Semiconductor Materials

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材料工学科 Department of Materials Science

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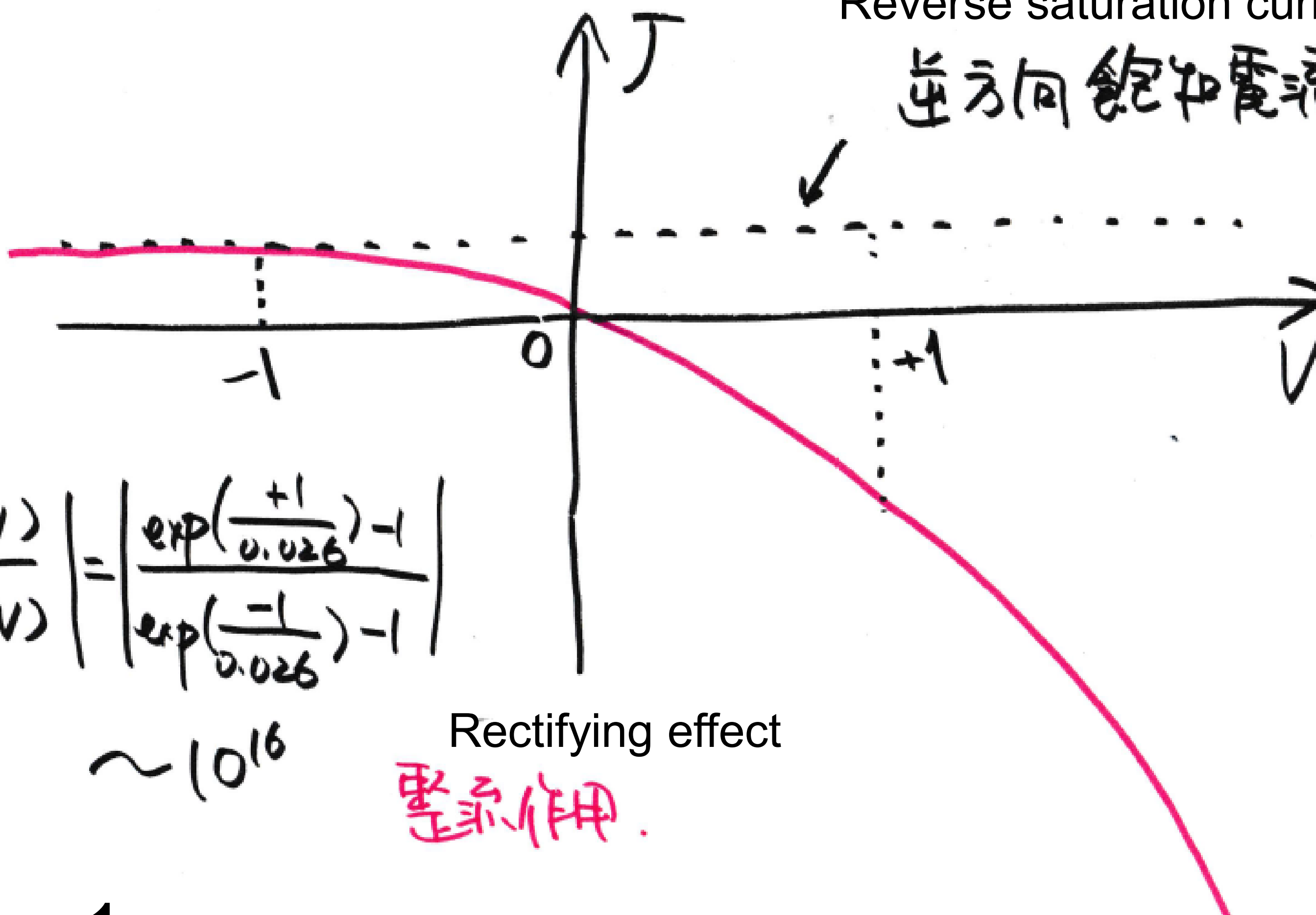


