

# Errata for *Fundamentals of Semiconductor Devices*

last updated 9/27/07

Anderson & Anderson, first edition, 2005.

Inside cover, Table “Some physical constants,”  $\hbar$  should be  $1.05 \times 10^{-34}$  J-s, not 1.06.

Inside cover, Table “Constants of some semiconductors,” the effective density of states in the conduction band  $N_C$  for InP should be  $5.4 \times 10^{17}$ .

Inside cover, Table “Constants of some semiconductors, the effective density of states in the valence band for InP should be  $N_V=6.9 \times 10^{18} \text{ cm}^{-3}$ .

Inside cover, Table “Constants of some semiconductors, the intrinsic carrier concentration for InP should be  $n_i=9.3 \times 10^6 \text{ cm}^{-3}$ .

Page 8 Equation 1.15: two equations are run together on the same line- the first should be deleted (the first one is wrong, the second one is correct)

Page 8, Equation 1.17: the value of  $\epsilon_0$  is incorrect: it should be 8.85, not 9.85

Page 8, Equation 1.17, third line, the number should be  $2.18 \times 10^{-18}$ , not  $10^{-17}$

Page 25, sentence after Equation 1.43, ...we can rearrange Equation 1.40...” (the Equation number is missing)

Page 27, Equation 1.54 should be  $\hbar^2 \frac{1}{m_0}$

Page 50, Equation 2.6, should read  $E = E_C + \left( \frac{dE}{dK} \right) \Big|_{K=0} - \left( \frac{1}{2} \frac{d^2E}{dK^2} \right) \Big|_{K=0} K^2 + HOTS$

(the K=)’s are missing).

Page 83, Example 2.5, After the word “similarly” the third line of equation should read  $8.4 \times 10^{18} \text{ cm}^{-3}$ .

Page 83, Example 2.5 after “Therefore, from Equation (2.67),” in calculating  $n_i$ , in the second line, the value of  $N_V$  is entered incorrectly as  $8.3 \times 10^{19}$  – it should be  $8.4 \times 10^{18}$  (note both the value and the exponent were wrong)

Page 83, last equation in example, the correct value of  $N_V$  is  $8.4 \times 10^{18}$ .

Page 84., second paragraph in blue box, should read “2.3 kT above the valence band edge, no about the valence band edge.

page 85, equation starting with  $E_C - E_f$  should be  $E_C - E_f = -kT \ln\left(\frac{n_0}{N_C}\right)$  (there is currently an  $N_D$  where  $n_0$  should be)

Page 97, paragraph 2, line 6, should be  $E_{g0}$  not  $E_g(0)$

Page 97, Figure 2.24: the arrow for  $E_{g0}$  should extend between  $E_{C0}$  and  $E_v$ .

Page 105, Problem 2.2 Problem statement should use  $\sin^2(Ka/2)$  instead of  $\sin^2(Ka)$  in both places.

Page 115, top paragraph, line 5, should be  $dQ$  instead of  $Q = qpAv_{dp} dt$

p. 116, Equation 3.17- should be  $6.3 \times 10^{16}$  in the denominator, not 1.3.

Page 141, Equation 3.66 has some wrong minus signs. The second equation should read

$$\frac{\partial p}{\partial t} = \frac{\partial \Delta p}{\partial t} = -p\mu_p \frac{\partial(\mathcal{E})}{\partial x} - \mu_p \mathcal{E} \frac{\partial p}{\partial x} + D_p \frac{\partial^2 p}{\partial x^2} + G_{op} - \frac{\Delta p}{\tau_p}$$

p 143, last line before equation (3.72), should say E is constant, and *therefore*  $dE/dx$ ,  $dn/dx$ , and thus  $dJn/dx$  all equal zero.

Page 147, Figure 3.21: the labels  $\tau_n$  and  $\tau_p$  are swapped in the graph. The upper trace should be  $\tau_p$ , and the lower trace should be  $\tau_n$

p. 149, Figure 3.23, the labels in the graph for  $L_n$  and  $L_p$  are reversed.

