doping of semiconductors

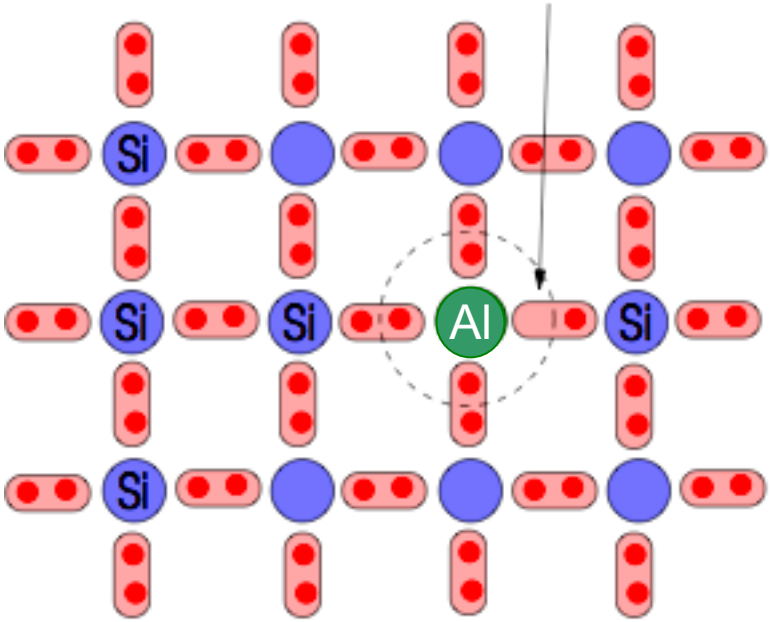
doping Si (group IV) with Al (group III) or P (group V)

Si: [Ne] $(3s)^2(3p)^2$

Al: [Ne] $(3s)^2(3p)^1$

acceptor

missing electron

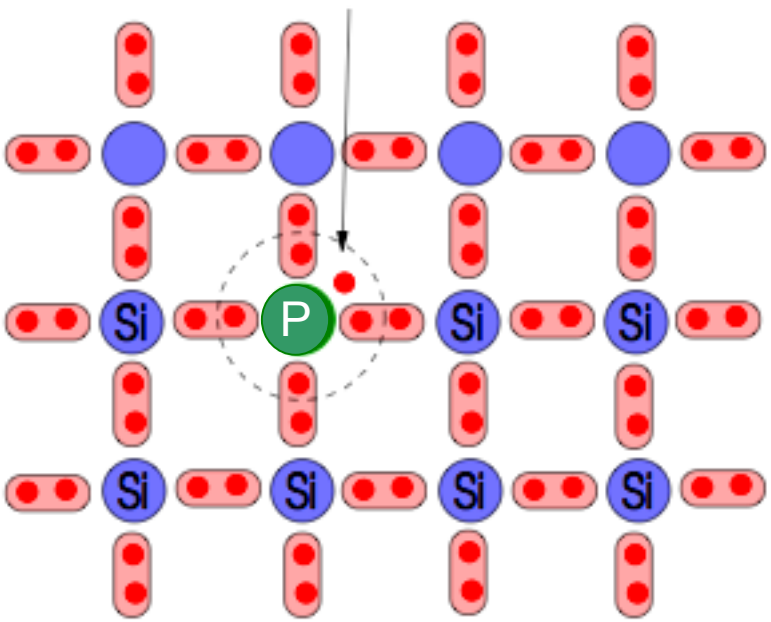


p-doped semiconductor

P: [Ne] $(3s)^2(3p)^3$

donor

additional electron



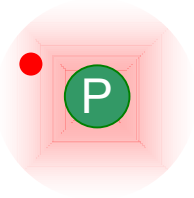
n-doped semiconductor

doping of semiconductors - impurity states

P-impurity: additional electron

n-doping

"hydrogen atom"



bound states

$$E_n = E_g - \frac{m_C e^4}{2\hbar^2 \varepsilon^2 n^2}$$

$$\left\{ -\frac{\hbar^2 \vec{\nabla}^2}{2m_C} - \frac{e^2}{\varepsilon |\vec{r}|} \right\} F(\vec{r}) = (E - E_g) F(\vec{r})$$

dielectric constant

envelop function

binding energy *n=1*

$$E_b \sim 20meV \ll E_g$$

"Bohr radius"

$$r_1 = \frac{\hbar^2 \varepsilon}{m_C e^2} \sim 3nm$$