Semiconductor physics and devices 3rd edition solution manual

Denunciar11.37 We find that V VT ≈ 0 2. Now I sat W C L V VD n ox GS T( ) = − µ 2 a f where C t x xox ox ox = ∈ = ( ) − − 3 9 8 85 10 425 10 14 8 . .b g or C x F cmox = −8 12 10 8 2. / We are given W L = 10 . From the graph, for V VGS = 3 , I satD( ) ≈ 0 033. , then Semiconductor Physics and Devices: Basic Principles, 3rd edition Chapter 11 Solutions Manual Problem Solutions 179 0 033 2 3 0 2. .= −( )W C L n oxµ or W C L x xn ox n µ µ 2 0 139 10 1 2 10 8 12 103 8= =− −( ). .b g which yields µ n cm V s= −342 2 / 11.38 (a) V sat V VDS GS T( ) = − or 4 0 8= − =VGS . V VGS = 4.8 (b) I sat K V V K V satD n GS T n DS( ) ( )= − =a f2 2 so 2 10 44 2x Kn − = ( ) or K A Vn = 12.5 2µ / (c) V sat V V VDS GS T( ) = − = − =2 0 8 1 2. . so V V satDS DS> ( ) I sat xD ( ) ( )= −−1 25 10 2 0 85 2. .b g or I sat AD ( ) = 18 µ (d) V V satDS DS< ( ) I K V V V VD n GS T DS DS= − −2 2a f = − −− ( )( ) ( )1 25 10 2 3 0 8 1 15 2. .xb g or I AD = 42.5 µ 11.39 (a) We have I sat W C L V VD n ox GS T( ) = − µ 2 2a f Now 6 10 3x − = −FH I K F H I K ( ) ( ) − − W L x x 525 2 3 9 8 85 10 400 10 5 0 75 14 8 2. . . b g b g which yields W L = 14.7 (b) I sat W C L V VD p ox SG T( ) = + µ 2 2a f We have 6 10 3x − = −FH I K F H I K ( ) ( ) − − W L x x 300 2 3 9 8 85 10 400 10 5 0 75 14 8 2. . . b g b g which yields W L = 25 7. 11.40 From Problem 11.30, we have (a) In nonsaturation I V V V VD GS T DS DS= − −0 333 2 2. a f Now g I V VmL D GS DS= ∂ ∂ = ( )0 333 2. a f At V VDS = 0 5. , we find g mSmL = 0 333. (b) In saturation I V VD GS T= −0 333 2. a f so that g I V V VmS D GS GS T= ∂ ∂ = −( )2 0 333. a f For V VT = 0 80. and at V VGS = 4 , We obtain g mSmS = 2.13 11.41 From Problem 11.31, we have (a) In nonsaturation, I V V V V mAD SG T SD SD= + − ( )0148 2 2. a f Then g I V VmL D SG SD= ∂ ∂ = ( )0 148 2. a f For V VSD = 0 5. , we obtain g mSmL = 0 148. (b) In saturation I V VD SG T= +0 148 2. a f so that Semiconductor Physics and Devices: Basic Principles, 3rd edition Chapter 11 Solutions Manual Problem Solutions 180 g I V V VmS D SG SG T= ∂ ∂ = +( )2 0 148. a f For V VT = −0 8. and at V VSG = 4 , We obtain g mSmS = 0 947. 11.42 We can write, for VSB = 0 , V V Q CTO FB SD ox fp= + ′ + ( )max 2φ We find φ fp x x V= =( ) FHG I KJ0 0259 5 10 15 10 0 389 16 10 . ln . . and x x x xdT = ( ) ( )L NM O QP − − 4 11 7 8 85 10 0 389 1 6 10 5 10 14 19 16 1 2 . . . . /b g b gb g gr or x mdT = 0 142. µ Then ′ =( ) − −Q x x xSD max . .16 10 5 10 0142 1019 16 4b gb gb g or ′ =( ) −Q x C cmSD max . /114 10 7 2 Also C t x xox ox ox = ∈ = ( ) − − 3 9 8 85 10 400 10 14 8 . .b g or C x F cmox = −8 63 10 8 2. / Now V x xTO = − + + − − ( )0 5 114 10 8 63 10 2 0 389 7 8 . . . . or V VTO = +1 60. Then I sat W C L V VD n ox GS T( ) = − µ 2 2a f = −FH I K F H I K − 10 2 450 2 8 63 10 8 2. x V VGS Tb ga f or I sat V V mAD GS T( ) ( )= −0 097 2. a f For I sat mAD ( ) = 1 , V V VGS T− = 3 21. Now with substrate voltage applied, ∆V e N C VT s a ox fp SB fp= ∈ + − 2 2 2φ φ = − − − ( )2 1 6 10 11 7 8 85 10 5 10 8 63 10 19 14 16 1 2 8 . . . . / x x x x b g b gb g × + −( ) ( )2 0 389 2 0 389. .VSB or ∆V VT SB= + −1 49 0 778 0 882. . . We find that VSB ∆VT VT 0 1 2 4 0 0.673 1.17 1.94 1.60 2.27 2.77 3.54 11.43 For a p-channel MOSFET, ∆V e N C VT s d ox fn BS fn= − ∈ + − 2 2 2φ φ We find φ fn x x V= =( ) FHG I KJ0 0259 5 10 15 10 0 329 15 10 . ln . . and C t x xox ox ox = ∈ = ( ) − − 3 9 8 85 10 600 10 14 8 . .b g or C x F cmox = −5 75 10 8 2. / Then ∆V VT = −15. = − − − − ( )2 1 6 10 11 7 8 85 10 5 10 5 75 10 19 14 15 1 2 8 . . . . / x x x x b g b gb g × + −0 658 0 811. .VBS or 15 0 708 0 658 0 811. . . .