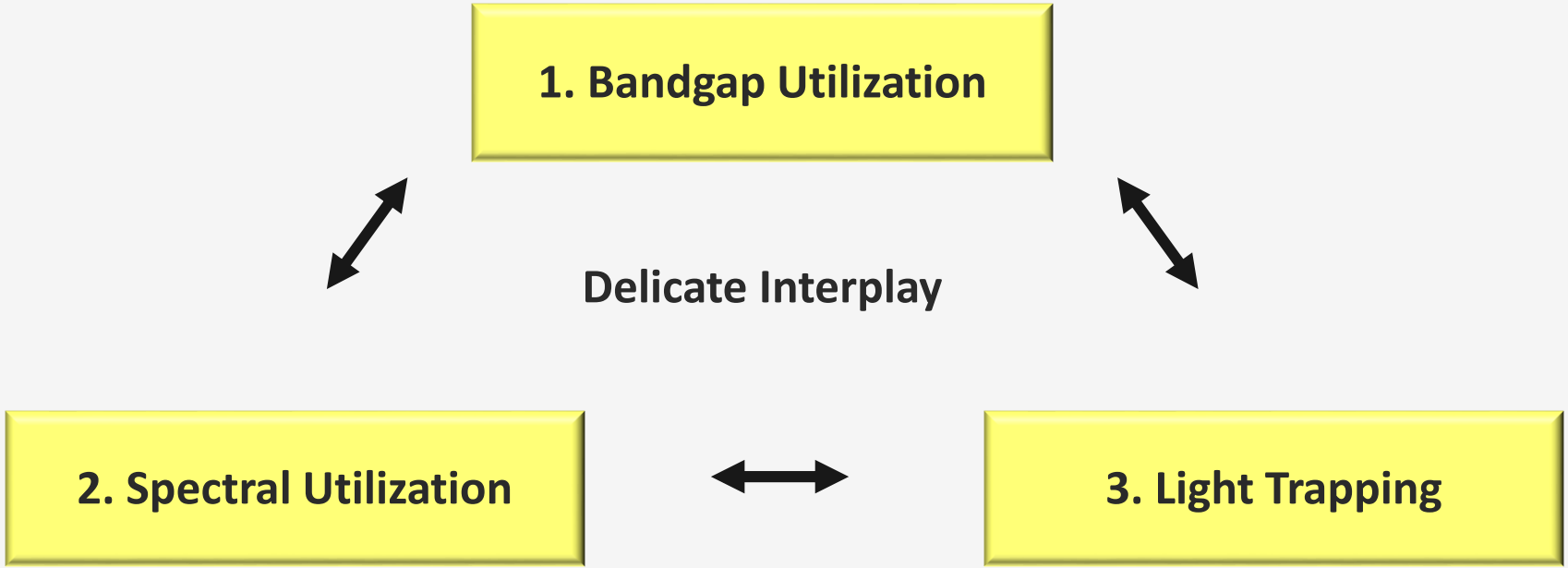
Solar Cell Operation, Performance and Design Rules

