Chap.4. No.2.

1. 由热电子发射理论.

$$\begin{cases} I = I_{st}\left[\exp\left(\frac{V}{nU_T}\right) - 1\right] \quad n=1 \quad T=300K \\ I_{st} = S \cdot J_{st} \\ J_{st} = R^{*} T^2 \exp\left(-\frac{\phi_{Bn}}{U_T}\right) \end{cases}$$

$$I_{st} = 10^{-4} \cdot 114 \cdot 300^2 \cdot \exp\left(-\frac{0.42V}{26mV}\right) = \cancel{1.0\times10^{-4}A}\ 9.9\times10^{-6}A.$$

$$I(V=0.5V) = 2.23\times10^{-4}A.$$

2.(1) V_{bi}由~~两个器件~~ I之间作差得到变化速率最大值得出,

R_{on}由开启电压和饱和电压之间线性拟合得出.

V_{bi}: speed(n) = I(n+1) - I(n)

accerate(n) = speed(n+1) - speed(n)

accerate最大值对应开启电压. 最小值对应饱和电压.

∴ $V_{bi} = 0.75V$.

$V_{饱和} = 2.08V$.

$R_{on} = (0.0562)^{-1} = 17.78\Omega$.

(2) 肖克莱方程只对饱和前有效. 先去除$V_{饱和}$及以后数据.

再取曲线中较为线性的部分 这里取[15, 51]

即 0.21~0.75V部分.

$$J = J_{st}\left[\exp\left(n\frac{V}{U_T}\right) - 1\right] \approx J_{st}\exp\left(\frac{V}{nU_T}\right).$$

$$\ln J = \ln J_{st} + \frac{1}{nU_T}V.$$

$$\begin{cases} \ln J_{st} = \cancel{-17.71}\ -18.46\ A\,\mu m^{-2}. \\ \frac{1}{nU_T} = \cancel{-17.37}\ \cancel{37.14}\ 37.08. \end{cases}$$

$m^*_{Ga_2O_3} = 0.34 m_0$

$$\therefore \begin{cases} n = \cancel{0.97}\ 1.04. \\ J_{st} = \cancel{3.71\times10^{-8}\,A\,\mu m^{-2} = 3.71\,A/cm^{-2}} \end{cases}$$

$3.1\times10^{-12}\,A\,cm^{-2}$.

$R^* = 120\frac{m^*}{m_0} = 40.8\,A/(cm^2K^2)$

$$q\phi_{Bn} = \ln\left(\frac{J_{ST}}{R^* T^2}\right)\cdot\left(-\frac{kT}{q}\right)\cdot q \approx 1.082\,eV.$$

建议值：$q = 1.6e{-19}$.
$\varepsilon_0 = 8.85e{-14}$.

Chap. 4. No. 3.

1. $V_{bi} = U_T \ln\left(\frac{N_a N_d}{n_i^2}\right) = 26mV \cdot \ln\left(\frac{10^{18} \cdot 10^{15}}{(9.65\times10^{9})^2}\right) = \cancel{0.78}\ 0.798\,V$.

$V_{p0} = \frac{q a^2 N_d}{2\varepsilon_{si}} = \cancel{3.02}\ 3.013\,V$.

$V_p = V_{p0} - V_{bi} = \cancel{2.24}\ 2.215\,V$.

$G_0 = \frac{2aqN_d\mu_n Z}{L} = \cancel{9.3mS}\ 9.28mS$.

$$\begin{cases} I_D = G_0\left(V_D - \frac{2}{3}\sqrt{\frac{1}{V_{p0}}}\left[(V_D+V_{bi}-V_G)^{3/2} - (V_{bi}-V_G)^{3/2}\right]\right) \\ V_G = 0. \end{cases}$$

$$\frac{\partial}{\partial V_D} I_D = \frac{\partial}{\partial V_D} G_0\left\{V_D - \frac{2}{3}\sqrt{\frac{1}{V_{p0}}}\left[(V_D+V_{bi})^{3/2} - V_{bi}^{3/2}\right]\right\}$$