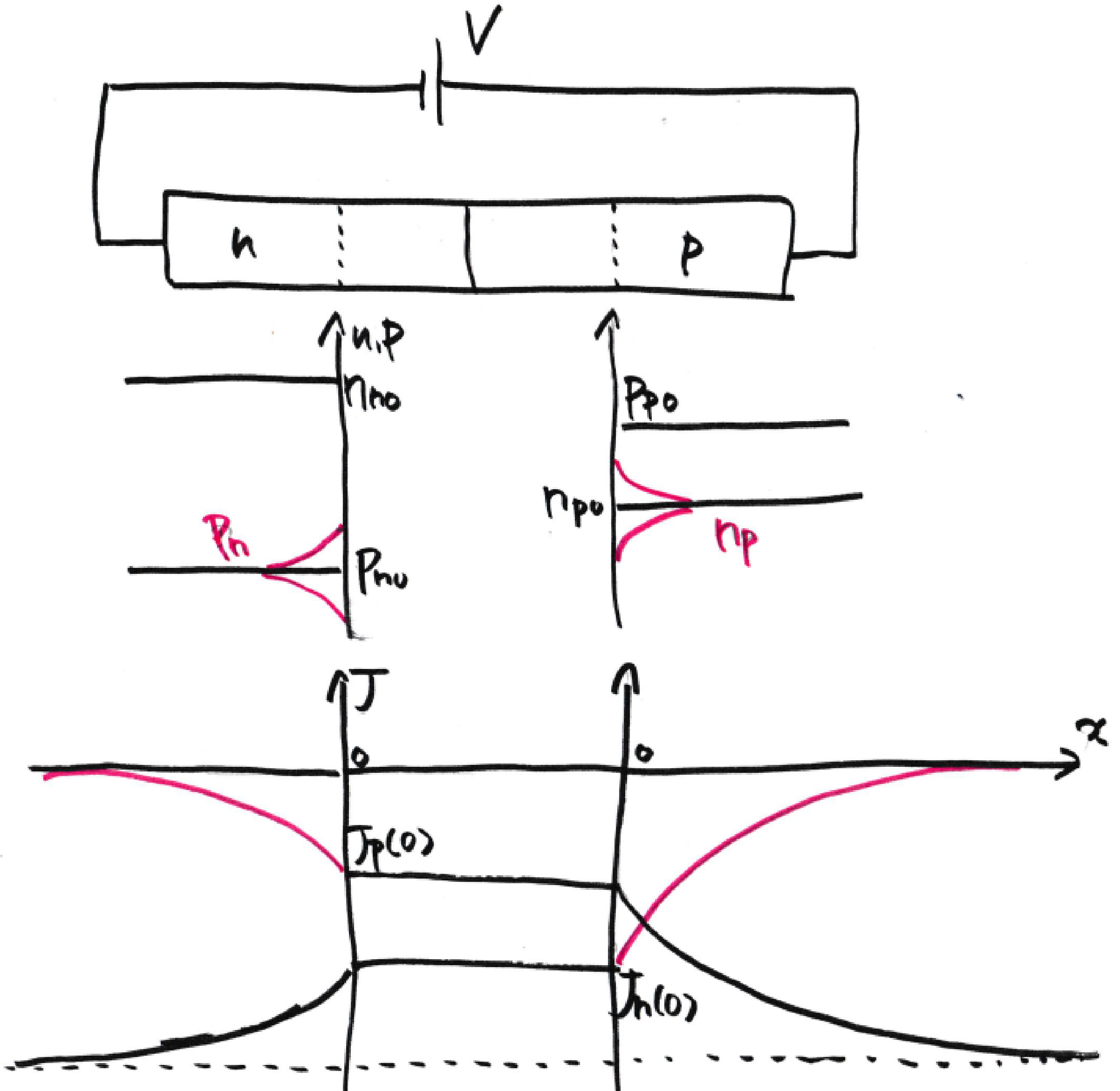
$$\left|\frac{J(+1V)}{J(-1V)}\right| = \left|\frac{\exp\left(\frac{+1}{0.026}\right)-1}{\exp\left(\frac{-1}{0.026}\right)-1}\right|$$

