半导体物理

期末复习大纲

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重要公式

$$\boxed{D = \frac{kT}{q}\mu}$$

$$\left\{\begin{array}{l} \left.\begin{array}{l} J_{n扩} = qD_n \dfrac{dn}{dx} \\ J_{n漂} = qn\mu_n E \end{array}\right\} \Rightarrow J_n = n\mu_n \dfrac{dE_F}{dx} \\ J_{p扩} = -qD_p \dfrac{dp}{dx} \\ J_{p漂} = qp\mu_p E \end{array}\right.$$

pn结

$$\boxed{V_D = \frac{kT}{q}\ln\left(\frac{N_A N_D}{n_i^2}\right)}$$

$$\boxed{n(x) = n_{p0}\exp\left[\frac{qV(x)}{kT}\right]}$$

$$\boxed{p(x) = p_{p0}\exp\left[-\frac{qV(x)}{kT}\right]}$$

重要公式

突变结耗尽近似

pn结

$$d=\left(\frac{2\varepsilon_0\varepsilon_r}{q}\frac{(V_D-V)}{N}\right)^{1/2}$$

$$\Delta n(x)=\Delta n(-x_p)\exp\left(\frac{x+x_p}{L_n}\right) \leftarrow \Delta n(-x_p)=n_{p0}\left[\exp\left(\frac{qV}{kT}\right)-1\right]$$

$$\Delta p(x)=\Delta p(x_n)\exp\left(-\frac{x-x_n}{L_p}\right) \leftarrow \Delta p(x_n)=p_{n0}\left[\exp\left(\frac{qV}{kT}\right)-1\right]$$

$$J_s=\left(\frac{qD_p n_i^2}{L_p N_D}+\frac{qD_n n_i^2}{L_n N_A}\right)\quad p_{n0}=\frac{n_i^2}{N_D}\quad n_{p0}=\frac{n_i^2}{N_A} \rightarrow J=J_s\left[\exp\left(\frac{qV}{kT}\right)-1\right]$$

重要公式

$$\boxed{q\phi_{ns} = W_m - \chi}$$

$$\boxed{d = \left[\frac{2\varepsilon_0\varepsilon_r}{qN_D}\left(V_D - V\right)\right]^{\frac{1}{2}}}$$

金半接触

$$\boxed{\begin{aligned} J(V) &= J_{s\to m}(V) + J_{m\to s}(0) \\ &= A^{*}T^{2}\exp\left(-q\phi_{ns}/kT\right)\left[\exp\left(qV/kT\right) - 1\right] \end{aligned}}$$

重要公式

半导体表面与MIS结构

$$\boxed{V_s = -\frac{E_{is} - E_{ib}}{q}}$$

$$\boxed{E(x) = \pm \frac{2kT}{qL_D} F\left(\frac{qV(x)}{kT}, \frac{n_{p0}}{p_{p0}}\right)} \leftarrow L_D = \left(\frac{2\varepsilon_s kT}{q^2 p_{p0}}\right)^{1/2}$$

$$F\left(\frac{qV}{kT}, \frac{n_{p0}}{p_{p0}}\right) = \left\{\left[\exp\left(-\frac{qV}{kT}\right) + \frac{qV}{kT} - 1\right] + \frac{n_{p0}}{p_{p0}}\left[\exp\left(\frac{qV}{kT}\right) - \frac{qV}{kT} - 1\right]\right\}^{1/2}$$

$$\boxed{C_{FB} = \lim_{V_s \to 0} \frac{dQ_s}{dV_s} = \frac{\sqrt{2}\varepsilon_s}{L_D}\left(1 + \frac{n_{p0}}{p_{p0}}\right)^{1/2} \approx \frac{\sqrt{2}\varepsilon_s}{L_D}}$$

$$\boxed{d_{\max} = \left(\frac{2\varepsilon_s}{q}\frac{2V_B}{N_A}\right)^{1/2}}$$