Utilization of Band Gap Energy

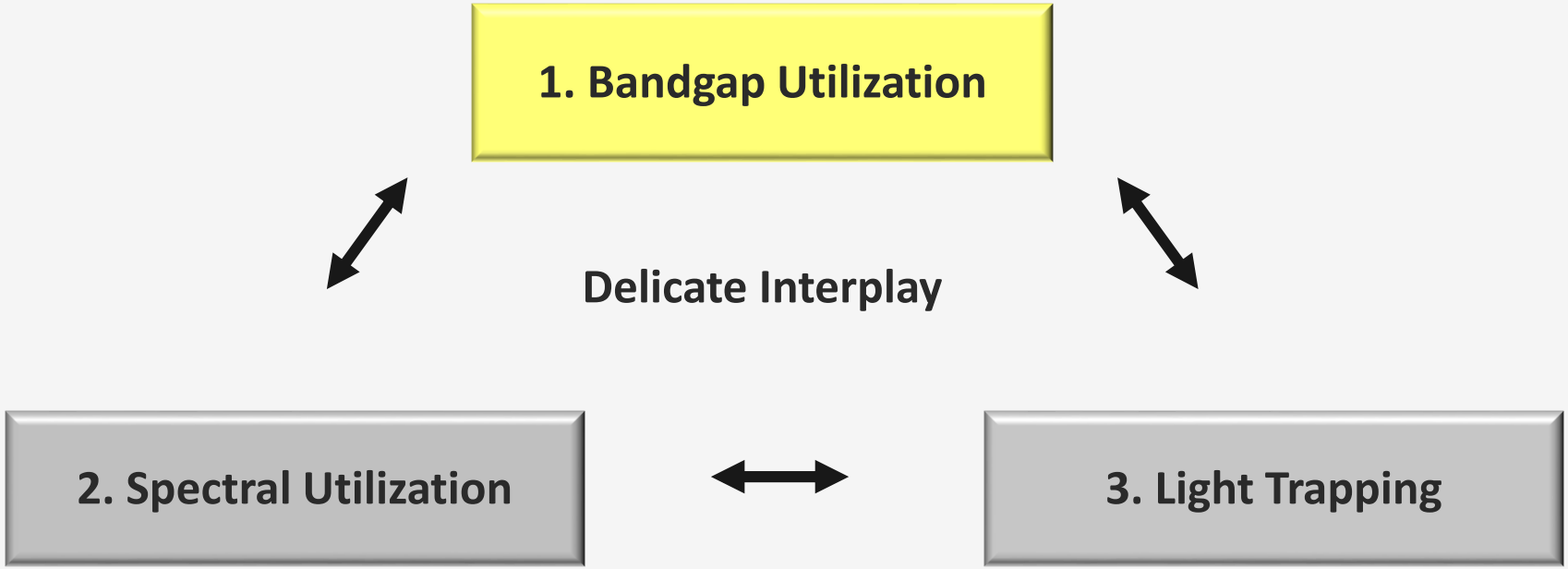
Week 3.3.1

Arno Smets