$$= G_0\left\{1 - \frac{2}{3}\sqrt{\frac{1}{V_{p0}}} \cdot \frac{3}{2}(V_D+V_{bi})^{\frac{1}{2}}\right\}$$

$$= G_0\left(1 - \sqrt{\frac{V_D+V_{bi}}{V_{p0}}}\right)$$

$$\left.\frac{\partial I_D}{\partial V_D}\right|_{V_D=0} = G_0\left(1 - \sqrt{\frac{V_{bi}}{V_{p0}}}\right) = 4.6mS.$$

$$\left\{ \begin{aligned} G &= \frac{a-W}{a} G_0 \\ W &= \sqrt{\frac{2\varepsilon_{si} V_{bi}}{qN_d}} = 1.09\times10^{-4}\,cm. \end{aligned} \right.$$

$G = 4.55mS$.

$f_T = \frac{a^2 q N_d \mu_n}{2\pi\varepsilon_{si}L^2} = \cancel{3.48\times10^8}\,Hz$. $695.3\,MHz$.

$= \frac{V_{p0}\mu_n}{2\pi L^2}$.

2. $V_{bi} = U_t \ln\left(\frac{N_a N_d}{n_i^2}\right) = \cancel{0.8580\,V}$ $0.84\,V$.

$V_{p0} = V_p + V_{bi} = 3.134\,V$

$a = \sqrt{\frac{2 V_{p0} \varepsilon_{si}}{q N_a}} = \cancel{6.42\times10^{-8}\,m = 4.54\times10^{-7}\,m = 0.45\,\mu m}$ $6.6\times10^{-5}\,cm$.

$2a = \cancel{0.9\,\mu m}$ $13.2\times10^{-5}\,cm = 1.332\,\mu m$.

3. $A = [2a - 2W(x)]^2$

$I_D = A\, n q \mu_n E$.

$E = -\frac{\partial V}{\partial x}$

$W(x) = \sqrt{\frac{2\varepsilon_s}{q N_a}(V(x) + V_{bi} - V_G)}$

$\cancel{I_D =} \int_0^L I_D\,dx = -4qN_d\mu_n \int_0^{V_D} \left(a - \cancel{W(x)} \sqrt{\frac{2\varepsilon_s}{qN_d}(V(x) + V_{bi} - V_G)}\right)^2 dV$

$I_D = \frac{4qN_d\mu_n}{L}\left(a^2 V_D - \frac{4a}{3}\sqrt{\frac{2\varepsilon_s}{qN_d}}\left[(V_D + V_{bi} - V_G)^{3/2} - (V_{bi} - V_G)^{3/2}\right] + \cancel{\frac{\varepsilon_s}{qN_d}}\right.$

$\left. + \frac{\varepsilon_s}{qN_d}\left[(V_D + V_{bi} - V_G)^2 - (V_{bi} - V_G)^2\right]\right)$

扫描全能王 创建

w<a 耗尽型. $N_C = \cancel{2.8\times10^{19}}\ 4.7\times10^{17}\ cm^{-3}$.

4. $E_F = E_C + \frac{kT}{q} \cdot q \ln\left(\frac{N_D}{N_C}\right) = E_C \cancel{- 0.11 eV} - 0.04 eV$.

$V_{bi} = \phi_{Bn} - \phi_n = 0.86V$.

$W = \sqrt{\frac{2\varepsilon_s V_{bi}}{qN_d}} = 0.11 \mu m < a$.

∴耗尽型 G_0.

$I_D = \cancel{\frac{qN_d \mu_n Z a}{L}} \left(V_D - \frac{2}{3}\sqrt{\frac{1}{V_{p0}}}\left[(V_D+V_{bi}-V_G)^{3/2} - (V_{bi}-V_G)^{3/2}\right]\right)$

