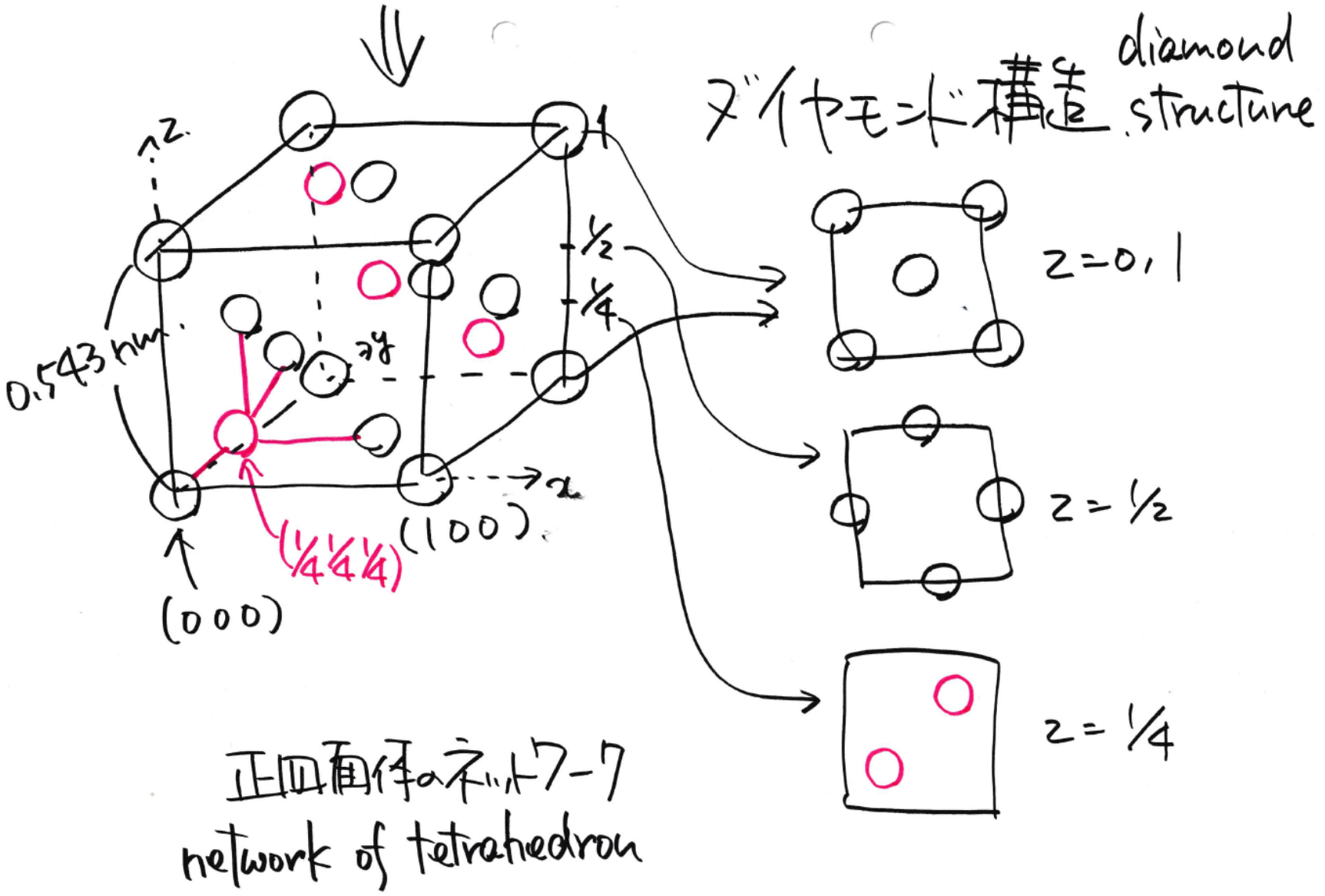
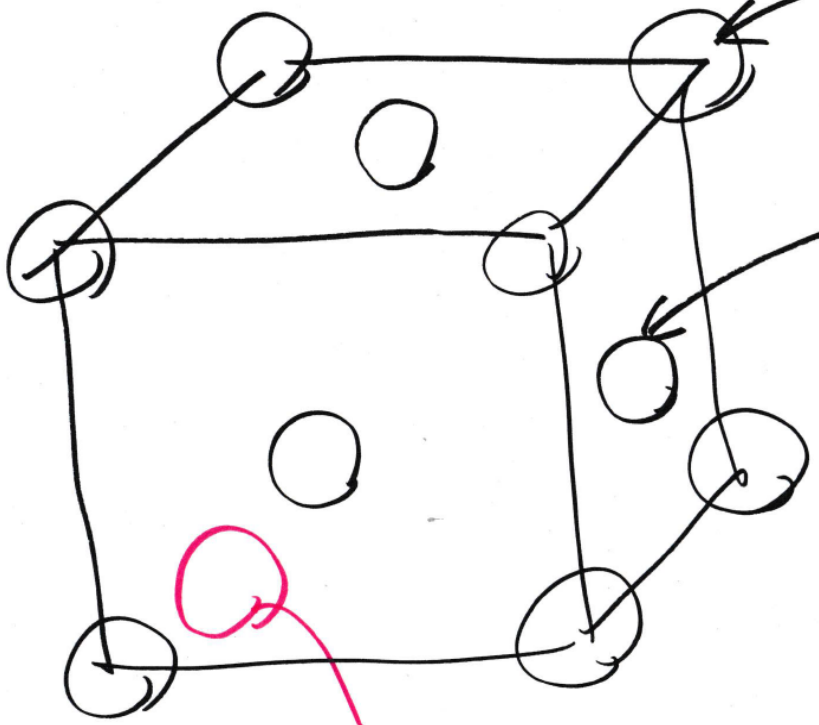
演習1　1 cm^3 中に存在する Si 原子の原子数を求めよ。

Exercise 1
Evaluate the number of Si atoms in 1 cm^3.