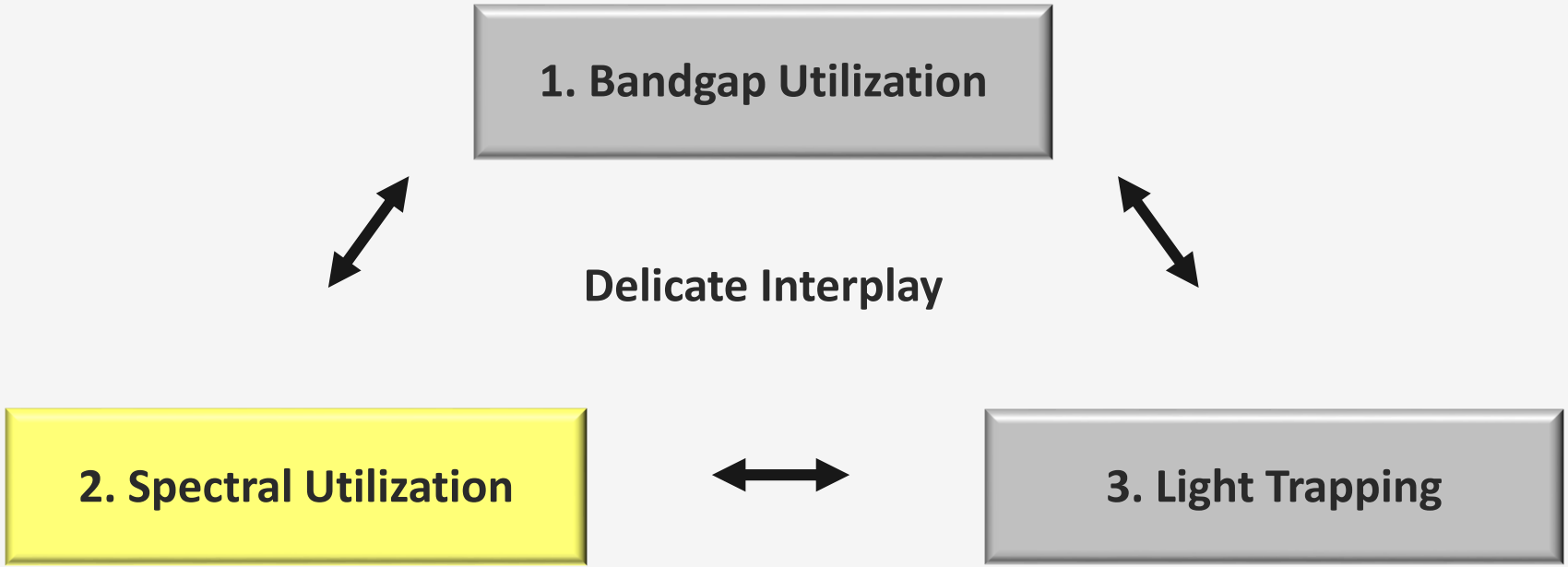
Design Rules Solar Cells



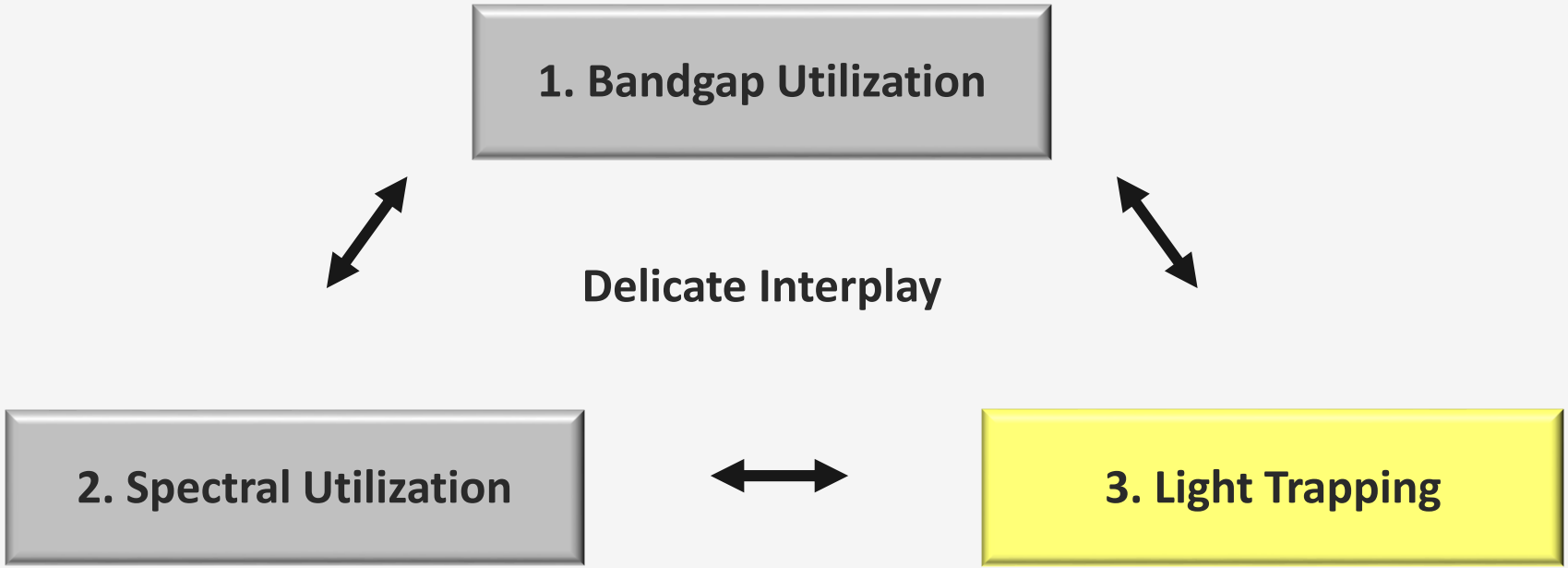
Design Rules Solar Cells



