公式表

物理常量：	$\hbar = 1.055\times10^{-34}$ [J-s] $m_0 = 9.109\times10^{-31}$ [kg] $k_B = 1.380\times10^{-23}$ [J/K] $q = 1.602\times10^{-19}$ [C] $\varepsilon_0 = 8.854\times10^{-12}$ [F/m]
材料“硅”相关参数：	$N_C = 3.23\times10^{19}$ cm^{-3} $N_V = 1.83\times10^{19}$ cm^{-3} $n_i = 1\times10^{10}$ cm^{-3} $K_S = 11.8$
两平面之间的夹角：	$\cos\theta = \dfrac{h_1h_2 + k_1k_2 + l_1l_2}{\sqrt{h_1^2+k_1^2+l_1^2}\sqrt{h_2^2+k_2^2+l_2^2}}$
两平面之间的距离：	$d = \dfrac{1}{\lvert\vec{N}\rvert} = \dfrac{a}{\sqrt{h^2+k^2+l^2}}$
DOS: $g_C(E) = \dfrac{(m_n^*)^{3/2}\sqrt{2(E-E_C)}}{\pi^2\hbar^3}$ FF: $f(E) = \dfrac{1}{1+e^{(E-E_F)/k_BT}}$ $n_i = \sqrt{N_CN_V}e^{-E_G/2k_BT}$	
平衡载流子浓度：	$n_0 = N_Ce^{(E_F-E_C)/k_BT}$ m^{-3} $N_C = \dfrac{1}{4}\left(\dfrac{2m_n^*k_BT}{\pi\hbar^2}\right)^{3/2}$ m^{-3} $n_0 = n_i e^{(E_F-E_i)/k_BT}$ $p_0 = N_Ve^{(E_V-E_F)/k_BT}$ m^{-3} $N_V = \dfrac{1}{4}\left(\dfrac{2m_p^*k_BT}{\pi\hbar^2}\right)^{3/2}$ m^{-3} $p_0 = n_ie^{(E_i-E_F)/k_BT}$
电中性关系：	$p - n + N_D^+ - N_A^- = 0$ $n_0p_0 = n_i^2$
电导和电阻率：	$\sigma = (\sigma_n + \sigma_p) = q(n\mu_n + p\mu_p) = 1/\rho$
电流公式：	$J_n = n\mu_n\dfrac{dF_n}{dx}$ $J_n = nq\mu_n\mathcal{E}_x + qD_n\dfrac{dn}{dx}$ $D_n/\mu_n = k_BT/q$ $J_p = p\mu_p\dfrac{dF_p}{dx}$ $J_p = pq\mu_p\mathcal{E}_x - qD_p\dfrac{dp}{dx}$ $D_p/\mu_p = k_BT/q$
SRH 复合：	$R = \Delta n/\tau_n$ m^{-3}s^{-1} or $R = \Delta p/\tau_p$ m^{-3}s^{-1}
半导体公式：	$\dfrac{\partial n}{\partial t} = -\nabla\cdot\left(\dfrac{\vec{J}_n}{-q}\right) + G_n - R_n$ $\dfrac{\partial p}{\partial t} = -\nabla\cdot\left(\dfrac{\vec{J}_p}{q}\right) + G_p - R_p$ $0 = -\nabla\cdot(\varepsilon\vec{E}) + \rho$