正四面体のネットワーク
network of tetrahedron



$\frac{1}{8} \times 8 = 1$

$\frac{1}{2} \times 6 = 3$

$1 \times 4 = 4$

8 atoms in a cube

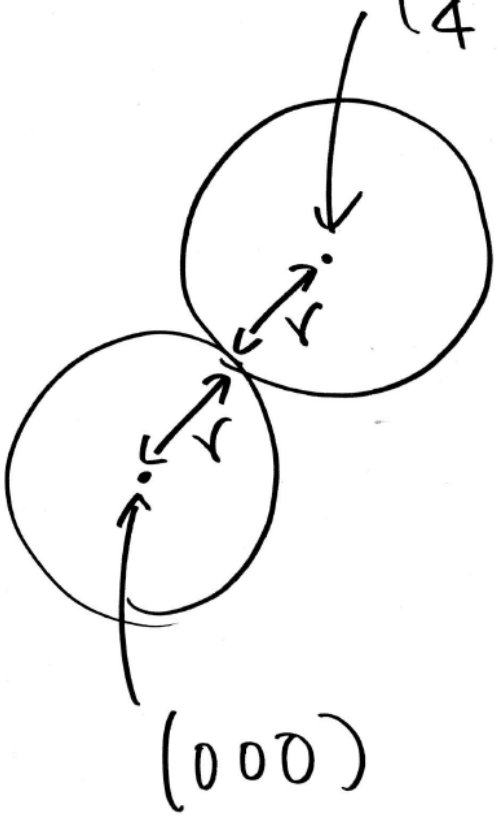
$$\frac{8 \text{ atoms}}{(0.543 \text{ nm})^3} = \frac{8}{(0.543 \times 10^{-7} \text{ cm})^3}$$

$$= 5 \times 10^{22} / \text{cm}^3$$

演習2　ダイヤモンド構造の充填率を計算せよ。

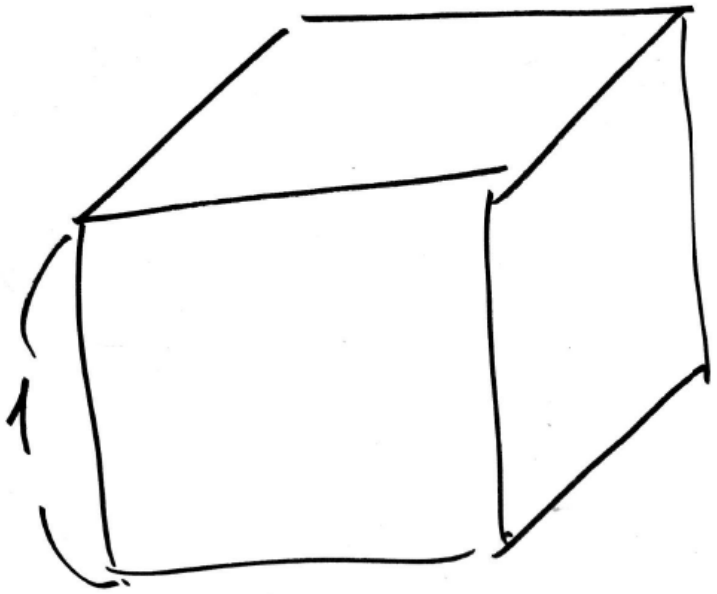
Exercise 2

Derive the volume fraction occupied by atomic spheres in the diamond structure.