重要公式

$$\frac{1}{C}=\frac{dV_G}{dQ}=\left|\frac{dV_{ox}}{dQ_m}\right|+\left|\frac{dV_s}{dQ_s}\right|=\frac{1}{C_{ox}}+\frac{1}{C_s}$$

$$C_{FB}=C_{ox}\Big/ 1+\frac{\varepsilon_{ox}}{d_{ox}}\left(\frac{kT}{q^2N_A\varepsilon_s}\right)^{\frac{1}{2}}$$

$$\frac{C'_{\min}}{C_{ox}}=\frac{1}{1+\dfrac{\varepsilon_{ox}}{\varepsilon_s}\dfrac{\left[\dfrac{4\varepsilon_s kT}{q^2N_A}\ln\left(\dfrac{N_A}{n_i}\right)\right]^{1/2}}{d_{ox}}}$$

$$V_{FB}=-V_{ms}-\frac{Q_f}{C_{ox}}-\frac{1}{C_{ox}}\int_0^{d_{ox}}\frac{x}{d_{ox}}\rho(x)dx$$

半导体表面与MIS结构

重要基础知识

$$\frac{d^2V(x)}{dx^2} = -\frac{\rho(x)}{\varepsilon_0\varepsilon_r}$$

$$\oint\!\!\!\oint_S \vec{E}\cdot d\vec{s} = \frac{Q}{\varepsilon_0\varepsilon_r}$$

$$V = -\int E(x)dx$$

$$\rho(x) = q\left(N_D^+ - N_A^- + p - n\right)$$

$$C = \frac{\varepsilon_0\varepsilon_r}{d}$$

玻尔兹曼统计

耗尽近似

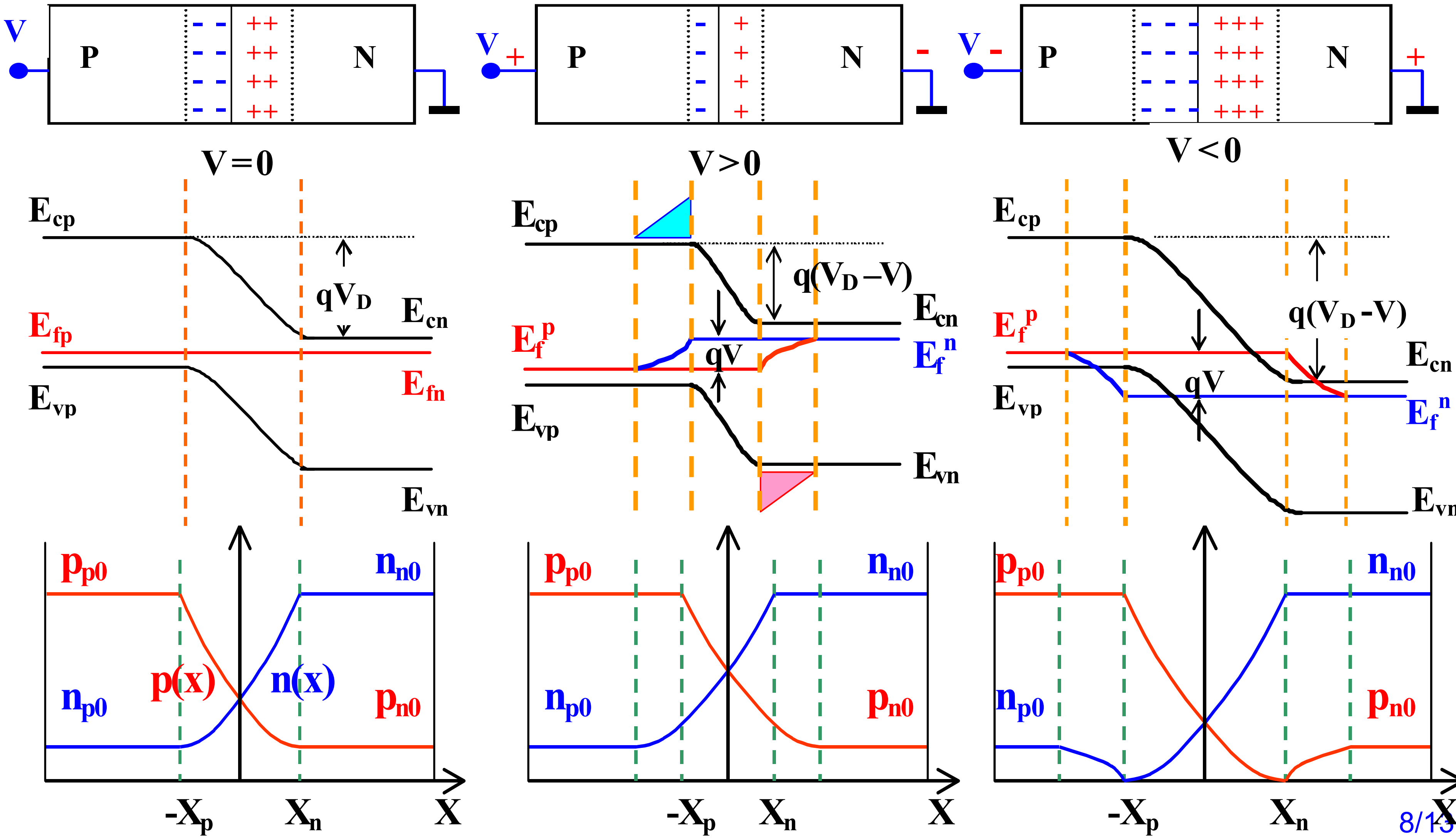
$$R_H = \frac{A}{q}\frac{(p-nb^2)}{(p+nb)^2} \leftarrow \left(\frac{\mu_H}{\mu}\right)_n = \left(\frac{\mu_H}{\mu}\right)_p = \frac{\mu_H}{\mu} = A$$

