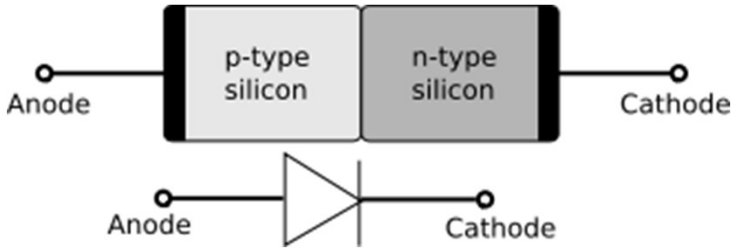
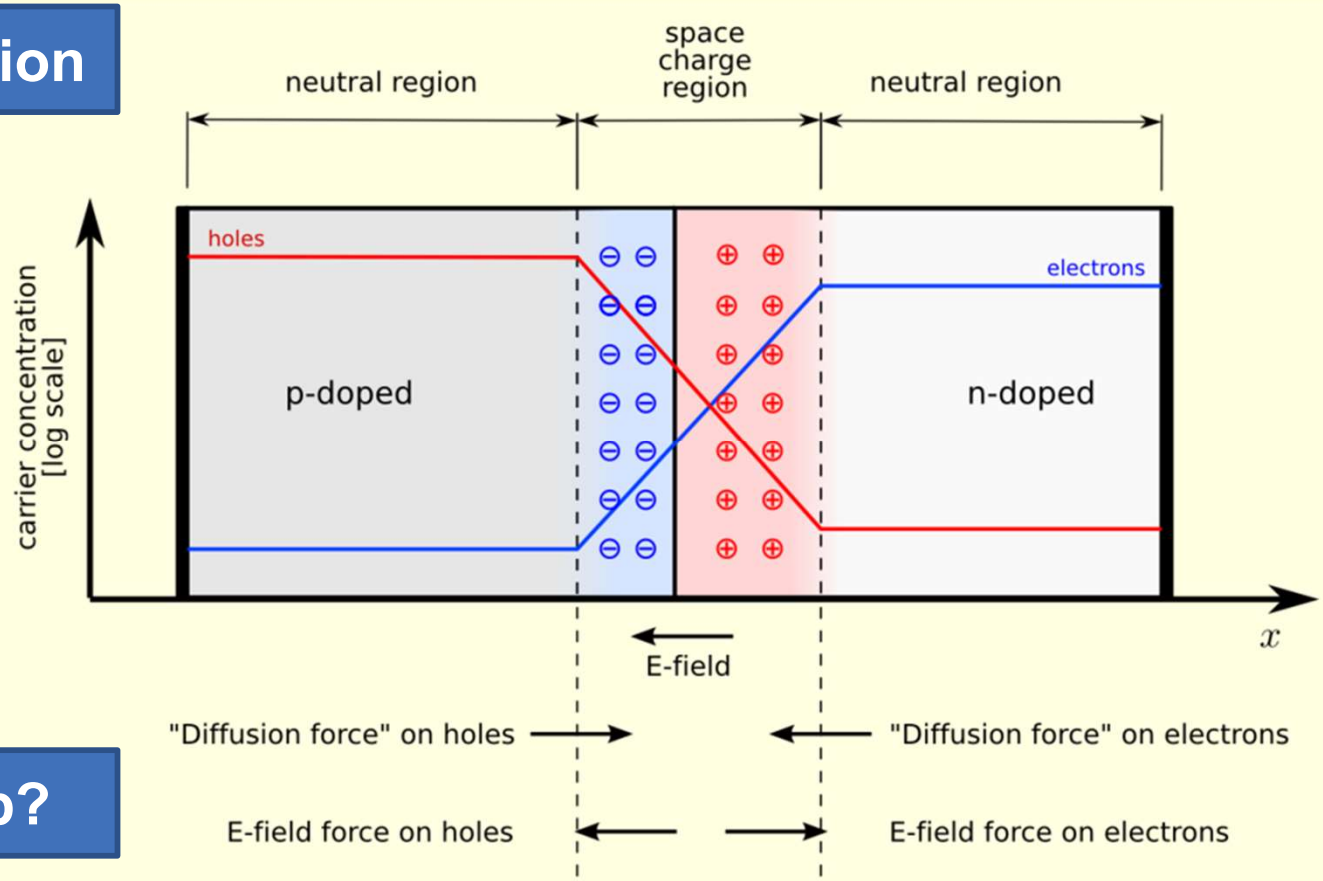
Idealized p-n junction diode