$$2r = \frac{\sqrt{3}}{4}$$

$$\therefore r = \frac{\sqrt{3}}{8}$$

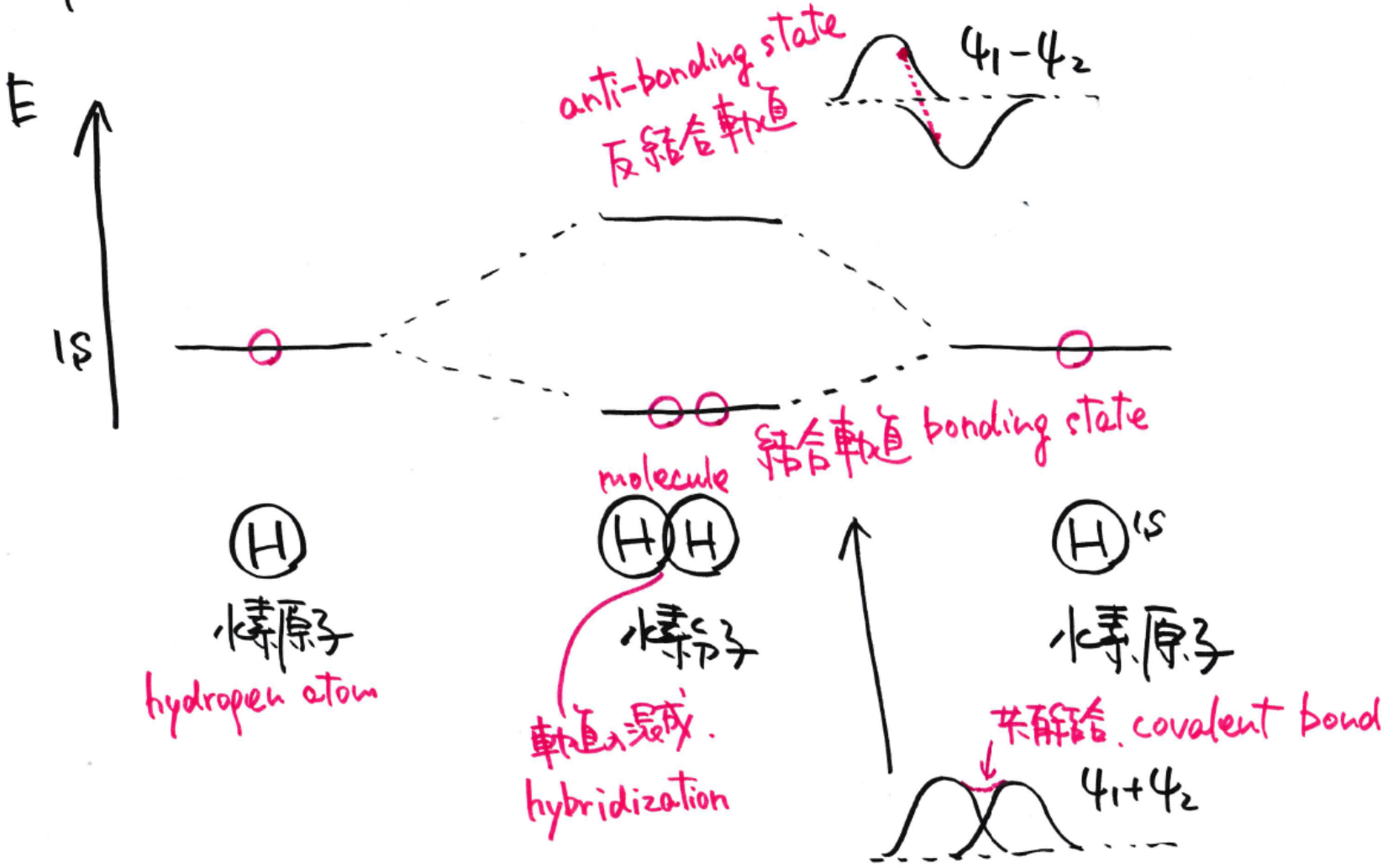


$$\frac{\frac{4}{3}\pi r^3 \times 8}{1^3}$$

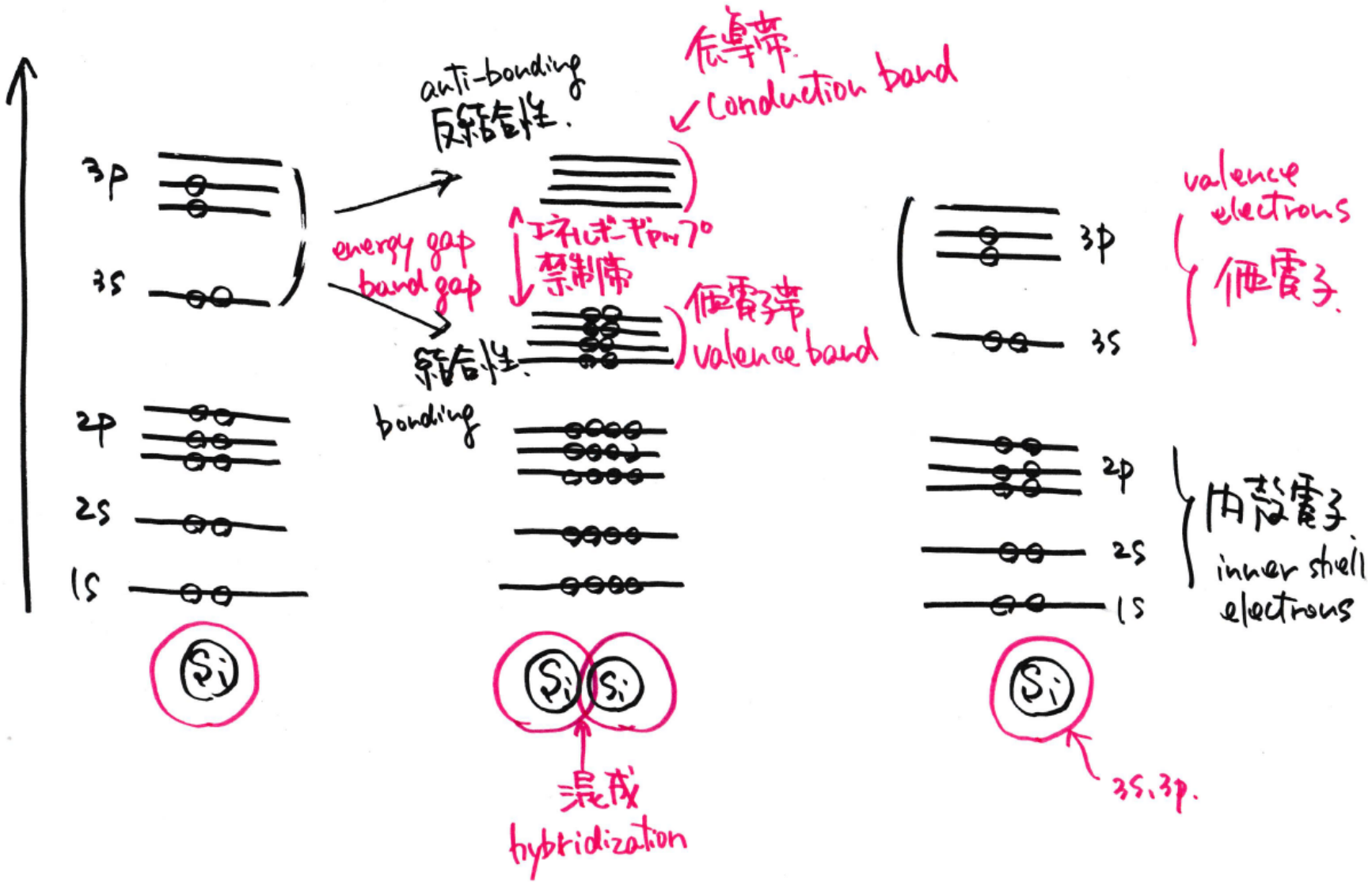
$$= \frac{\sqrt{3}}{16}\pi \sim 0.34$$

34%