重要物理图象

非平衡p-n结的能带图

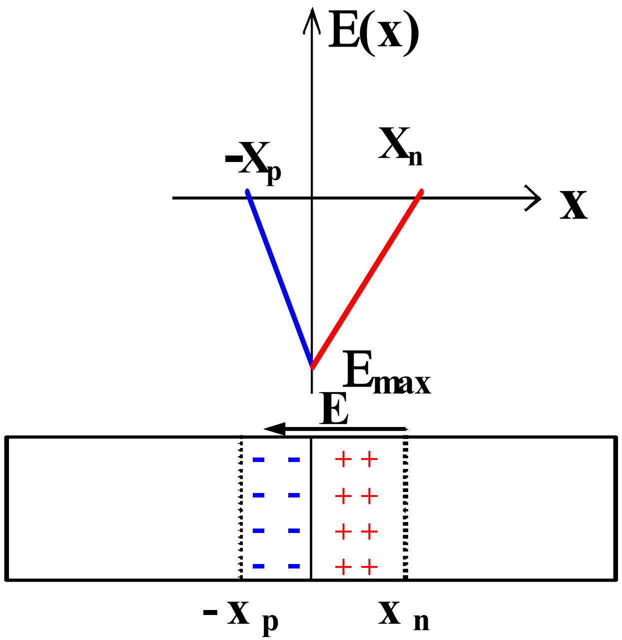
—非平衡p-n结的能带图

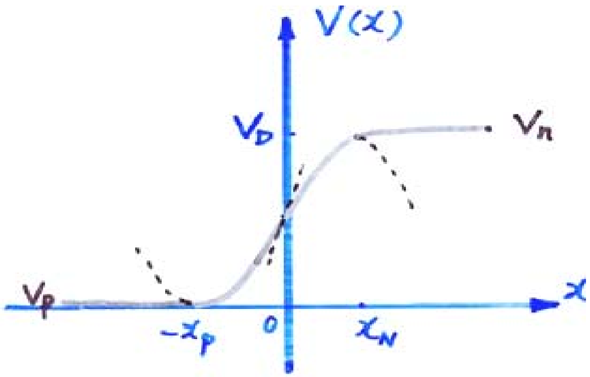
—电压完全降在势垒区



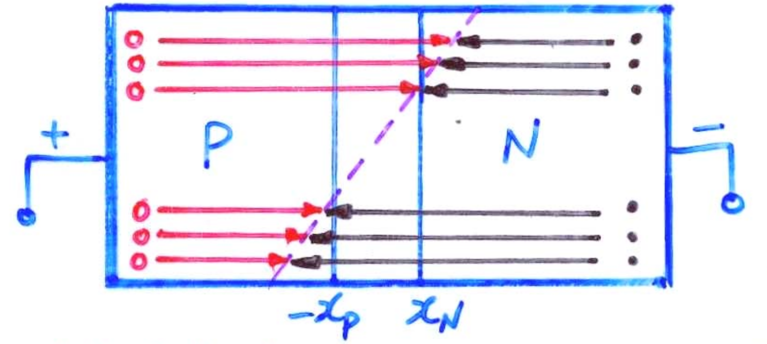
重要物理图象

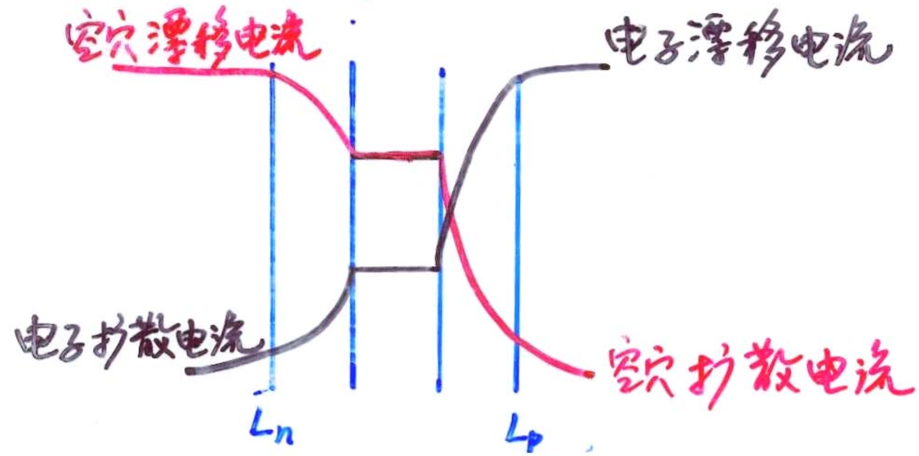
p-n结中的电场和电势分布





四种电流的动态平衡