$$\sim 10^{16}$$

Exercise 1

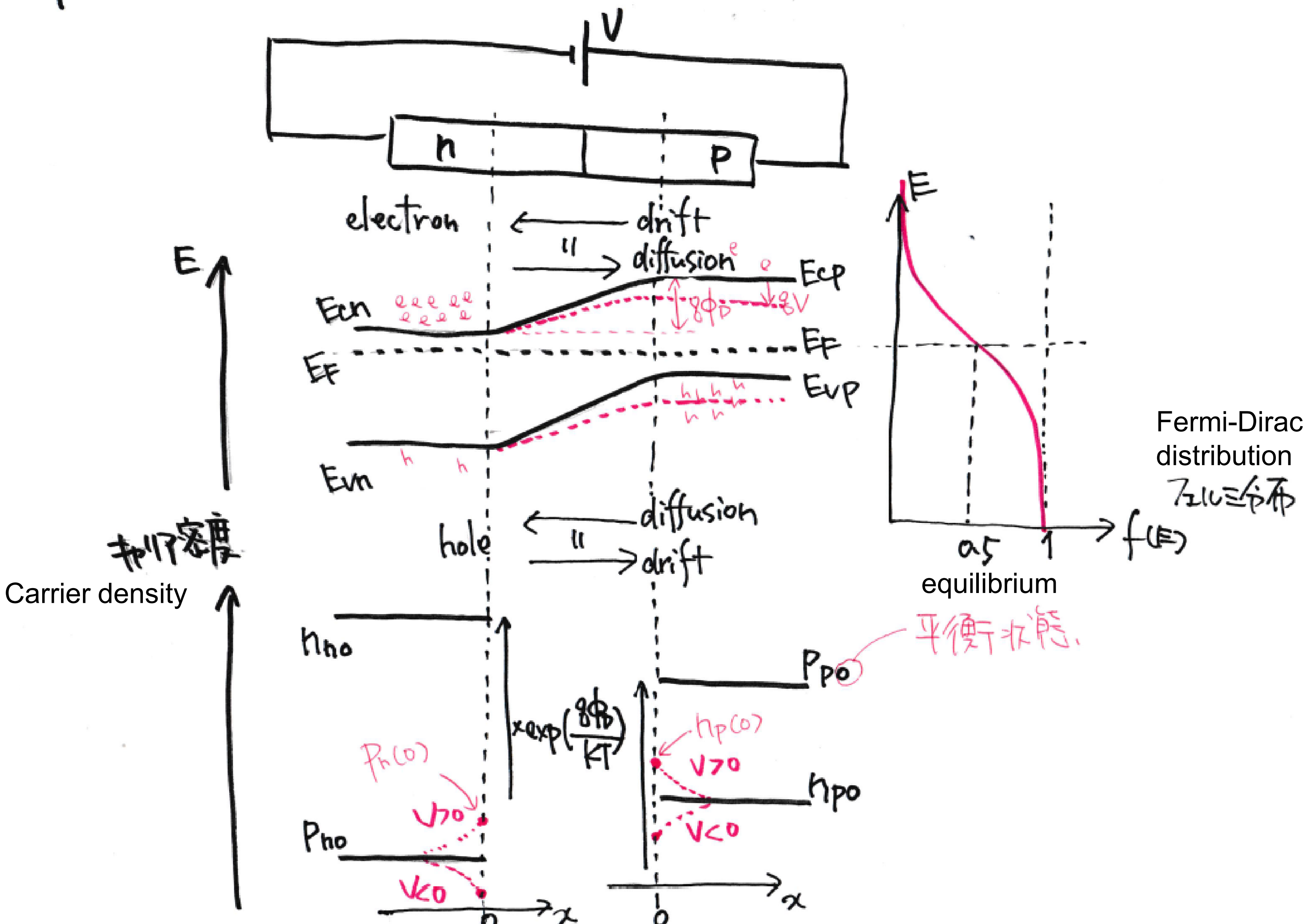
pn接合（室温）において、バイアスが+1(V)、-1(V)のときの電流値の比を求めよ。

Evaluate the ratio of current across a pn junction at V=+1(V) and -1(V) at room temperature.



$$J_{total} = J_n(0) + J_p(0) = \left(-\frac{qD_n}{\sqrt{D_n \tau_n}} n_{po} - \frac{qD_p}{\sqrt{D_p \tau_p}} p_{no} \right) \left\{ \exp\left(\frac{qV}{kT}\right) - 1 \right\} \quad \cdots\cdots (1)$$

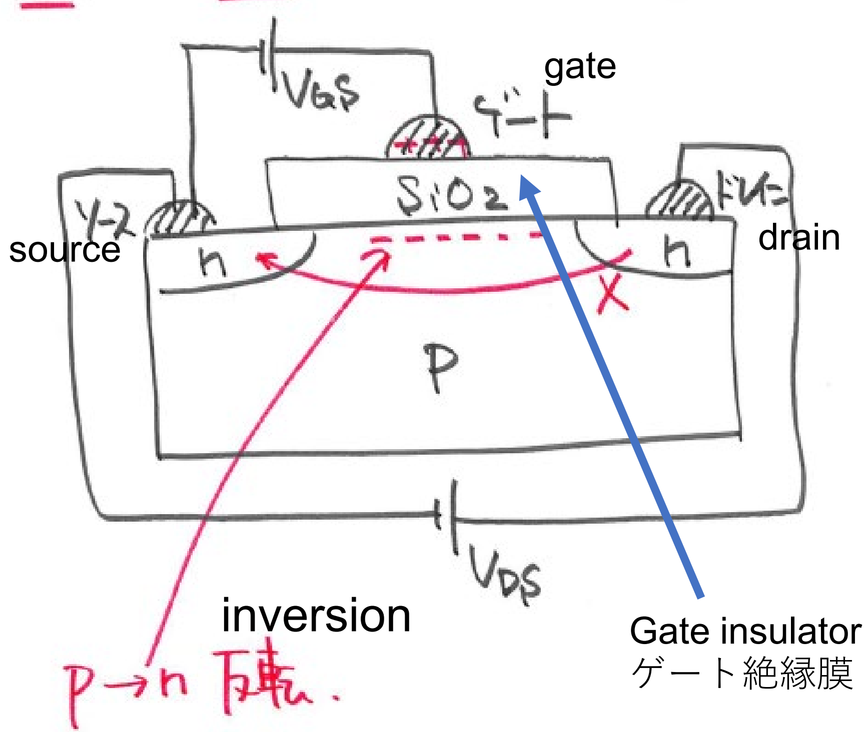
pn接合における電気伝導 Electrical current through the pn junction



電界効果トランジスタ.

MOS FET.

Metal **O**xide **S**emiconductor **F**ield **E**ffect **T**ransistor.



増幅. amplification

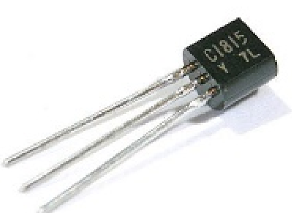
スイッチ. switch

↓

Logic circuit

- 論理回路(CPU)
- メモリ Memory device
- ディスプレイ.