半導体のバンド構造，電子構造 Electronic structure of semiconductors



バンド構造の形成 Band structure of Si



状態密度 Density of states

effective density of states (conduction band)
伝導帯の有効状態密度

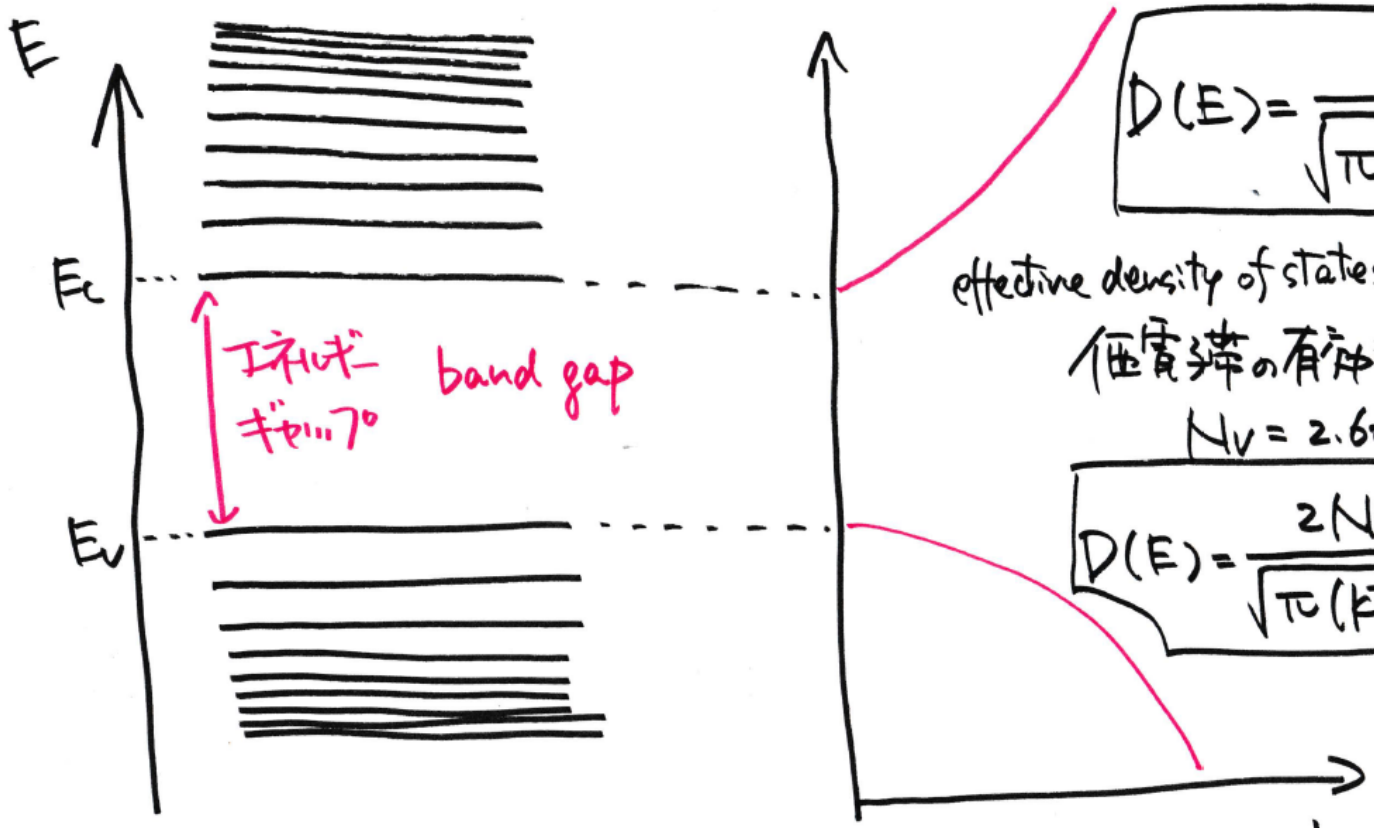
$N_C = 2.86 \times 10^{19} /cm^3$ (Si)