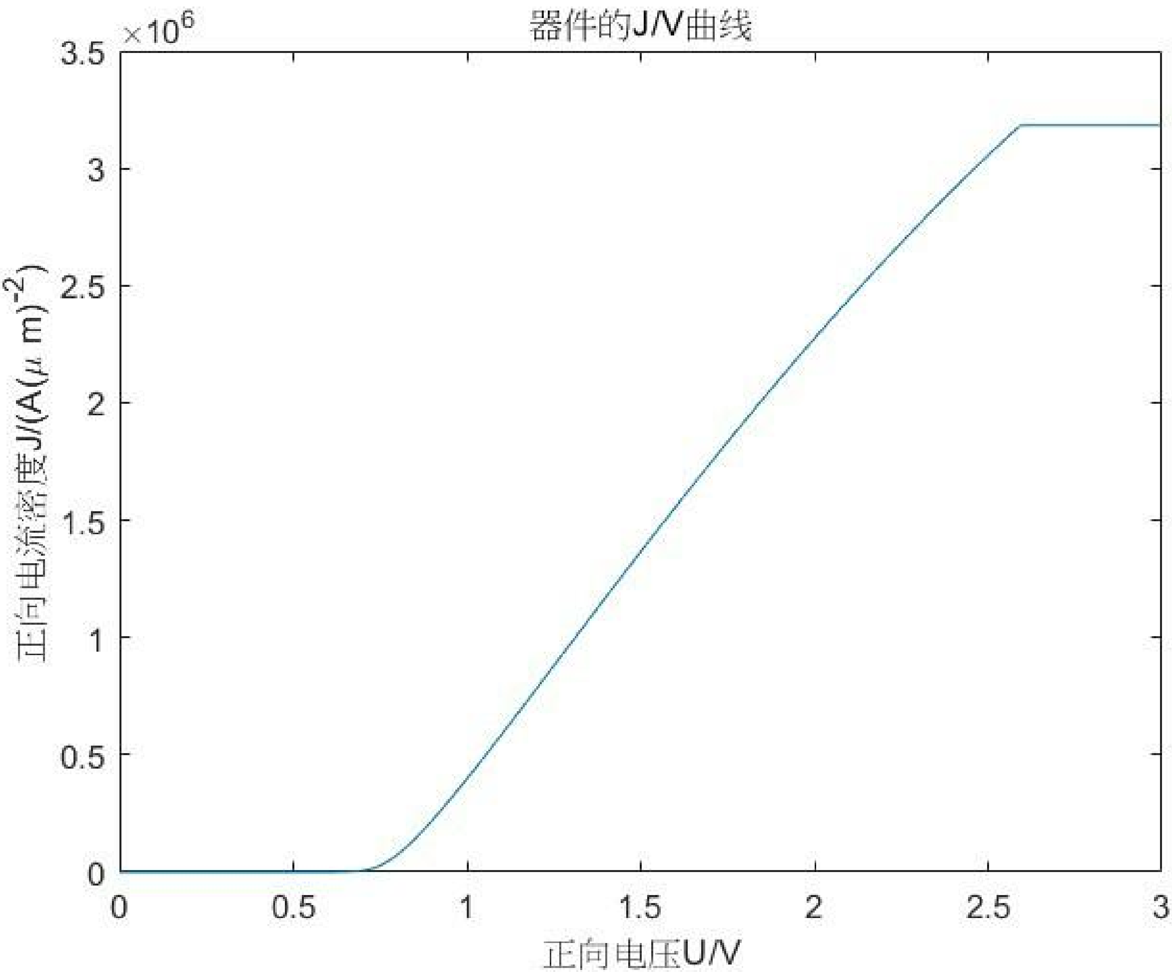
$G_0 = \frac{aqN_d \mu_n Z}{L} = 8mS$.