Ideal approximation: 1-D, abrupt

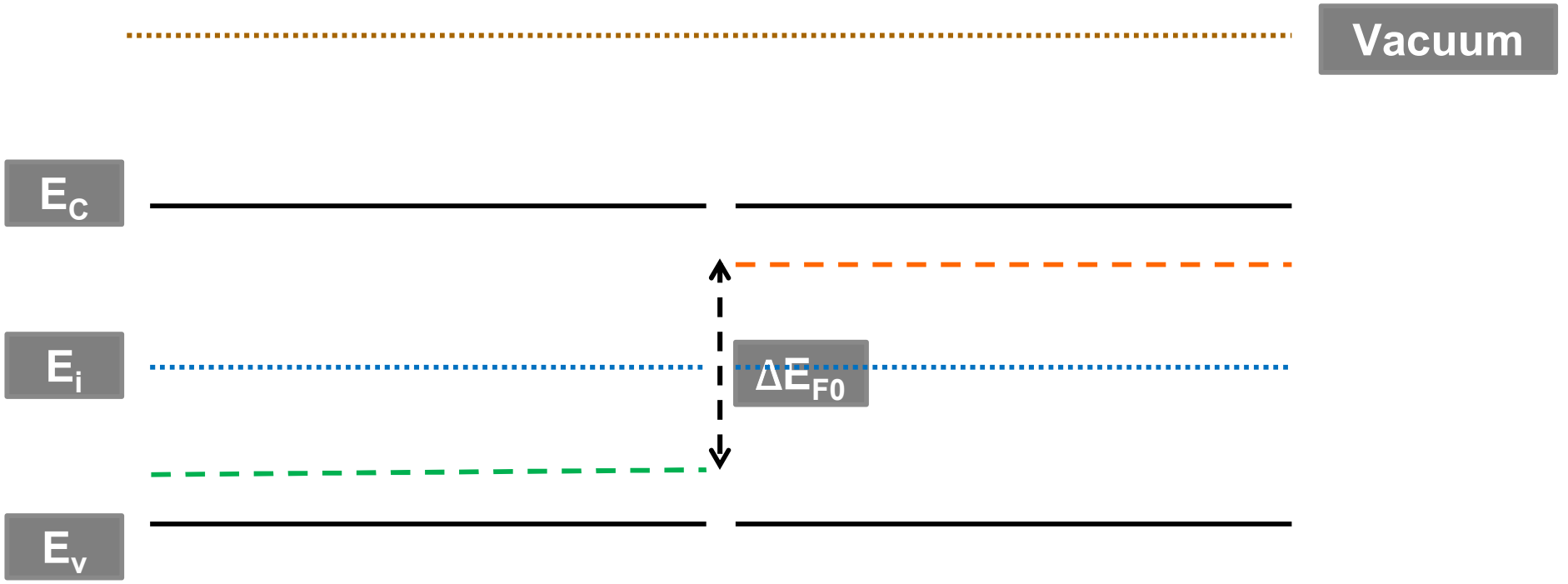


Inhomogeneity → diffusion



Why/where does it stop?