$$D(E) = \frac{2N_C}{\sqrt{\pi}(kT)^3}\sqrt{E - E_C}$$

effective density of states (valence band)
価電子帯の有効状態密度

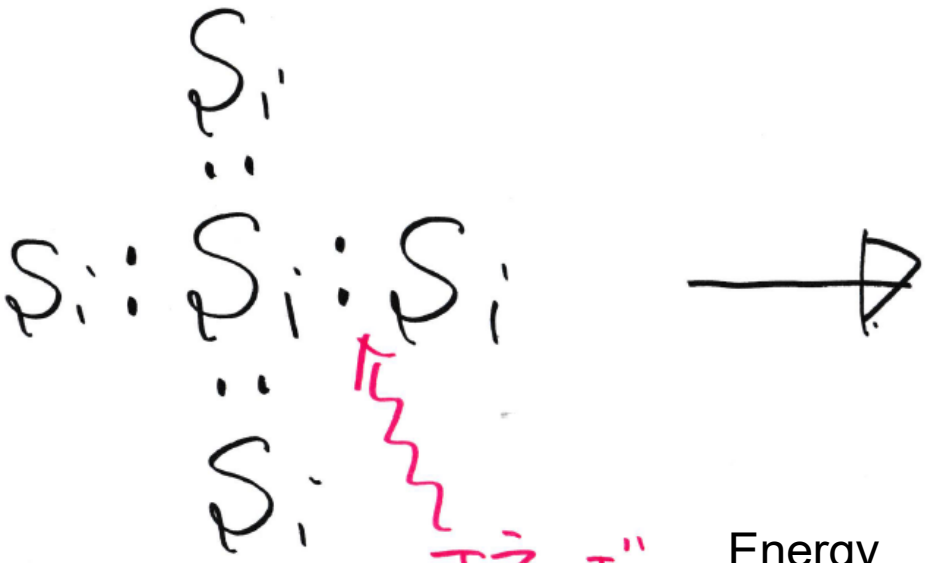
$N_V = 2.66 \times 10^{19} /cm^3$ (Si)

$$D(E) = \frac{2N_V}{\sqrt{\pi}(kT)^3}\sqrt{E_V - E}$$



キャリアの生成

Carrier generation



エネルギー
(熱、光)

Energy
(heat, light)

~1eV エレクトロンボルト
$=1.6\times10^{-19}$ J

Conduction electron

伝導電子 (−)

Hole

ホール (+)