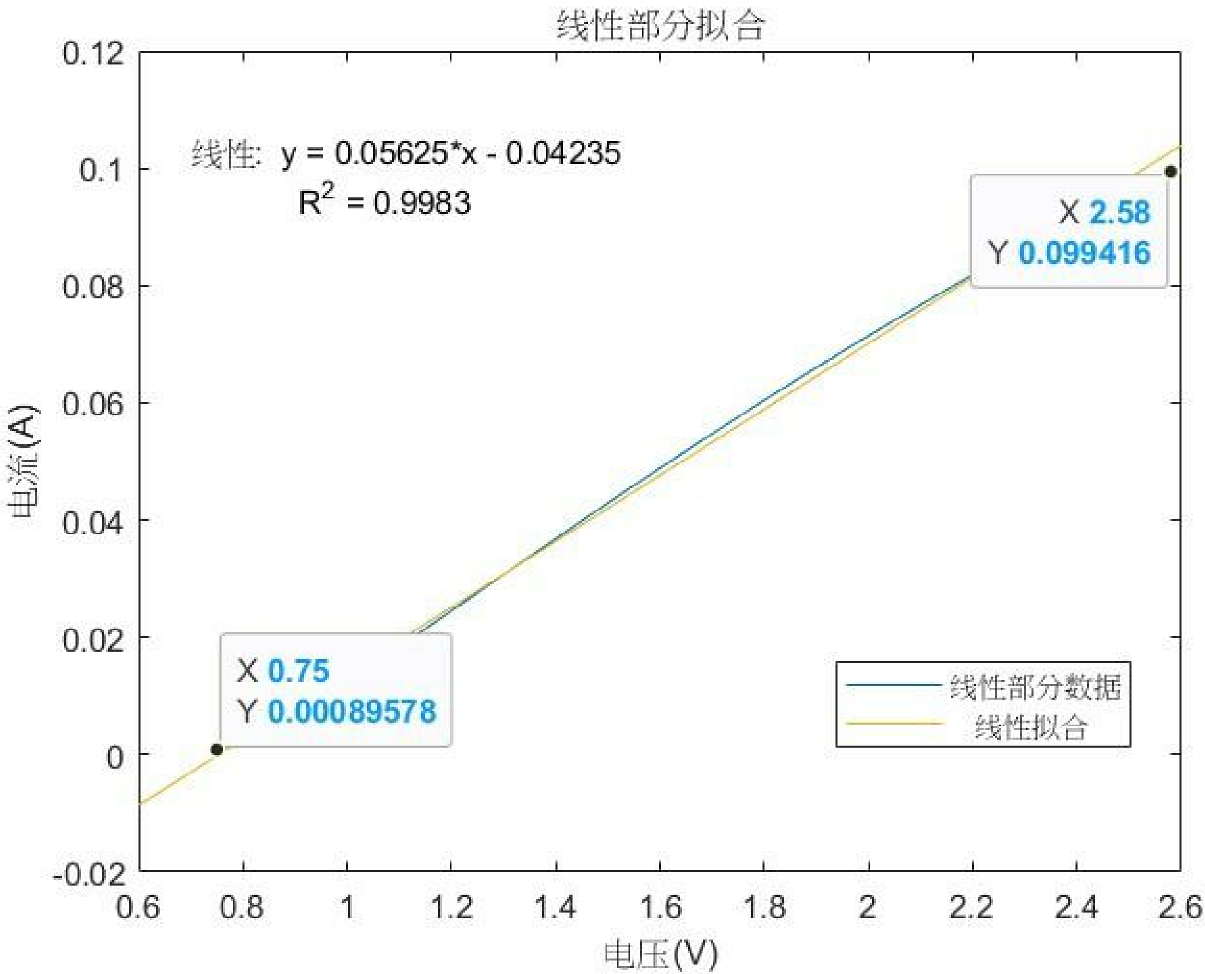
$V_{p0} = \frac{qa^2 N_d}{2\varepsilon_s} = 2.8V$.

$V_p = V_{p0} - V_{bi} = 1.94V$.