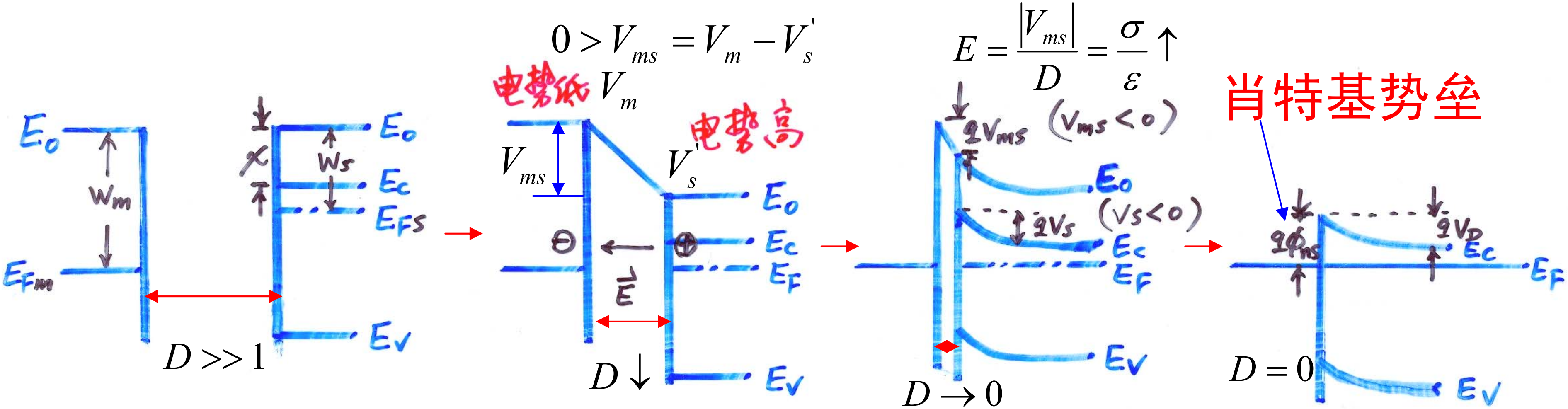


中性区	扩散区	耗尽区	扩散区	中性区

P型　　N型

重要物理图象

金半接触电势差和肖特基势垒的形成



$(W_m > W_s)$

$$q\boxed{V_{ms}} = W_s - W_m$$

接触电势差 $V_{ms} = V_m - V_s'$

$$qV_{ms} + q\boxed{V_s} = W_s - W_m$$

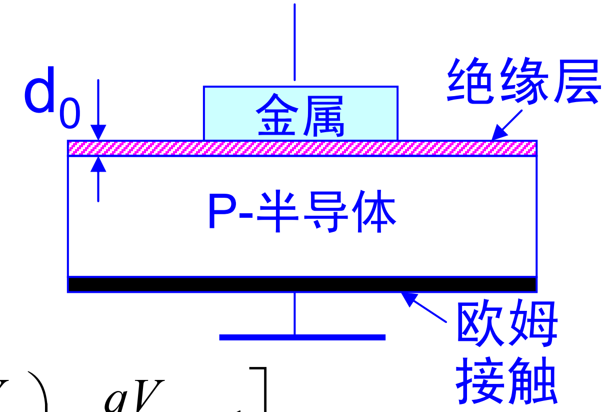
