (print first name) _____
 Tuesday, February 18, 2003, 9:30 AM, 106 Nedderman Hall
75 minutes allowed (last four digits of your student #) _____ (e-mail if new) _____

Instructions:

- Do your own work. DO NOT REMOVE THE STAPLE ON THIS EXAM.
- You may use either a legal copy of the text OR ONE sheet of hand-written notes. You may NOT pass a book or note sheet to another student. You may NOT use class notes, nor previously solved problems.
- Calculator allowed. You may NOT share a calculator with another student.
- Use values given on this cover sheet. If a value is not given, explicitly state definitions and assumptions that you use.
- Where possible, calculate parameters rather than read them from a graph.
- Do all work in the spaces provided on this exam paper. If you write on the back of a sheet, make the notation "PTO" in your solution in order to assure that material written on the back of the page is evaluated for a grade. AN EXTRA BLANK SHEET IS ATTACHED AT THE BACK OF THE EXAM.
- Show all calculations, making numerical substitutions and giving numerical results where possible.
- Write answers in space given.
- Unless stated otherwise,
 $T = 300\text{K}$, $V_t = 25.852\text{ mV}$
- Unless otherwise stated, the material is silicon with
 $n_i = 1.07\text{E}10\text{ cm}^{-3}$ $N_c = 2.84\text{E}19\text{ cm}^{-3}$ $q\chi_{\text{Si}} = 4.05\text{ eV}$
 $E_{g,\text{Si}} = 1.125\text{ eV}$ $N_v = 3.08\text{E}19\text{ cm}^{-3}$
- For the work function of poly silicon, use
 $\phi_{n+} = \chi_{\text{Si}} = 4.05\text{ V}$
 $\phi_{p+} = \chi_{\text{Si}} + E_{g,\text{Si}}/q = 5.175\text{ V}$.
- For minority carrier (either electrons or holes) lifetime in silicon, use the relationship
 $\tau_{\text{min}} = (45\text{E}-6\text{ sec}) / (1 + 7.7\text{E}-18 * N_{\text{imp}} + 4.5\text{E}-36 * N_{\text{imp}}^2)$,
 where N_i = the total impurity concentration
- For holes in silicon, assume
 $\mu_p = \{418.3 \div [1 + (N_i \div 1.6\text{E}17)^{0.7}]\} + 49.7$, in $\text{cm}^2/\text{V-sec}$
 (where N_i = the total impurity concentration in n- or p-type material, compensated or not).
- For electrons in silicon, assume
 $\mu_n = \{1268 \div [1 + (N_i \div 1.3\text{E}17)^{0.91}]\} + 92$, in $\text{cm}^2/\text{V-sec}$
 (where N_i = the total impurity concentration in n- or p-type material, compensated or not).
- Metal gate work functions should be assumed to be
 $\phi_{\text{Au}} = 4.75\text{ V}$ for gold, $\phi_{\text{Al}} = 4.1\text{V}$ for aluminum.
- The electron affinity of SiO_2 is $\chi_{\text{SiO}_2} = 0.95\text{ V}$.
- Planck constant $h = 6.62618 \times 10^{-34}\text{ J-s} = 4.1354 \times 10^{-15}\text{ eV-s}$, $1\text{ eV} = 1.60218 \times 10^{-19}\text{ Joule}$
- free electron mass $m_o = 9.1095 \times 10^{-28}\text{ g}$.
- Boltzmann constant, $k = 1.38066 \times 10^{-23}\text{ J/K}$
- Electron charge, $q = 1.60218 \times 10^{-19}\text{ Coulomb}$
- Permittivity of free space, $\epsilon_o = 8.85418 \times 10^{-14}\text{ Fd/cm}$
- Relative permittivity of silicon, $\epsilon_r = 11.7$
- Relative permittivity of silicon dioxide, $\epsilon_{\text{rOx}} = 3.9$
- The breakdown voltage of an abrupt (step) junction (assymetrical or one-sided) diode with doping on the lightly doped side of N_B is $V_B = 60(E_g/1.1)^{3/2} (10^{16}/N_B)^{3/4}\text{ V}$.
- Each part is worth [x] points, as given in the problem.