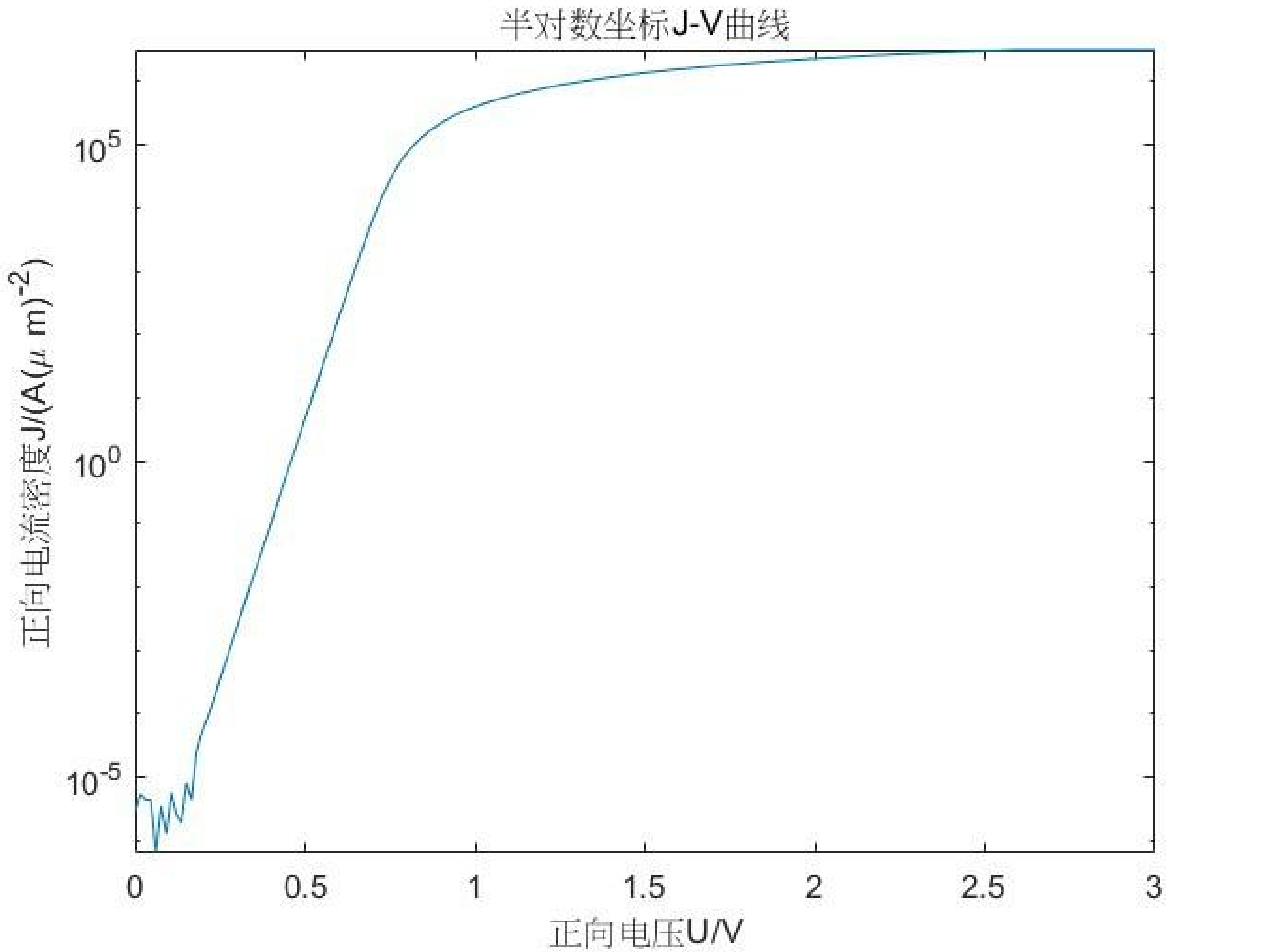
饱和区 时 $V_D = \cancel{V_{p0} - V}\ V_p + V_G$

$I_{DS}\big|_{饱和区, V_G=0} = G_0\left(\frac{2}{3}\sqrt{\frac{V_{bi}}{V_{p0}}} - 1\right) V_{bi} + \frac{1}{3} G_0 V_{p0} = 3.13 mA$