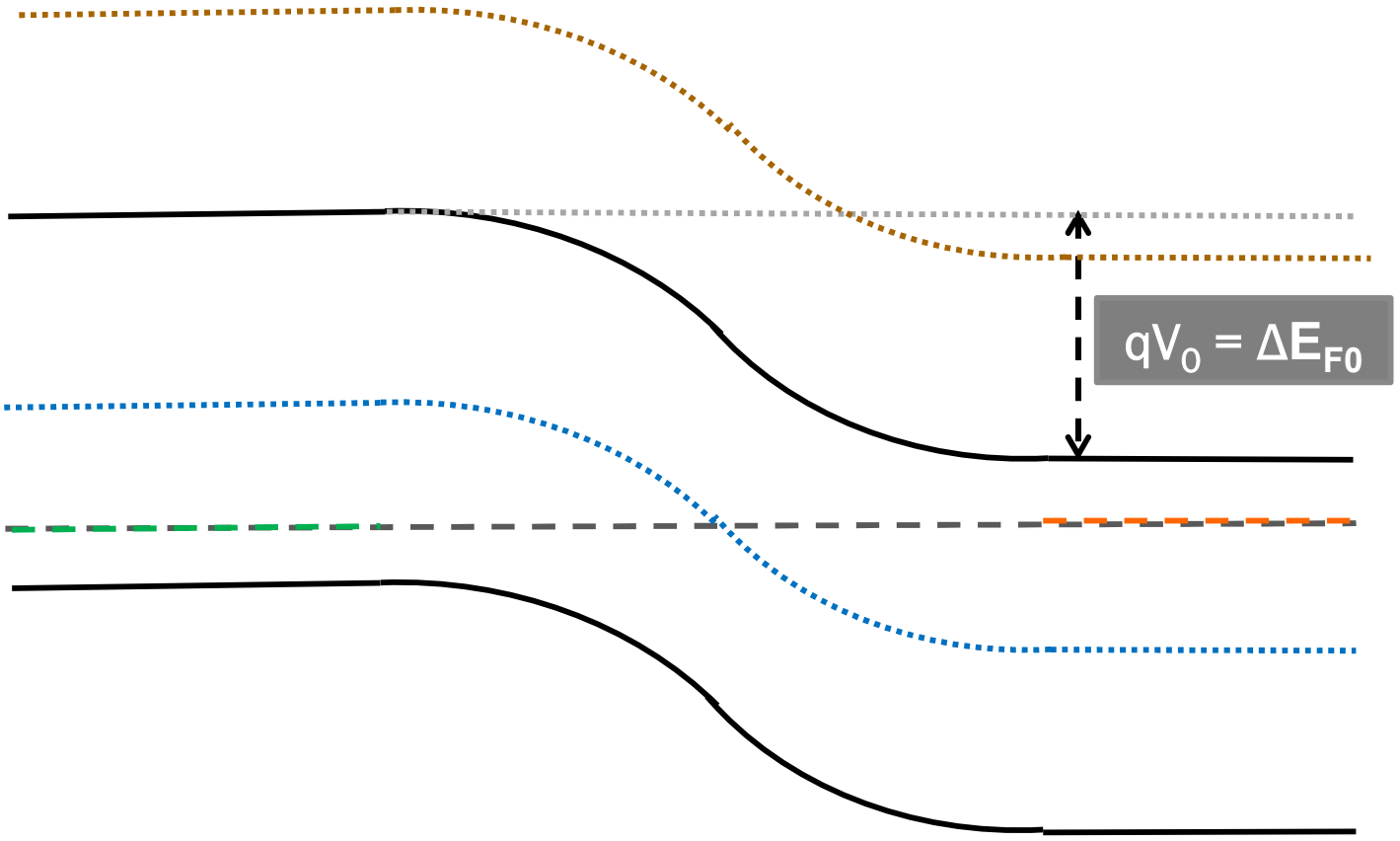
Equilibrium barrier height…



$$E_{Fp} = E_i - \ln\left(\frac{p_{p0}}{n_i}\right) = E_i - k_B T \ln\left(\frac{N_A}{n_i}\right) \quad E_{Fn} = E_i + \ln\left(\frac{n_{n0}}{n_i}\right) = E_i + k_B T \ln\left(\frac{N_D}{n_i}\right)$$

$$\Delta E_{F0} = E_{Fn} - E_{Fp} = k_B T \ln\left(\frac{N_D}{n_i}\right) + k_B T \ln\left(\frac{N_A}{n_i}\right)$$

…from band diagram



$$V_0 = \frac{k_B T}{q} \ln\left(\frac{N_D}{n_i}\right) + \frac{k_B T}{q} \ln\left(\frac{N_A}{n_i}\right)$$

Contact potential / built-in voltage

$$V_0 = \frac{k_B T}{q} \ln\left(\frac{N_A N_D}{n_i^2}\right)$$

Hetero-junction?

Equilibrium with potentials/band-bending

Equilibrium, homogeneous

$$n_0 = n_i \exp\left(\frac{E_F - E_{i0}}{k_B T}\right) \qquad p_0 = n_i \exp\left(\frac{E_{i0} - E_F}{k_B T}\right)$$

Equilibrium, inhomogeneous

$$n = n_i \exp\left(\frac{E_F - E_{i0} + eV}{k_B T}\right) = n_0 \exp\left(\frac{+eV}{k_B T}\right) \qquad E_i = E_{i0} - eV$$

$$p = n_i \exp\left(\frac{E_{i0} - E_F - eV}{k_B T}\right) = p_0 \exp\left(\frac{-eV}{k_B T}\right)$$

Drift = Diffusion?

Contact potential?

Finis

Artwork Sources:

1. Saumitra Mehrotra & Prof. Gerhard Klimeck, commons.wikimedia.org
2. TheNoise, commons.wikimedia.org
3. Raffamaiden, commons.wikimedia.org
4. www.instructables.com
5. en.wikipedia.org
6. www.thefoa.org