= + −VBS which yields V VBS = 7.92 Semiconductor Physics and Devices: Basic Principles, 3rd edition Chapter 11 Solutions Manual Problem Solutions 181 11.44 (a) n+ poly-to-p type = ≈ −φ ms V1 0. φ fp x V= =( ) FHG I KJ0 0259 10 15 10 0 288 15 10 . ln . . also x eNdT fp a = ∈L NM O QP 4 1 2φ / = ( ) ( )L NM O QP − − 4 11 7 8 85 10 0 288 1 6 10 10 14 19 15 1 2 . . . . / x x b g b gb g or x mdT = 0 863. µ ′ =( ) − −Q x xSD max . .16 10 10 0 863 1019 15 4b gb gb g or ′ =( ) −Q x C cmSD max . /1 38 10 8 2 also C t x xox ox ox = ∈ = ( ) − − 3 9 8 85 10 400 10 14 8 . .b g or C x F cmox = −8 63 10 8 2. / Now ′ = =− −Q x x x C cmSS 16 10 5 10 8 10 19 10 9 2. /b gb g Then V Q Q CT SD SS ox ms fp= ′ − ′ + + ( )maxa f φ φ2 = − − + − − − F HG I KJ ( ) 1 38 10 8 10 8 63 10 1 0 2 0 288 8 9 8 . . . . x x x or V VT = −0 357. (b) For NMOS, apply VSB and VT shifts in a positive direction, so for VT = 0 , we want ∆V VT = +0 357. . So ∆V e N C VT a ox fp SB fp= ∈ + − 2 2 2φ φ + = − − − ( ) 0 357 2 1 6 10 11 7 8 85 10 10 8 63 10 19 14 15 8 . . . . . x x x b g b gb g × + −( ) ( )2 0 288 2 0 288. .VSB or 0 357 0 211 0 576 0 759. . . .= + −VSB which yields V VSB = 5 43. 11.45 Computer plot 11.46 (a) g W C L V Vms n ox GS T= − µ a f = − ( )( )( ) ( ) − − 10 400 3 9 8 85 10 475 10 5 0 65 14 8 . . . x x b g or g mSms = 1 26. Now ′ = + =′ = = + g g g r g g g rm m m s m m m s1 0 8 1 1 . which yields r gs m = − = − FH IK FH IK 1 1 0 8 1 1 1 26 1 0 8 1 . . . or r ks = 0 198. Ω (b) For V V g mSGS ms= = =3 0 683. Then ′ = + =(Denunciar(c) Magnitude of potential difference is φ = = ∈ +z zEdx eN x x dxd Oa f = ∈ + ⋅ + F HG I KJ eN x x x Cd O 2 22 Let φ = 0 at x xO= − , then 0 2 2 2 2 2 2 2 = ∈ − + = = ∈ F HG I KJ eN x x C C eN xd O O d O Then we can write φ = ∈ + eN x xd O2 2a f At x m= −1 µ φ 1 19 15 14 4 1 6 10 5 10 2 117 8 85 10 1 2 10= − + − − − ( ) ( ) . . . x x x x b gb g b g or φ 1 386= . V Potential difference across the intrinsic region φ i d x x= ⋅ =( ) −E 0 7.73 10 2 104 4b gb g or φ i V= 155. By symmetry, potential difference across the p- region space charge region is also 3 86. V . The total reverse-bias voltage is then VR = + =( )2 3 86 15 5. . V VR = 23 2. 7.34 (a) For the linearly graded junction, ρ x eax( ) = , Then d dx x eaxE = ∈ = ∈ ( )ρ Now E = ∈ = ∈ ⋅ +z eaxdx ea x C2 12 At x xO= + and x xO= − , E = 0 So 0 2 2 2 1 1 2 = ∈ + = = − ∈ F HG I KJ F HG I KJ ea x C C ea xO O Then E = ∈ − ea x xO2 2 2b g (b) φ x dx ea x x x CO( ) LNM O QP= − = = − ∈ − ⋅ +z E 2 3 3 2 2 Set φ = 0 at x xO= − , then 0 2 3 3 3 3 2 2 3 = − ∈ − + + = = ∈ L NM O QP ea x x C C eaxO O O Then φ x ea x x x eaxO O( ) FHG I KJ= − ∈ − ⋅ + ∈2 3 3 3 2 3 Semiconductor Physics and Devices: Basic Principles, 3rd edition Chapter 7 Solutions Manual Problem Solutions 96 7.35 We have that ′ = ∈ + L NM O QPC ea V Vbi R 2 1 3 12a