表面势：半导体表面和体内的电势差

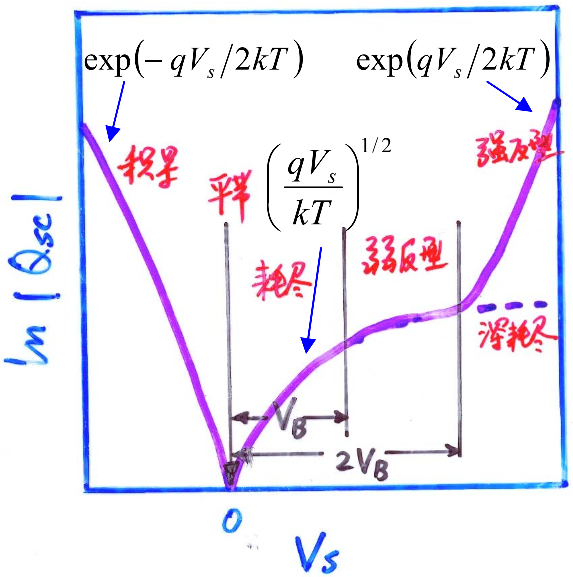
$$q\phi_{ns} = W_m - \chi$$

$$qV_D = W_m - W_s$$

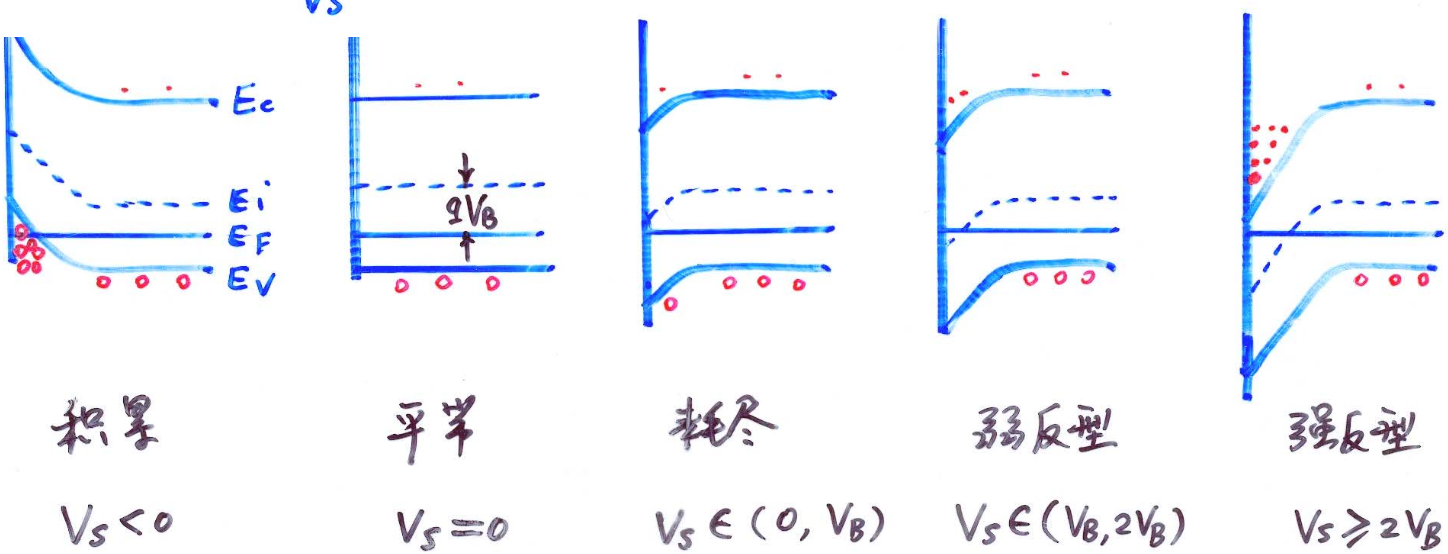
重要物理图象

半导体表面层的五种基本状态



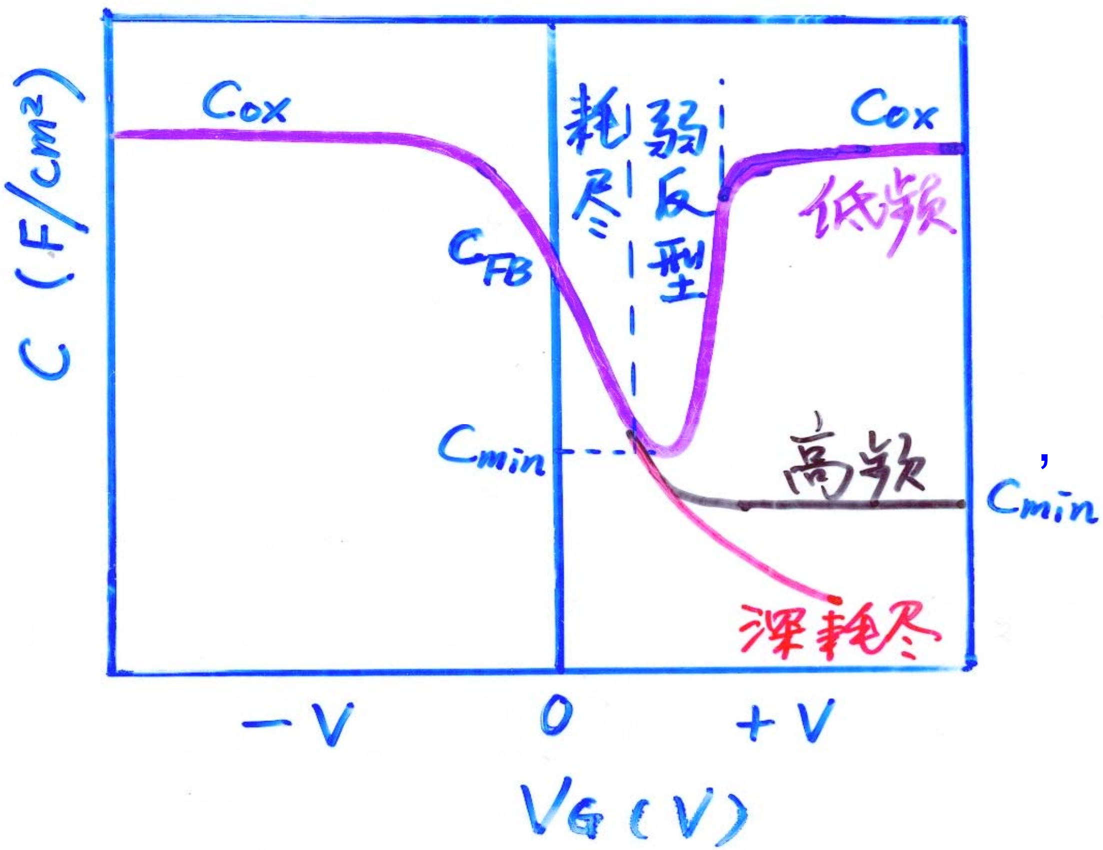


