Project 1 Test - EE 5342 (print last name) ________________________ (print first name) _____________________
9:30 AM, Thursday March 24, 2005, 105 Nedderman Hall
80 minutes allowed (last four digits of your student #) _____________ (e-mail if new)______________________

Instructions: Seat Number ____________

1. Do your own work. DO NOT REMOVE THE STAPLE ON THIS EXAM.
2. You may use a legal copy of the text by Massobrio and Antognetti. You may write notes in your text. You may NOT pass a book or note sheet to another student, or class notes or previously solved problems. **You may use your Project 1 solution and must submit it with this test in your exam packet**.
3. Calculator allowed. You may NOT share a calculator with another student.
4. Where values or equations are given on this cover sheet, use them in lieu of any other source. If a value is not given, explicitly state definitions and assumptions that you use.
5. Where possible, calculate parameters rather than read them from a graph.
6. 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.
7. Show all calculations, making numerical substitutions and giving numerical results where possible.
8. **The total for the test is 75. Up to 25 additional points will be given for the Project report**.
9. Unless stated otherwise,
   $T = 300K$, $V_t = 25.843$ mV (to agree with M&K k and q values)
10. Unless otherwise stated, the material is silicon (300K) with
    $n_i = 1.45E10\ cm^{-3}$ $N_c = 2.8E19\ cm^{-3}$ $q\chi_{Si} = 4.05$ eV
    $E_{g,Si} = 1.124$ eV. $N_v = 1.04E19\ cm^{-3}$
11. For the work function of poly silicon, use $\phi_{n+} = \chi_{si} = 4.05$ V
    $\phi_{p+} = \chi_{Si} + E_{g,Si}/q = 5.174$ V.
12. For minority carrier (either electrons or holes) lifetime in silicon, use the relationship
    $\tau_{min} = (4.5E\text{-}5\ sec)/(1 + N_i/1E17 + (N_i/5E17)^2)$,
    where N_i = the total impurity concentration in cm^{-3}
13. For holes in silicon doped primarily with boron*, assume
    $\mu_p = \{470.5 \div [1+(N_i \div 2.23E17)^{0.719}]\}+44.9$, in cm^2/V-sec.
14. For electrons in silicon doped primarily with phosphorous*, assume
    $\mu_n = \{1414 \div [1+(N_i \div 9.2E16)^{0.711}]\}+68.5$, in cm^2/V-sec.
15. For electrons in silicon doped primarily with arsenic, assume
    $\mu_n = \{1417 \div [1+(N_i \div 9.68E16)^{0.68}]\}+52.2$, in cm^2/V-sec.
    (In 12 through 15, N_i = the total impurity concentration in n- or p-type material, compensated or not.)
    (*13 may be used as an approximation for holes as minority carriers, likewise *14 for minority electrons.)
16. Metal gate work functions should be assumed to be
    $\phi_{M,Al} = 4.1$ V for aluminum, $\phi_{M,Pt} = 5.3$ V for platinum, $\phi_{M,Au} = 4.75$ V for gold
17. The electron affinity of SiO_2 is $\chi_{SiO2} = 1.00$ V.
18. Planck constant $h = 6.625E\text{-}34$ J-s = 4.135E-15 eV-s, (1 eV = 1.602E-19 Joule).
19. free electron mass $m_o = 9.11E\text{-}28$ g.
20. Boltzmann constant, $k = 1.38E\text{-}23$ J/K
21. Electron charge, $q = 1.602E\text{-}19$ Coulomb
22. Permittivity of free space, $\varepsilon_o = 8.854E\text{-}14$ Fd/cm
23. Relative permittivity of silicon, $\varepsilon_r = 11.7$
24. Relative permittivity of silicon dioxide, $\varepsilon_{rOx} = 3.9$
25. The breakdown voltage of an abrupt (step) junction (asymmetrical or one-sided) diode with doping on the lightly doped side of N_B is $V_B = 60(Eg/1.1)^{3/2}(10^{16}/N_B)^{3/4}$ V. The critical field for breakdown is modeled as $E_{crit} = (120V \cdot qN_B/(\varepsilon_r\varepsilon_0))^{1/2} \cdot (Eg/1.1)^{3/4} \cdot (10^{16}/N_B)^{3/8}$
26. Each part is worth [x] points, as given in the problem.