

## COVER SHEET DRAFT

Test 1-EE 5340/001&051 (print last name) \_\_\_\_\_ (print first name) \_\_\_\_\_

Thursday, September 25, 2003, 8:00 AM, 206 Activities Building

**75 minutes allowed** (last four digits of your student #) \_\_\_\_\_ (e-mail if new) \_\_\_\_\_

Seat Number \_\_\_\_\_ Enrolled in (circle one) 8:00 AM or 9:30 AM class

### Instructions:

1. Do your own work. **DO NOT REMOVE THE STAPLE ON THIS EXAM.**
2. You may use either a legal copy of the text OR reference text. You may NOT pass a book or note sheet to another student. You may NOT use class notes. Do not use previously solved problems.
3. Calculator allowed. You may NOT share a calculator with another student.
4. Use values given on this cover sheet. 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. Write answers in space given.
9. Unless stated otherwise,

$$T = 300\text{K},$$

$$V_t = 25.843 \text{ mV (to agree with M\&K } k \text{ and } q \text{ values)}$$

10. Unless otherwise stated, the material is silicon (300K) with

$$n_i = 1.45\text{E}10 \text{ cm}^{-3}$$

$$N_c = 2.8\text{E}19 \text{ cm}^{-3}$$

$$q\chi_{\text{Si}} = 4.05 \text{ eV}$$

$$E_{g,\text{Si}} = 1.124 \text{ eV.}$$

$$N_v = 1.04\text{E}19 \text{ cm}^{-3}$$

11. For the work function of poly silicon, use

$$\phi_{n+} = \chi_{\text{Si}} = 4.05 \text{ V}$$

$$\phi_{p+} = \chi_{\text{Si}} + E_{g,\text{Si}}/q = 5.174 \text{ V.}$$

12. For minority carrier (either electrons or holes) lifetime in silicon, use the relationship

$$\tau_{\text{min}} = (45\text{E}-6 \text{ sec}) / (1 + 7.7\text{E}-18 * N_i + 4.5\text{E}-36 * N_i^2),$$

where  $N_i$  = the total impurity concentration

13. For holes in silicon doped primarily with boron, assume

$$\mu_p = \{470.5 \div [1 + (N_i \div 2.23\text{E}17)^{0.719}]\} + 44.9, \text{ in cm}^2/\text{V-sec.}$$

14. For electrons in silicon doped primarily with phosphorous, assume

$$\mu_n = \{1414 \div [1 + (N_i \div 9.2\text{E}16)^{0.711}]\} + 68.5, \text{ in cm}^2/\text{V-sec.}$$

15. For electrons in silicon doped primarily with arsenic, assume

$$\mu_n = \{1417 \div [1 + (N_i \div 9.68\text{E}16)^{0.68}]\} + 52.2, \text{ in cm}^2/\text{V-sec.}$$

(In 12 through 16,  $N_i$  = the total impurity concentration in n- or p-type material, compensated or not).

16. Metal gate work functions should be assumed to be

$$\phi_{\text{M,Al}} = 4.1 \text{ V for aluminum,}$$

$$\phi_{\text{M,Pt}} = 5.3 \text{ V for platinum,}$$

$$\phi_{\text{M,Au}} = 4.75 \text{ V for gold}$$

17. The electron affinity of  $\text{SiO}_2$  is  $\chi_{\text{SiO}_2} = 1.00 \text{ V.}$

18. Planck constant

$$h = 6.625\text{E}-34 \text{ J-s} = 4.135\text{E}-15 \text{ eV-s, (1 eV = 1.602E-19 Joule).}$$

19. free electron mass

$$m_o = 9.11\text{E}-28 \text{ g.}$$

20. Boltzmann constant,

$$k = 1.38\text{E}-23 \text{ J/K}$$

21. Electron charge,

$$q = 1.602\text{E}-19 \text{ Coulomb}$$

22. Permittivity of free space,

$$\epsilon_o = 8.854\text{E}-14 \text{ Fd/cm}$$

23. Relative permittivity of silicon,

$$\epsilon_r = 11.7$$

24. Relative permittivity of silicon dioxide,  $\epsilon_{r\text{Ox}} = 3.9$

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  $V_B = 60(E_g/1.1)^{3/2} (10^{16}/N_B)^{3/4} \text{ V.}$

26. Each part is worth [x] points, as given in the problem.