少数载流子扩散密度：	$\frac{\partial \Delta p}{\partial t} = D_p \frac{\partial^2 \Delta p}{dx^2} - \frac{\Delta p}{\tau_p} + G_L$ $L_p = \sqrt{D_p \tau_p}$
载流子密度和QFL’s:	$n = N_C e^{(F_n - E_C)/k_B T}$ $\quad n = n_i e^{(F_n - E_i)/k_B T}$ $p = N_V e^{(E_V - F_p)/k_B T}$ $\quad p = n_i e^{(E_i - F_p)/k_B T}$
非平衡关系：	$E_F \to F_n(x), F_p(x)$ $\quad n_0 p_0 = n_i^2 \to np = n_i^2 e^{(F_n - F_p)/k_B T}$ $n_0 = N_C e^{(E_F - E_C)/k_B T} \to n = N_C e^{(F_n - E_C)/k_B T}$ $p_0 = N_V e^{(E_V - E_F)/k_B T} \to p = N_V e^{(E_V - F_p)/k_B T}$
PN 结静电关系：	$V_{bi} = \frac{k_B T}{q} \ln\left(\frac{N_D N_A}{n_i^2}\right)$ $\quad \frac{d\mathcal{E}}{dx} = \frac{\rho(x)}{K_S \varepsilon_0}$ $W = \left[\frac{2K_S \varepsilon_0}{q}\left(\frac{N_A + N_D}{N_D N_A}\right) V_{bi}\right]^{1/2}$ $\quad x_n = \frac{N_A}{N_A + N_D} W$ $\quad x_p = \frac{N_D}{N_A + N_D} W$ $\mathcal{E}(0) = \sqrt{\frac{2qV_{bi}}{K_S \varepsilon_0}\left(\frac{N_D N_A}{N_A + N_D}\right)}$
二极管电流：	$\Delta n(0) = \frac{n_i^2}{N_A}\left(e^{qV_A/k_B T} - 1\right)$ $\quad \Delta p(0) = \frac{n_i^2}{N_D}\left(e^{qV_A/k_B T} - 1\right)$ $I_D = I_0\left(e^{qV_A/k_B T} - 1\right)$ $I_0 = qA\left(\frac{D_n}{L_n}\frac{n_i^2}{N_A} + \frac{D_p}{L_p}\frac{n_i^2}{N_D}\right)$ (long) $\quad I_0 = qA\left(\frac{D_n}{W_p}\frac{n_i^2}{N_A} + \frac{D_p}{W_n}\frac{n_i^2}{N_D}\right)$ (short) non-ideal $I_D = I_0\left(e^{q(V - IR_S)/nk_B T} - 1\right)$ $\quad I_{gen} = -qA\frac{n_i}{2\tau_0} W$
小信号：	$G_d = \frac{I_D + I_0}{k_B T/q}$ $\quad C_J(V_R) = \frac{K_S \varepsilon_0 A}{\left[\frac{2K_S \varepsilon_0}{qN_A}(V_{bi} - V_A)\right]^{1/2}}$ $\quad C_D = G_d \tau_n$
MS 二极管：	$qV_{bi} = \lvert \Phi_M - \Phi_S \rvert$ $\quad \Phi_{BP} = \chi + E_G - \Phi_M$ $\quad \Phi_{BN} = \Phi_M - \chi$ $J = J_0\left(e^{qV_A/k_B T} - 1\right)$ $\quad J_0 = A^* T^2 e^{-\Phi_B/k_B T}$ $\quad A^* = \frac{4\pi q m^* k_B^2}{h^3}$
MOS 电容：	$W = \sqrt{\frac{2K_S \varepsilon_0 \phi_S}{qN_A}}$ cm $\quad \mathcal{E}_S = \sqrt{\frac{2qN_A \phi_S}{K_S \varepsilon_0}}$ V/cm $Q_B = -qN_A W(\phi_S) = -\sqrt{2qK_S \varepsilon_0 N_A \phi_S}$ C/cm^2 $V_G = V_{FB} + \phi_S + \Delta\phi_{ox} = V_{FB} + \phi_S - \frac{Q_S(\phi_S)}{C_{ox}}$ $\quad C_{ox} = K_O \varepsilon_0 / x_o$ $V_{FB} = \Phi_{ms}/q - Q_F/C_{ox}$

	$C=\dfrac{C_{ox}}{1+\dfrac{K_O W(\phi_S)}{K_S x_o}}$ $\quad V_T=-\dfrac{Q_B(2\phi_F)}{C_{ox}}+2\phi_F$ $\quad Q_n=-C_{ox}(V_G-V_T)$
MOSFETs:	$I_D=-WQ_n(y=0)\langle\upsilon_y(y=0)\rangle$ $I_D=\dfrac{W}{L}\mu_n C_{ox}(V_{GS}-V_T)V_{DS}$ $\quad I_D=WC_{ox}\upsilon_{sat}(V_{GS}-V_T)$ 平方律原理: $I_D=\dfrac{W}{L}\mu_n C_{ox}\left[(V_{GS}-V_T)V_{DS}-V_{DS}^2/2\right]$ $\quad\begin{pmatrix}0\le V_{DS}\le V_{GS}-V_T,\\ V_{GS}\ge V_T\end{pmatrix}$ $I_D=\dfrac{W}{2L}\mu_n C_{ox}(V_{GS}-V_T)^2$ $\quad\begin{pmatrix}V_{DS}>V_{GS}-V_T\\ V_{GS}\ge V_T\end{pmatrix}$
双极型晶体管: （NPN，短发射极，基极和集电极）	Ebers-Moll equations: $I_C(V_{BE},V_{BC})=\alpha_F I_{F0}\left(e^{qV_{BE}/k_BT}-1\right)-I_{R0}\left(e^{qV_{BC}/k_BT}-1\right)$ $I_E(V_{BE},V_{BC})=I_{F0}\left(e^{qV_{BE}/k_BT}-1\right)-\alpha_R I_{R0}\left(e^{qV_{BC}/k_BT}-1\right)$ $I_{F0}=qA\left(\dfrac{D_{nB}}{W_B}\dfrac{n_i^2}{N_{AB}}+\dfrac{D_{pE}}{W_E}\dfrac{n_i^2}{N_{DE}}\right)$ $I_{R0}=qA\left(\dfrac{D_{nB}}{W_B}\dfrac{n_i^2}{N_{AB}}+\dfrac{D_{pC}}{W_C}\dfrac{n_i^2}{N_{DC}}\right)$ $\alpha_F=\gamma_F\alpha_T$ $\alpha_R=\gamma_R\alpha_T$ $\alpha_F I_{F0}=\alpha_R I_{R0}$ $\gamma_F=\dfrac{I_{En}}{I_{En}+I_{Ep}}=\dfrac{1}{1+\dfrac{D_{pE}}{D_{nB}}\dfrac{W_B}{W_E}\dfrac{N_{AB}}{N_{DE}}}$ $\alpha_T=\dfrac{I_{Cn}}{I_{En}}=\dfrac{1}{1+\dfrac{1}{2}\left(\dfrac{W_B}{L_{nB}}\right)^2}$ $\beta_F=\dfrac{\alpha_F}{1-\alpha_F}$ $\alpha_F=\dfrac{\beta_F}{1+\beta_F}$