Design Rules Solar Cells

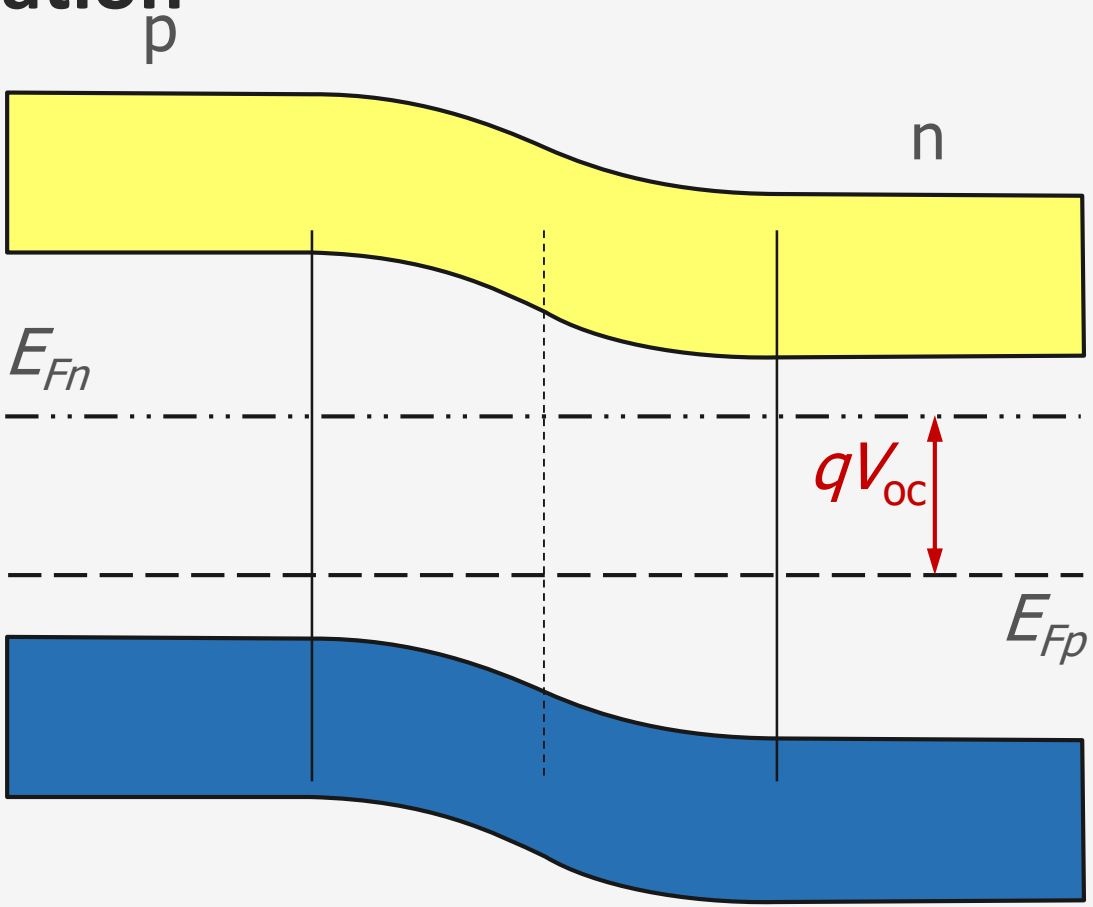


Design Rules Solar Cells



Band gap utilization