Page 155, Problem 3.3, change “Repeat for Si with  $N_D = 10^{18} \text{ cm}^{-3}$ .” to “What happens to this trend when the semiconductor is very heavily doped? Why?”

Page 187 Equation S1A.16: the 3-D case should show a vector sign on the velocity, e.g.

$$v_g = \frac{1}{\hbar} \frac{dE}{dK} \quad \text{one dimension}$$

$$\vec{v}_g = \frac{1}{\hbar} \nabla_K E \quad \text{three dimensions}$$

Page 188, last sentence just before Equation S1A.18 should read “All are with minima at  $K=0$  and  $E=E_0$ . (not  $E=0$ )

Page 189, Equation S1A.21: the K should be a vector, e.g.  $|\vec{K}| = \frac{2\pi}{\lambda}$

Page 189, Equation S1A.16 (repeated): the 3-D case should show a vector sign on the velocity, e.g.

$$v_g = \frac{1}{\hbar} \frac{dE}{dK} \quad \text{one dimension}$$

$$\vec{v}_g = \frac{1}{\hbar} \nabla_K E \quad \text{three dimensions}$$

page 197, Equation S1A.46 should not have negative sign in front of  $j$  in exponent.

Page 211, Problem S1A.3: there should be a minus sign in the exponent, e.g.

$\Psi_2 = A \sin(2\pi x / L) e^{-j(E_2 / \hbar)t}$ . This error also appears in the problem statement in the solutions manual, but not the solution.

page 213 Problem S1A.12 part b: should be an = sign in  $\psi_c(x) = D e^{-a(x-L)x}$

Page 233, problem S1B.1, Current should be 1 mA, not 10 mA, and Hall voltage should be  $-3.12$  mV, not  $-3.12$   $\mu$ V.

Page 233, Problem S1B.3a, Insert “Since the lattice constants are nearly equal, we can assume the force between atoms to be comparable.” Before “For a material consisting of a single atom type (e.g. silicon), the lattice becomes a diamond lattice and  $M_1=M_2$ . Explain why the optical phonon energy for diamond (carbon) is greater than that for silicon, which is in turn greater than that for germanium.

Page 241, Figure 5.2:  $V_{bi}$  should be  $qV_{bi}$ .

Page 292, Equation 5.116: missing a factor of  $q/kT$ . It should be

$$C_{sc} = \frac{dQ_{st}}{dV_a} = \delta \frac{dQ_s}{dV_a} = \delta I \tau_n \frac{q}{kT}$$

Page 293, Stored charge capacitance example, second to last line on the page:

$$C_{sc}(-5) = \delta I \tau_n$$

$$= (0.5)(3.4 \times 10^{-19} \text{ A})(3 \times 10^{-6} \text{ s}) \left( \frac{1.6 \times 10^{-19} \text{ C}}{1.38 \times 10^{-23} \text{ J / K} \cdot 300 \text{ K}} \right) = 1.97 \times 10^{-23} \text{ F} \approx 0$$

Page 294, continuing example, first equation on page should be

$$C_{sc}(0.75) = \delta I \tau_n \frac{q}{kT} = (0.5)(3.4 \times 10^{-6} \text{ A})(3 \times 10^{-6} \text{ s}) \frac{1.6 \times 10^{-19} \text{ C}}{1.38 \times 10^{-23} \text{ J / K} \cdot 300 \text{ K}} = 63.7 \text{ pF}$$

Page 294, Table in example: in the last cell of the table, the value should be  $C_{sc}=63.7$  pf (not 1.65 pF)

P 309, question 5.19. “ A junction as  $N_D'=10^{17}$   $\text{cm}^{-3}$  and  $N_A'=10^{18}$ ... make it “A junction has a degenerately doped  $n$  side and the  $p$ -side is doped with  $N_A'=...$

P 318 Figure 6.7, the figures for Type II and type III are swapped, but the captions are correct.

p. 319, Figure 6.8 (b) Quantity labeled gamma 2 should be chi 2.