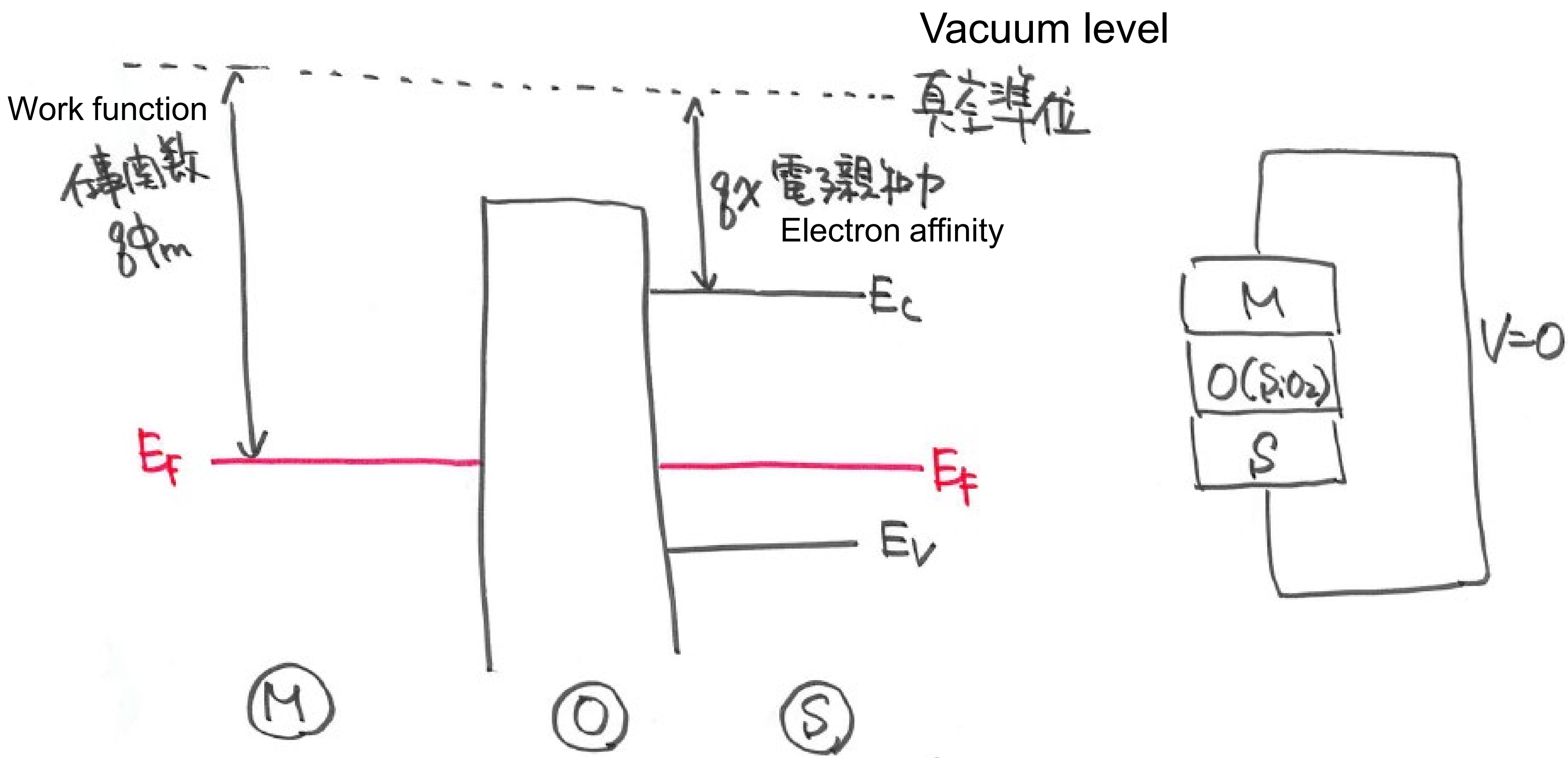
Display device



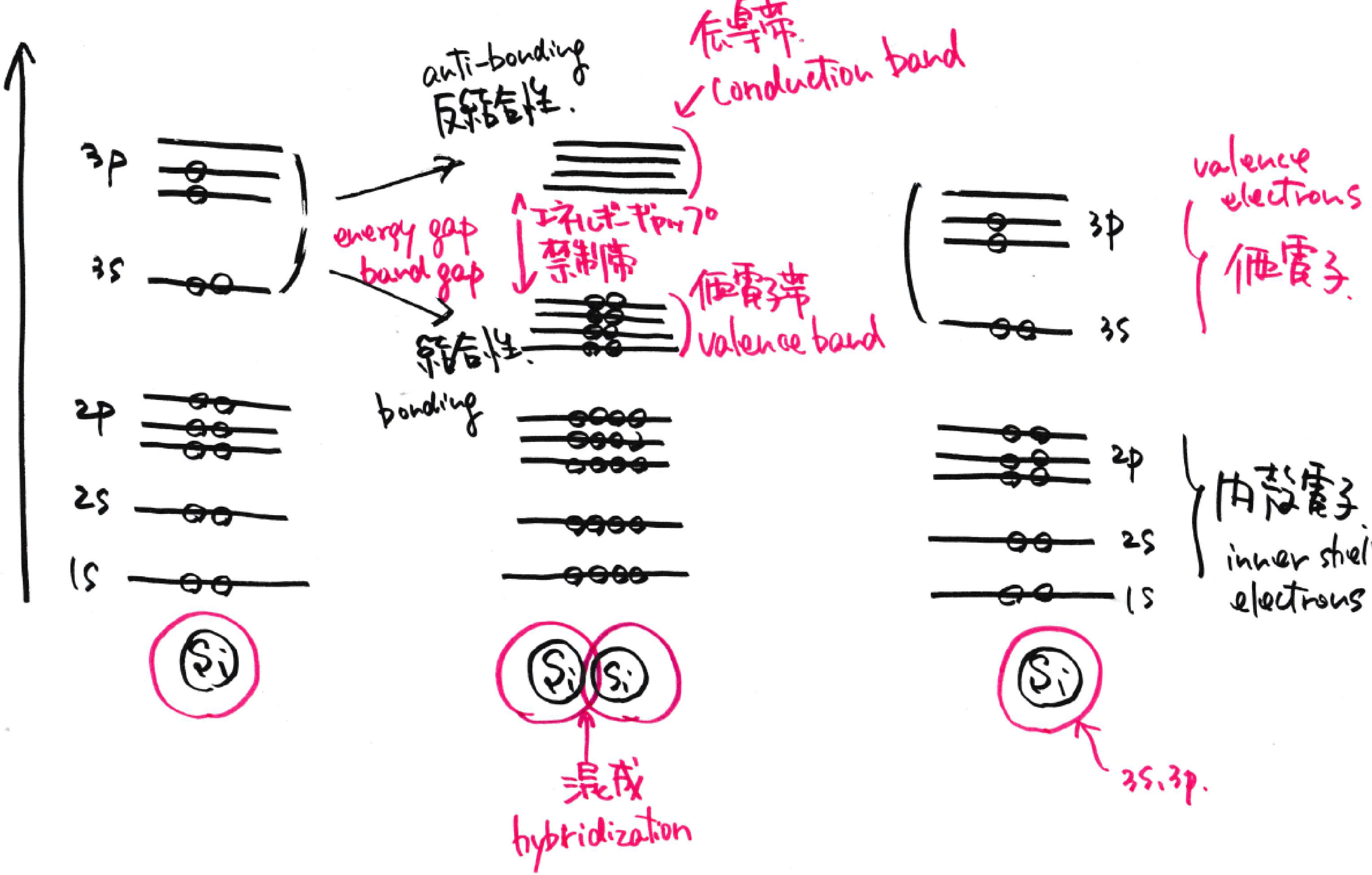