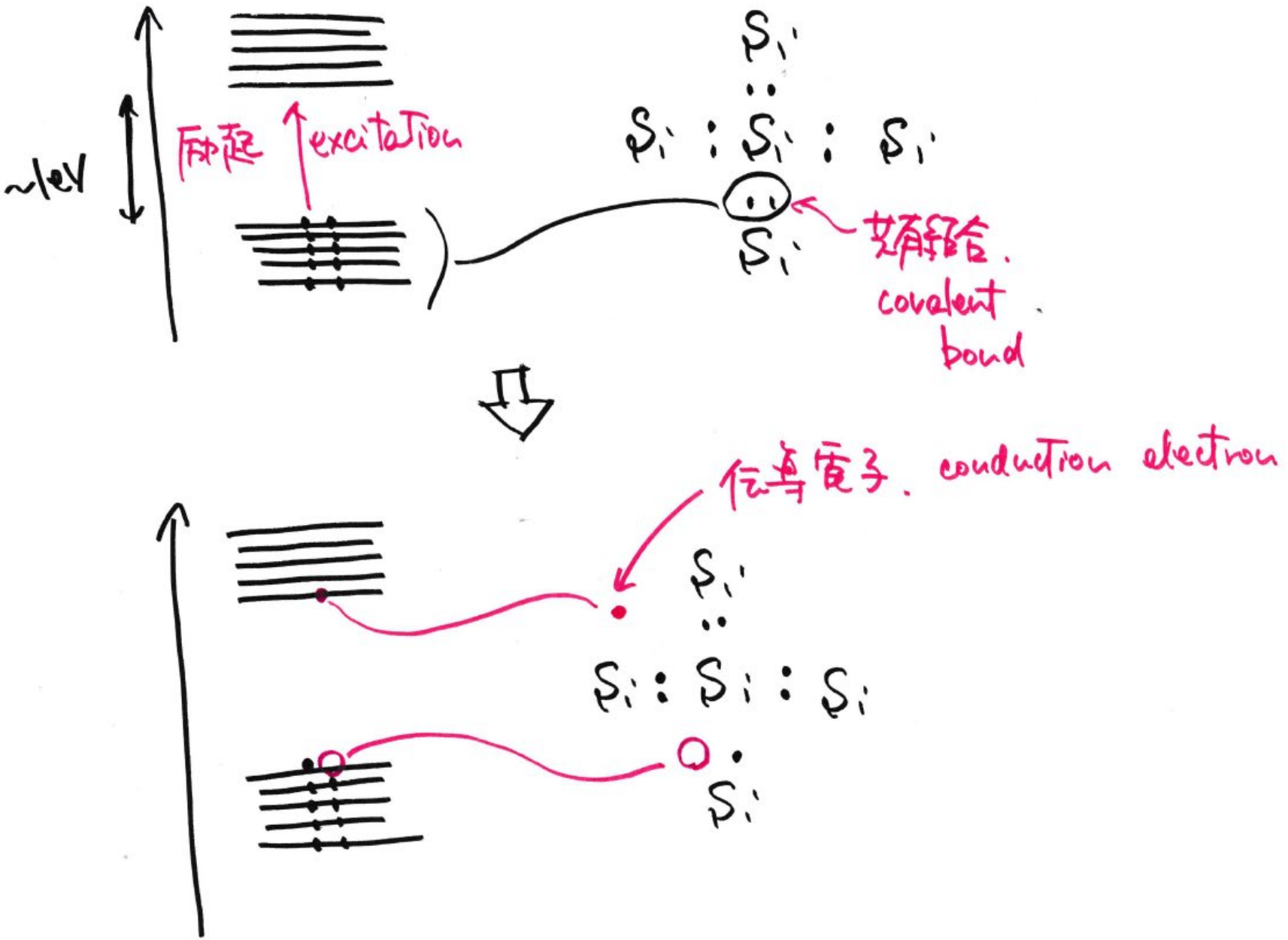
Carrier density

キャリア密度

$\sim 10^{10}/cm^3$

(金属は $\sim 10^{22}/cm^3$)

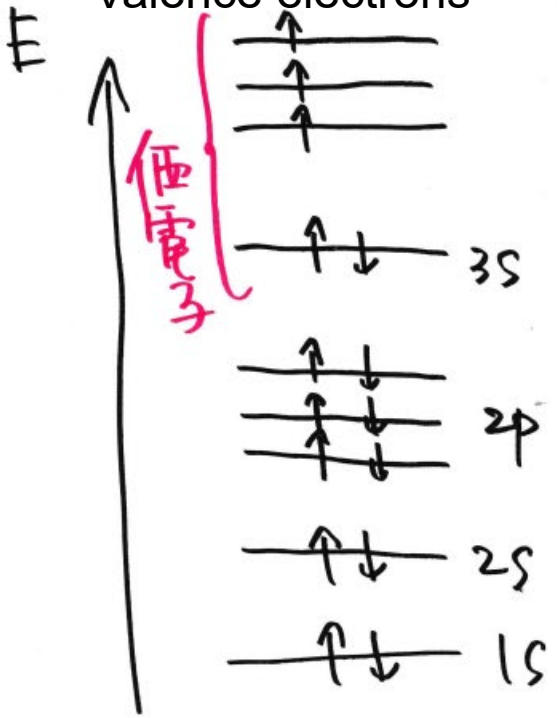
Metal


~1eV
励起 excitation
Si
Si : Si : Si
Si
共有結合.
covalent bond.
伝導電子. conduction electron
Si
Si : Si : Si
Si