P335. Bottom equation, exponential should be  $E_B(0)$ , not  $E_g(0)$

Page 343, Problem 6.7, line 5: ...  $w_n$  and  $w_p$  on the  $N$  and  $p$  sides ... (“ $N$ ” is capitalized)

p. 334 Sect 6.4.3, second paragraph, line 5 should be “from the metal to the semiconductor is equal...” (“to” and “from” are mixed up)

Page 355, Equation S2.35 should be

$$C_{sc} = \frac{dQ_s}{dV_a} = \delta \frac{dQ_s}{dV_a} = \delta I \tau_n \frac{q}{kT}$$

Page 356, example S2.2 solution, for long base diode result should be

$$C_{sc} = \delta I \tau_n \frac{q}{kT} = \frac{1}{2} \times 10^{-2} \times 2.9 \times 10^{-6} \times \frac{1.6 \times 10^{-19}}{1.38 \times 10^{-23} (300)} = 5.6 \times 10^{-7} F$$

For the short-base diode the result should be

$$C_{sc} = \delta I \tau_n \frac{q}{kT} = \delta I \frac{(W_B)^2}{2D_n} = \frac{2}{3} \times 10^{-2} A \frac{(0.3 \times 10^{-4} \text{ cm})^2}{2 \times 20 \text{ cm}^2 / \text{s}} = 1.5 \times 10^{-12} F$$

The following text should say that the stored-charge capacitance for the long-base diode is about  $4 \times 10^5$  times as large as for the short-base diode.

Page 369, Problem S2.2. At the end of the problem statement, it should say, “The junction size is  $10^{-4} \times 10^{-4}$  cm.”

Page 369, Problem S2.3, let the junction area be  $5 \times 10^{-7}$  not  $5 \times 10^{-8}$   $\text{cm}^2$ .

P 371, problem S2.7, the “ $N$ ” should not be in italics since it is a SPICE variable

Page 374, paragraph 2, line 7, should be “ $V_{GS}$ ,” not “ $V_{DS}$ ”

P 439 Problem 7.2 a, should read “Draw an energy band diagram similar to Figure 7.5(b)...” (Not Figure 7.2(c))

P 440 Problem 7.5, "...is equal to the hole concentration in the p-type bulk."

p. 440. Problem 7.7, The permittivity of silicon DIOXIDE is..."

p 440, problem 7.12, should have a question mark.

P 434, middle of page, second-to-last equation should be  $R_s=R_D=19.9 \Omega$ . (Second R has subscript "D" not "S")

Page 449, Figure 8.4 (a) is drawn incorrectly. The gate electrodes should be over the gate

P. 481, Figure 8.31, lower right figure,  $E_i$  in the semi-insulating GaAs should be near the mid gap.

p 489, problem 8.9, should have "cm<sup>-3</sup>" after  $N_A$ '.

P 498, Figure S3.4: the arrows for the quantity  $q\phi_f$  should indicate the difference between  $E_i$  and  $E_f$ , not  $E_f$  and  $E_V$ .

Page 501, top of example wording should be "... and n-channel MOSFE with an n<sup>+</sup> poly Si gate, (add comma), having  $N_A=10^{16} \text{ cm}^{-3}$  in the substrate, ... (add "in the substrate")

p 548, problem S3.3 should refer to figure S3.3., not Figure 8.2

p. 549, problem S3.10, should be  $N_D$ ' not  $N_A$ '.

p. 550, problem S3.11, should be cm<sup>2</sup>, not just cm.

P. 585, Eqn. 9.67, there is a sign error in the second equation,  $I_C = I_{CT} - \dots$ ; the last term of the third equation,  $I_R$  should be  $I_S$ .

p. 641, problem 10.13, "...and the leakage current density..." add "density." At the end of the problem add "Assume that the area of the base-collector junction is 10 times that of the Schottky diode."

P 699, Figure 11.19: indicate critical angle in figure since it is defined with respect to the surface, not the normal (hence cosine version of Equation 11.27)