N-channel transistor

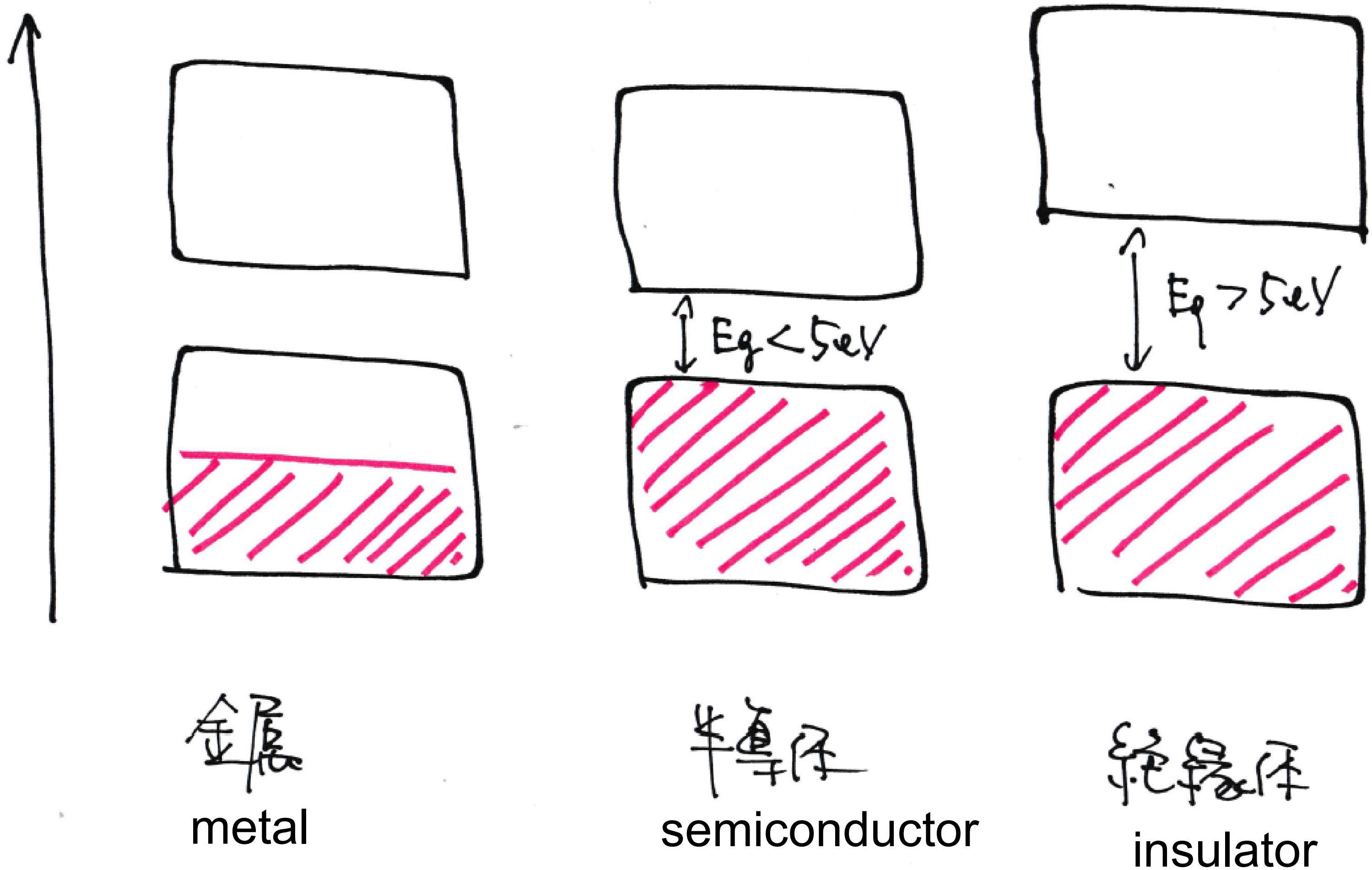
equilibrium

平衡状態 (V=0)