ドープ

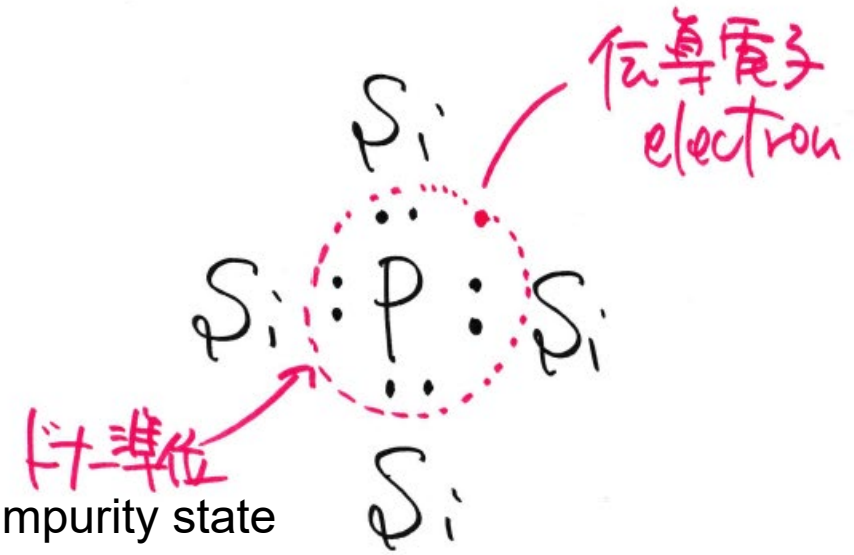
P(リン)の添加

Valence electrons　　Doping



原子番号15

Atomic number



Impurity state

ドナー

donor

n-type semiconductor

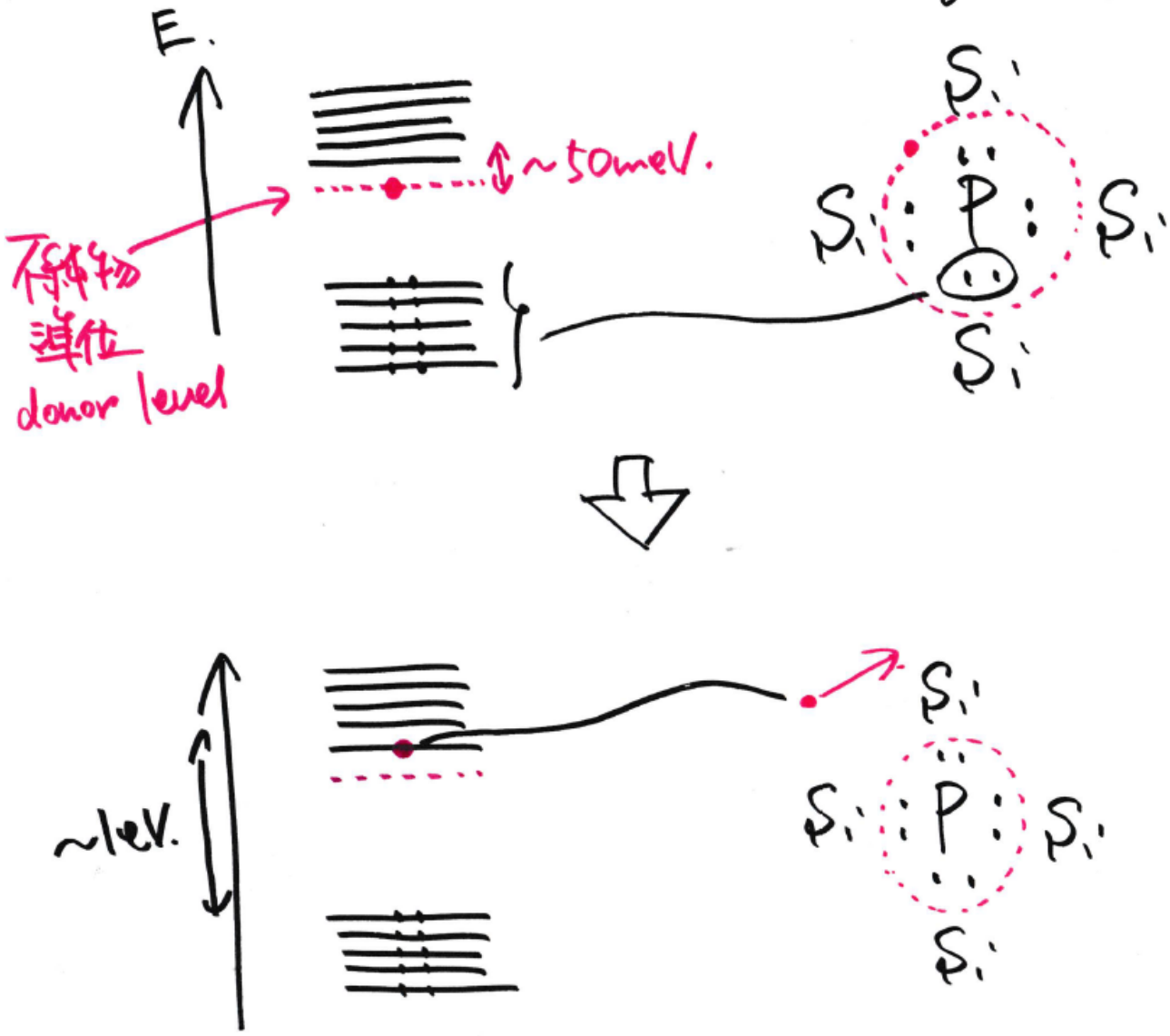
n型半導体

conduction electron density

Pの濃度～伝導電子濃度

density

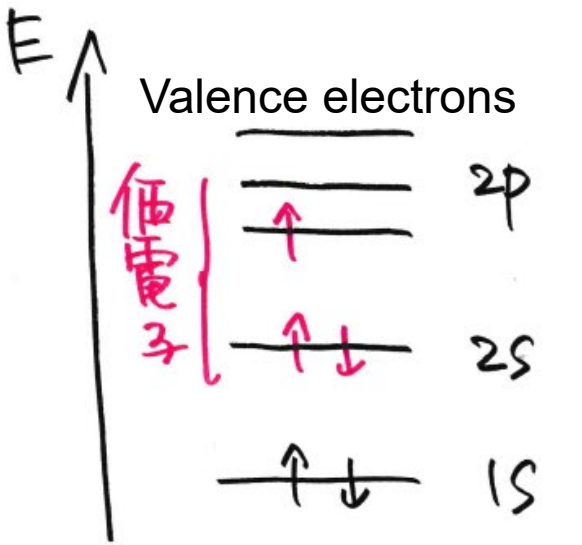
ドナーのドープ　doping with donors



ドープ

B(ホウ素)の添加

Doping



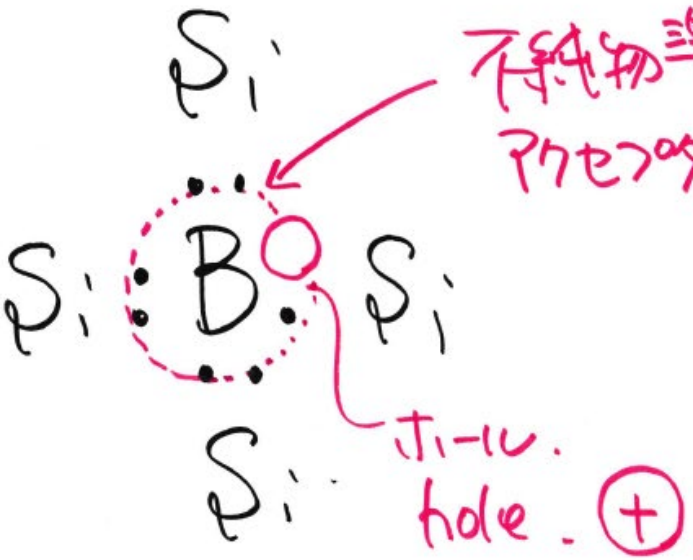
原子番号 5

Atomic number