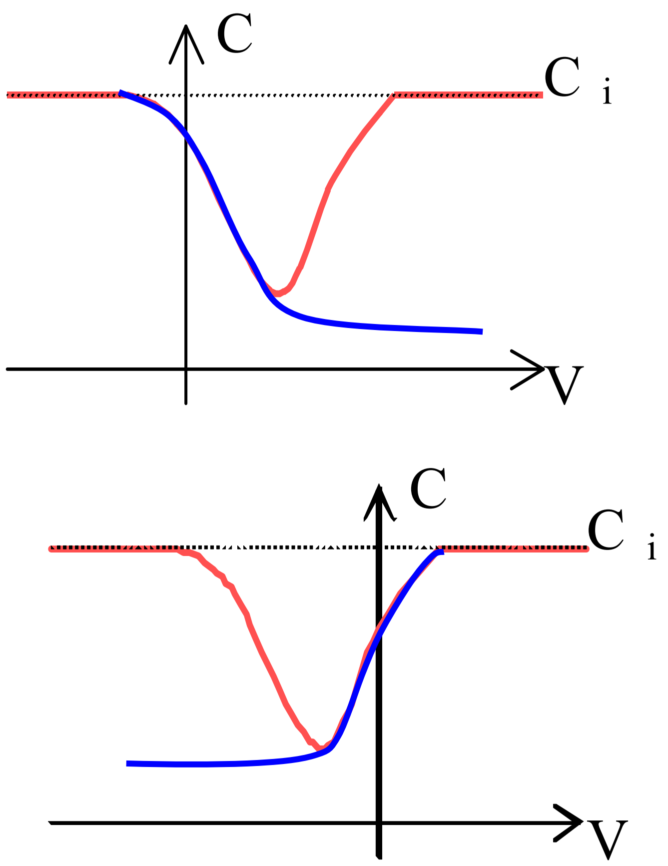
$$Q_s \propto E_s \propto F(V_s) = \left\{\left[\exp\left(-\frac{qV_s}{kT}\right) + \frac{qV_s}{kT} - 1\right] + \frac{n_{p0}}{p_{p0}}\left[\exp\left(\frac{qV_s}{kT}\right) - \frac{qV_s}{kT} - 1\right]\right\}^{1/2}$$