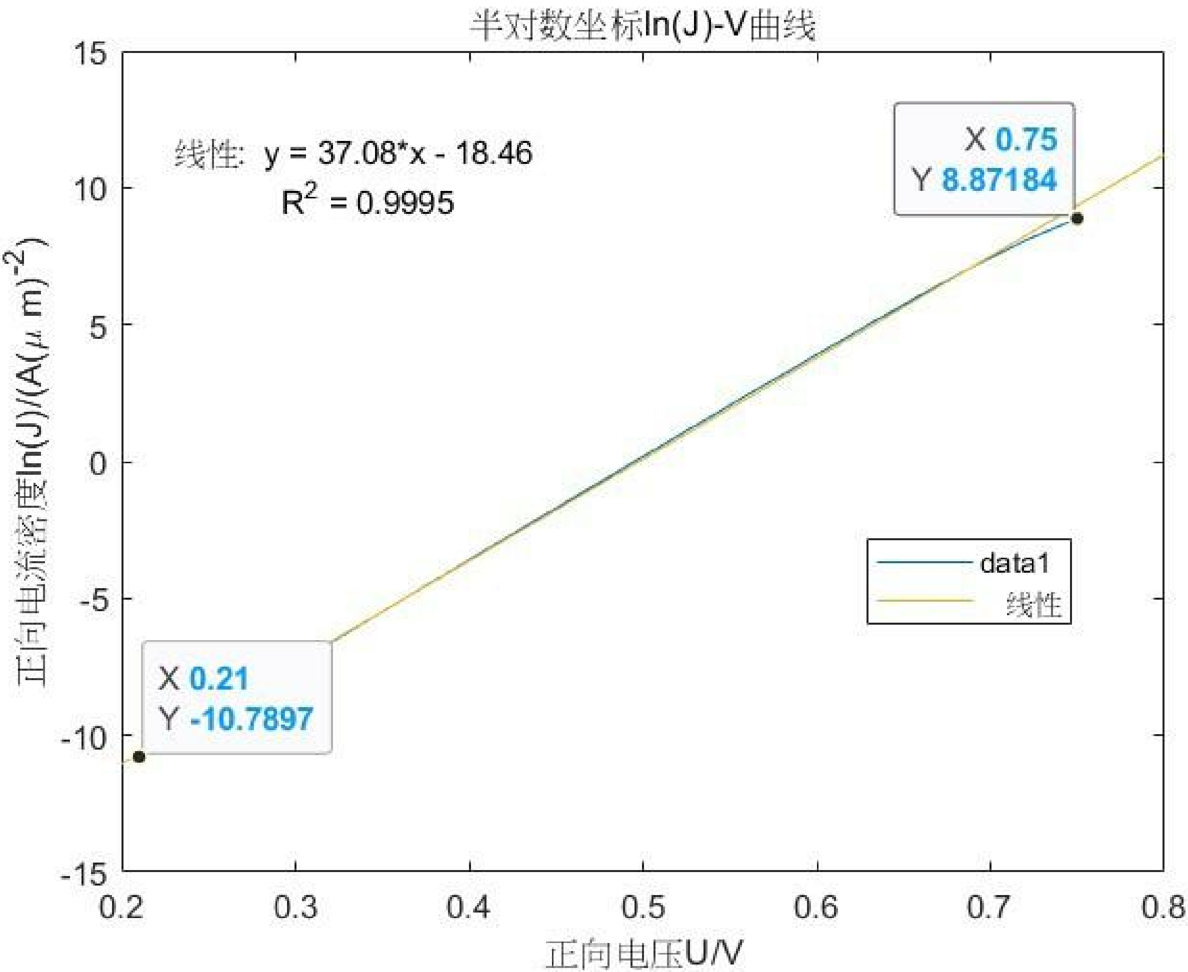

器件的J/V曲线
×10^6
3.5
3
2.5
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
3
正向电压U/V
正向电流密度J/(A(μ m)^-2)



线性部分拟合
线性: y = 0.05625*x - 0.04235
R^2 = 0.9983
X 2.58
Y 0.099416
X 0.75
Y 0.00089578
线性部分数据
线性拟合
电流(A)
电压(V)
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6



半对数坐标J-V曲线
正向电流密度J/(A(μ m)^-2)
10^5
10^0
10^-5
0
0.5
1
1.5
2
2.5
3
正向电压U/V


半对数坐标ln(J)-V曲线
线性: y = 37.08*x - 18.46
R^2 = 0.9995
X 0.75
Y 8.87184
X 0.21
Y -10.7897
data1
线性
正向电流密度ln(J)/(A(μ m)$^{-2}$)
正向电压U/V
15
10
5
0
-5
-10
-15
0.2
0.3
0.4
0.5
0.6
0.7
0.8