Impurity state

不純物準位

アクセプター準位



アクセプター

acceptor

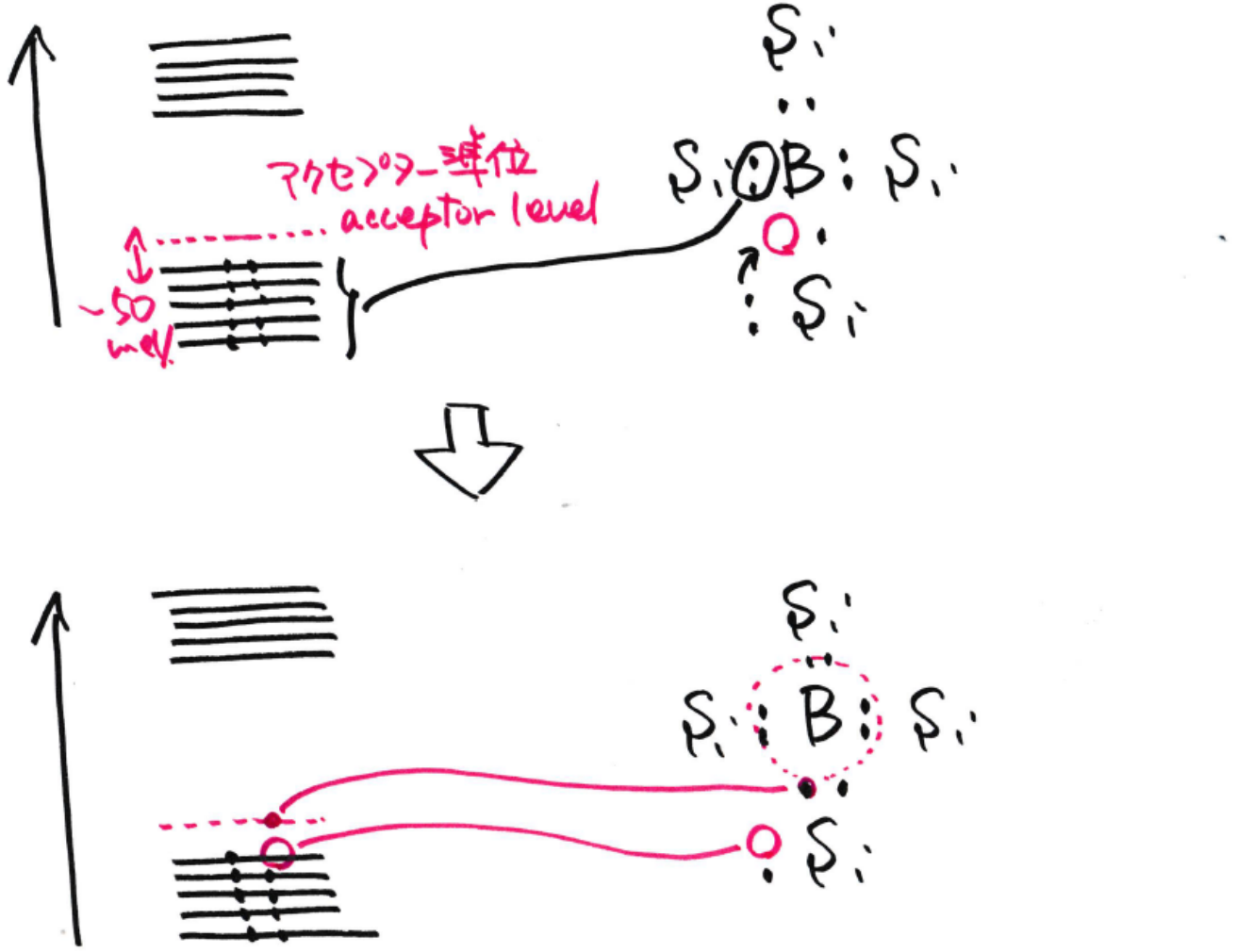
p-type semiconductor

p型半導体.

Ba濃度 ~ ホール濃度.

density hole density

アクセプターのドープ. doping with acceptors



Exercise

Evaluate the concentration of P atoms (at%), which is necessary to increase the conduction electron density in Si at room temperature to 1 x 10^{16} /cm^3.

（室温におけるSiの伝導電子密度を 1 x 10^{16} /cm^3 とするために必要なP原子の濃度 (at%) を計算せよ。）