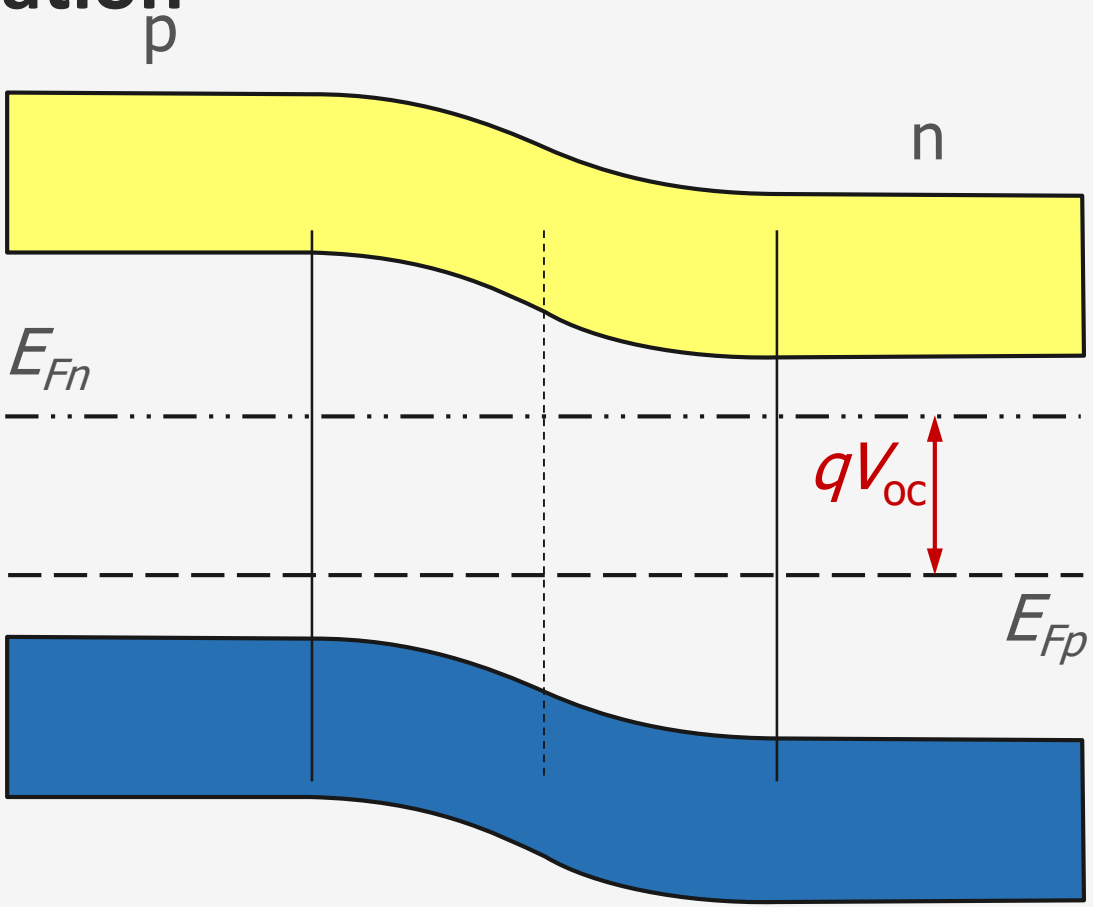
$$V_{OC} = \frac{k_B T}{q} \ln\left(\frac{J_{PH}}{J_0} + 1\right)$$