重要物理图象

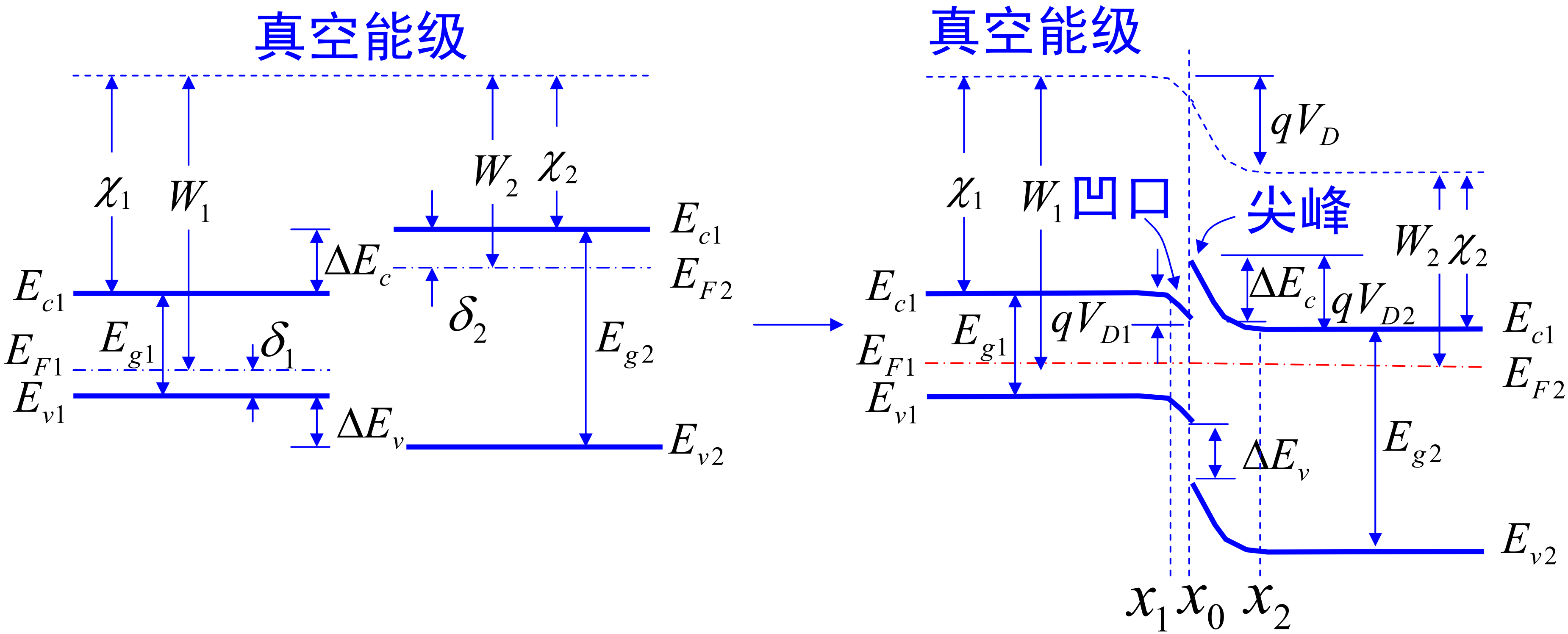
MIS电容的C－V特性





重要物理图象

异质结的能带图



复习提示

- 讲义、视频必看
- 书本、作业通读有帮助
- 基本常数、核心公式、重要物理图像要记牢
- 各个概念、基础物理常识要熟悉
- 该理解的要自己推导一遍，理顺思路
- 上课只讲n（p）型Si的内容，最好自己推导对应的p（n）型Si的内容。
- 复习大纲只是重点提示，考试内容则覆盖全部授课内容。