f / then 7.2 10 9 3 x −b g = a x x1 6 10 11 7 8 85 10 12 0 7 3 5 19 14 2. . . . . − −( ) ( ) L N MM O Q PP+ b g b g which yields a x cm= −11 1020 4. Semiconductor Physics and Devices: Basic Principles, 3rd edition Chapter 8 Solutions Manual Problem Solutions 101 Chapter 8 Problem Solutions 8.1 In the forward bias I I eV kTf S ≈ FH IKexp Then I I I I eV kT eV kT e kT V Vf f S S 1 2 1 2 1 2= ⋅ = − FH IK FH IK L NM O QP exp exp a f or V V kT e I I f f 1 2 1 2 − = F H I K F HG I KJln (a) For I I f f 1 2 10= ⇒ V V mV mV1 2 59.9 60− = ≈ (b) For I I V V mV mVf f 1 2 1 2100 119.3 120= ⇒ − = ≈ 8.2 I I eV kTS = − FH IKLNM O QPexp 1 or we can write this as I I eV kTS + = FH IK1 exp so that V kT e I I S = + F H I K F HG I KJln 1 In reverse bias, I is negative, so at I I S = −0 90. , we have V = − =( ) ( )0 0259 1 0 90. ln . or V mV= −59.6 8.3 Computer Plot 8.4 The cross-sectional area is A I J x x cm= = = − − 10 10 20 5 10 3 4 2 We have J J V VS D t ≈ ⇒ F HG I KJexp 20 0 65 0 0259 = FH IKJS exp . . so that J x A cmS = −2.52 10 10 2/ We can write J en N D N D S i a n nO d p pO = ⋅ + ⋅ L NM O QP 2 1 1 τ τ \ We want 1 1 1 0 10 N D N D N D a n nO a n nO d p pO ⋅ ⋅ + ⋅ = τ τ τ . or 1 25 5 10 1 25 5 10 1 10 5 10 7 7 7 N x N x N x a a d ⋅ ⋅ + ⋅ − − − − = + = 7.07 10 7.07 10 4.47 10 0 10 3 3 3 x x N N xa d b g . which yields N N a d = 14.24 Now J x x xS = = − −2.52 10 1 6 10 15 1010 19 10 2 . .b gb g × ⋅ + ⋅( ) L NM O QP− − 1 14.24 25 5 10 1 10 5 107 7N x N xd d We find N x cmd = −7.1 1014 3 and N x cma = −1 01 1016 3. Semiconductor Physics and Devices: Basic Principles, 3rd edition Chapter 8 Solutions Manual Problem Solutions 102 8.5 (a) J J J eD n L eD n L eD p L n n p n pO n n pO n p nO p + = + = ⋅ ⋅ + ⋅ D n N D n N D n N n n nO i a n nO i a p pO i d τ τ τ 2 2 2 = + ⋅ F HG I KJ 1 1 D D N N p nO n pO a d τ τ We have D D p n p n = = µ µ 1 2.4 and τ τ nO pO = 1 0 1. so J J J N N n n p a d + = + ⋅ F HG I KJ 1 1 1 2.4 1 0 1. or J J J N N n n p a d + = + ( )FHG I KJ 1 1 2.04 (b) Using Einstein's relation, we can write J J J e L n N e L n N e L n N n n p n n i a n n i a p p i d + = ⋅ ⋅ + ⋅ µ µ µ 2 2 2 = + ⋅ e N e N L L e N n d n d n p p a µ µ µ We have σ µn n de N= and σ µp p ae N= Also L L D D n p n nO p pO = = = τ τ 2.4 0 1 4.90 . Then J J J n n p n p n p+ = + σ σ σ σ b g b g 4.90 8.6 For a silicon p n+ junction, I Aen N D S i d p pO = ⋅ 2 1 τ = ⋅− − − 10 1 6 10 15 10 1 10 12 10 4 19 10 2 16 7b gb gb g. .x x or I x AS = −3 94 10 15. Then I I V V xD S D t = = F HG I KJ FH IK−exp . exp . . 3 94 10 0 50 0 0259 15b g or I x AD = −9.54 10 7 8.7 We want J J J n n p+ = 0 95. = + = + eD n L eD n L eD p L D L N D L N D L N n pO n n pO n p nO p n n a n n a p p d = + ⋅ D L D L D L N N n n n n p p a d We obtain L D xn n nO= = =( ) −τ 25 0 1 10 6.b g L mn = 158. µ L D xp p pO= = =( ) −τ 10 0 1 10 6.b g L mp = 10 µ Then Semiconductor Physics and Devices: Basic Principles, 3rd edition Chapter 8 Solutions Manual Problem Solutions 103 0 95 25 15 8 25 158 10 10 . . . = + ⋅ F HG I KJ N N a d which yields N N a d = 0 083. 8.8 (a) p-side: E E kT N nFi F a i − = F HG I KJln = =( ) FHG I KJ0 0259 5 10 15 10 15 10 . ln . x x E E eVFi F− = 0 329. Also n-side: E E kT N nF Fi

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