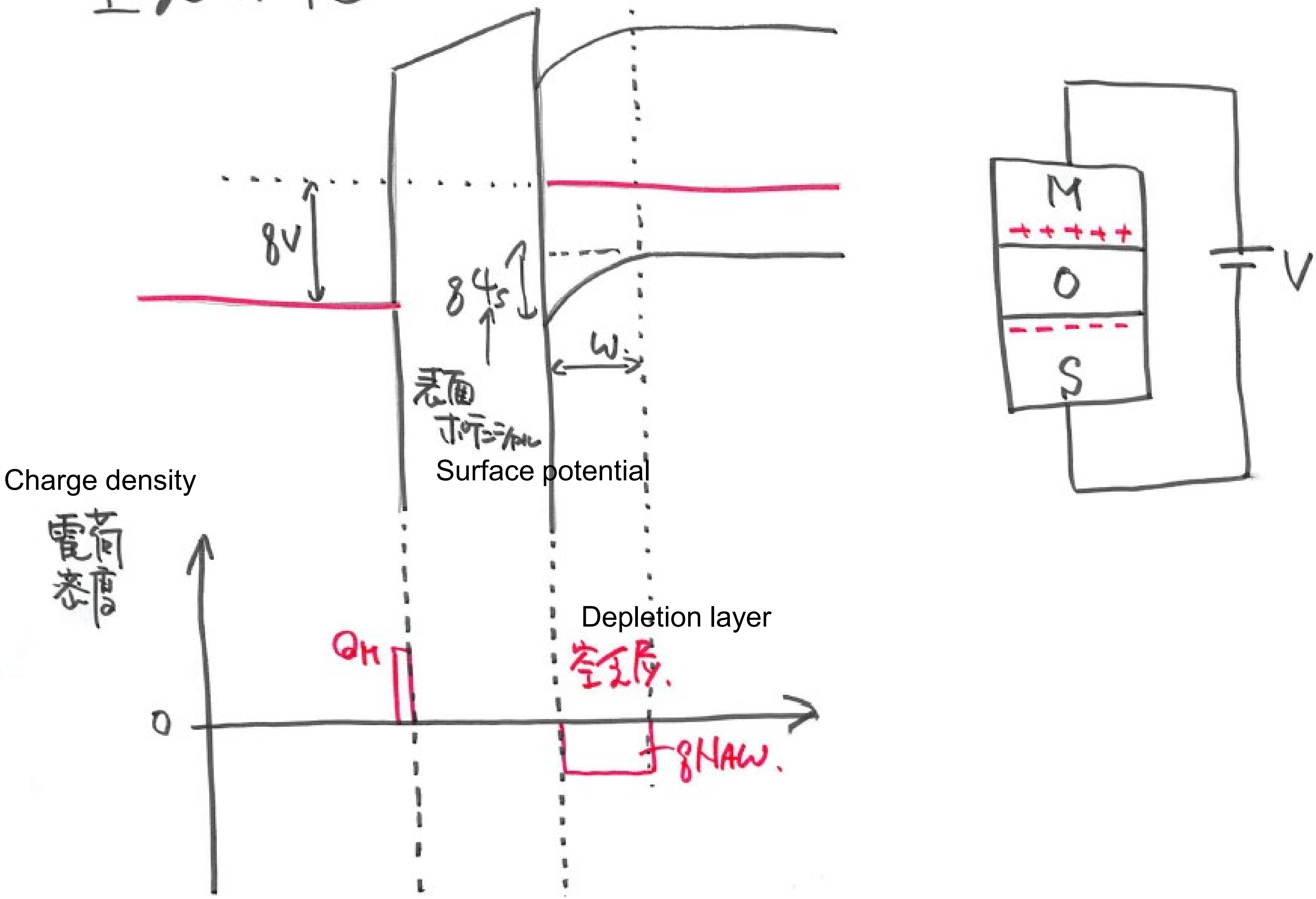
バンド構造の形成　Band structure of Si




Eg < 5eV
Eg > 5eV
金属
metal
半導体
semiconductor
絶縁体
insulator

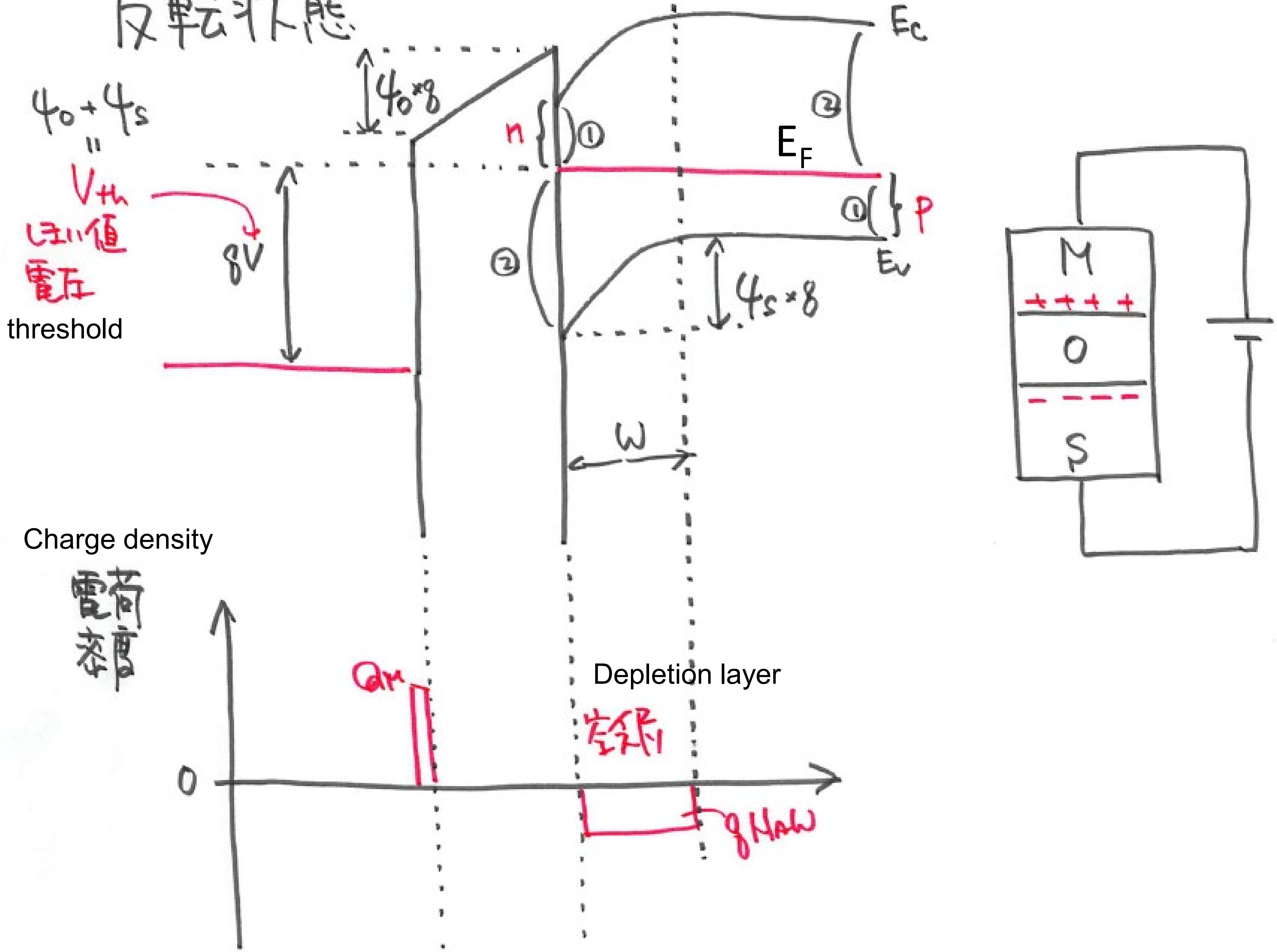
Depletion

空乏状態



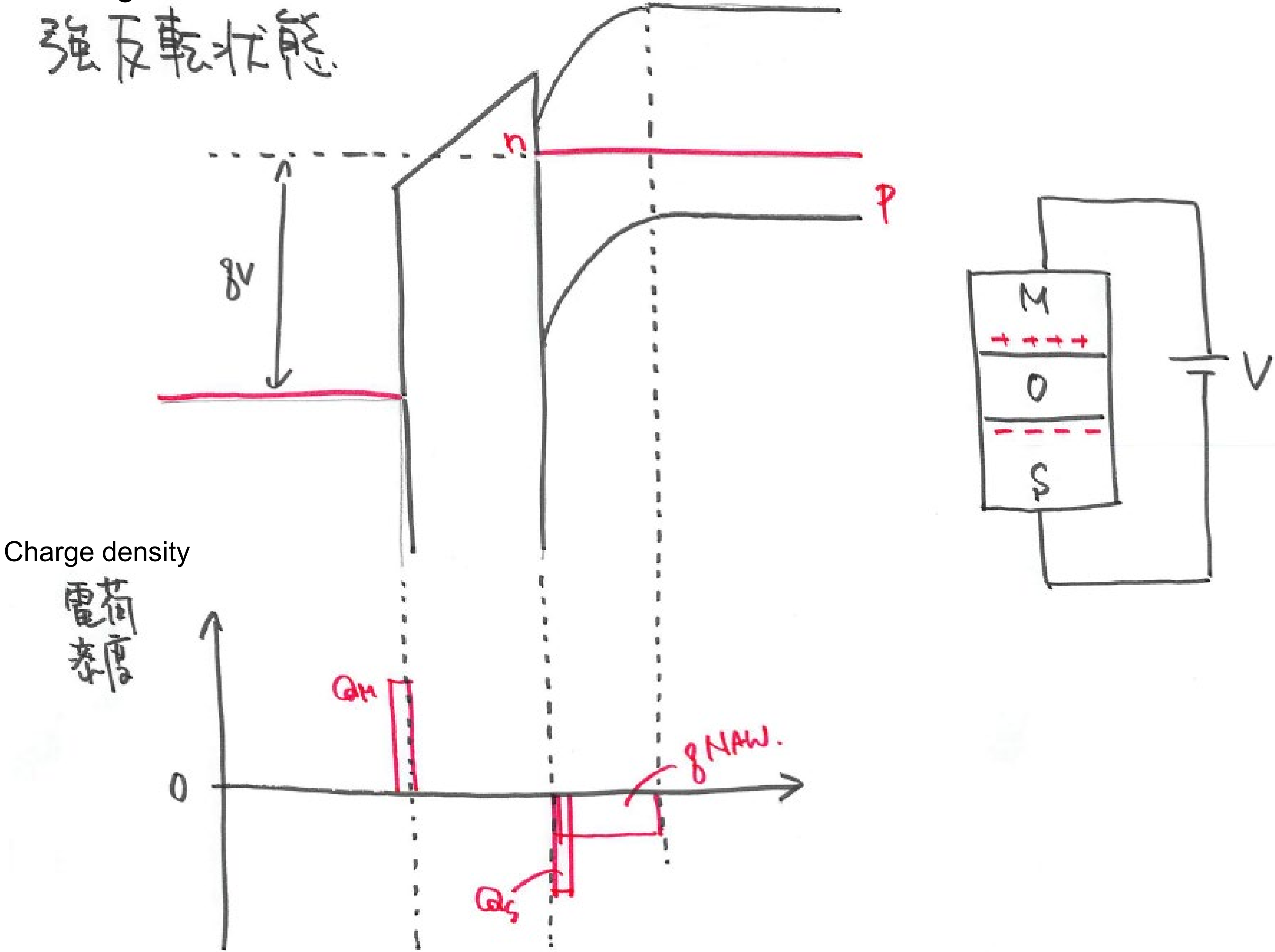
Inversion

反転状態



Strong inversion

強反転状態



伝導電子密度

Conduction electron density

$$n = N_c \exp\left(-\frac{E_c - E_F}{kT}\right)$$

ホール密度

Hole density

$$p = N_v \exp\left(-\frac{E_F - E_v}{kT}\right)$$

Exercise1

Derive the surface potential (Ψ_S) at the onset of inversion when the acceptor density in Si (N_A) is 1×10^{16} /cm^3.

Si のアクセプター濃度(N_A) を 1×10^{16} /cm^3　とする。
反転状態における表面ポテンシャル (Ψ_S) を求めよ.

Band gap

(Siのバンドギャップ $E_g = 1.12\,\mathrm{eV}$, $kT = 0.026\,\mathrm{eV}$ at 300K,
$N_v = 2.66 \times 10^{19}/\mathrm{cm}^3$, $q = 1.6 \times 10^{-19}$

permittivity

$\varepsilon_s = 11.9 \times 8.85 \times 10^{-12}\,\mathrm{F/m}$ (Siの誘電率)
$\varepsilon_{ox} = 3.9 \times 8.85 \times 10^{-12}\,\mathrm{F/m}$ (SiO_2 〃))

permittivity

$$C_{ox} = \frac{\varepsilon_{ox}}{t}$$