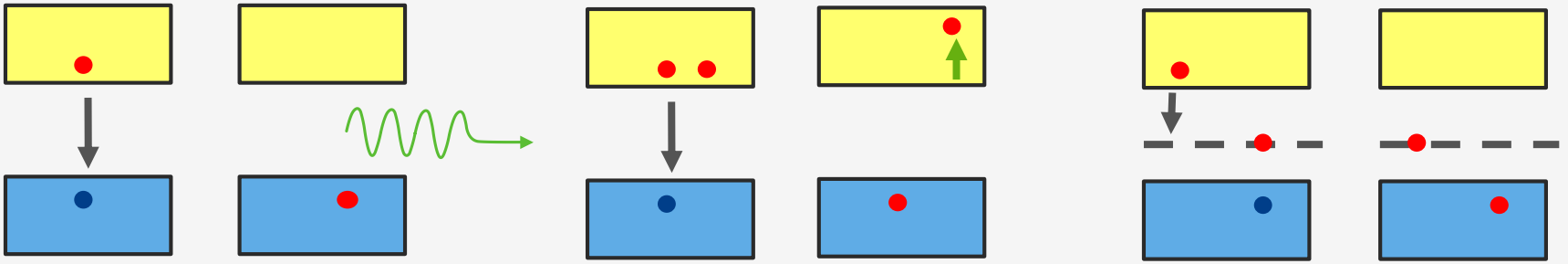
Band gap utilization

$$V_{OC} = \frac{k_B T}{q} \ln\left(\frac{J_{PH}}{J_0} + 1\right)$$

$$V_{oc} = \frac{2kT}{q} \ln\left(\frac{G_L t_0}{n_i}\right)$$



Charge Carrier Recombination



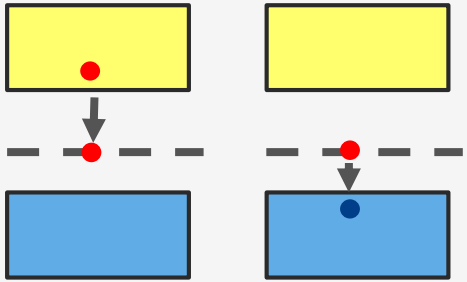
Radiative

Auger

SRH

Charge Carrier Recombination

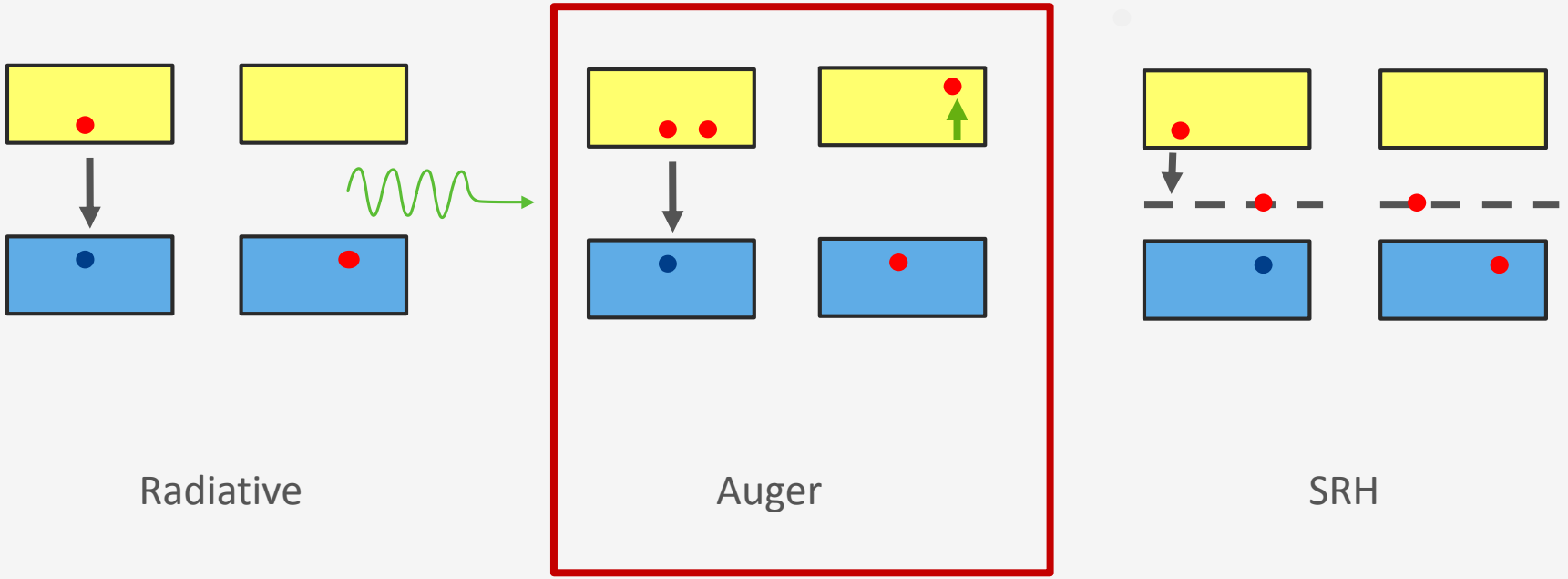
Shockley Read Hall



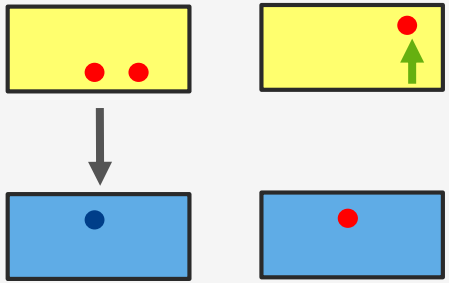
$$\tau_0 \propto N_t^{-1}$$

$$V_{oc} = \frac{2kT}{q} \ln\left(\frac{G_L t_0}{n_i}\right)$$

Charge Carrier Recombination



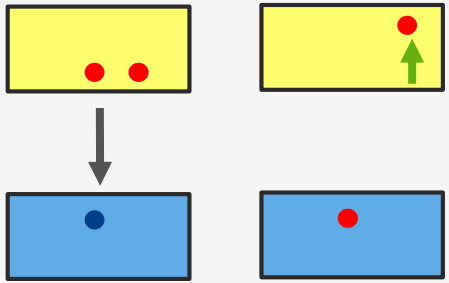
Charge Carrier Recombination



$$R_{electron} = kn^2p$$

$$R_{hole} = kp^2n$$

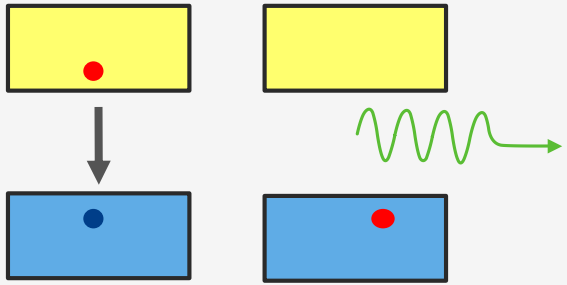
Charge Carrier Recombination



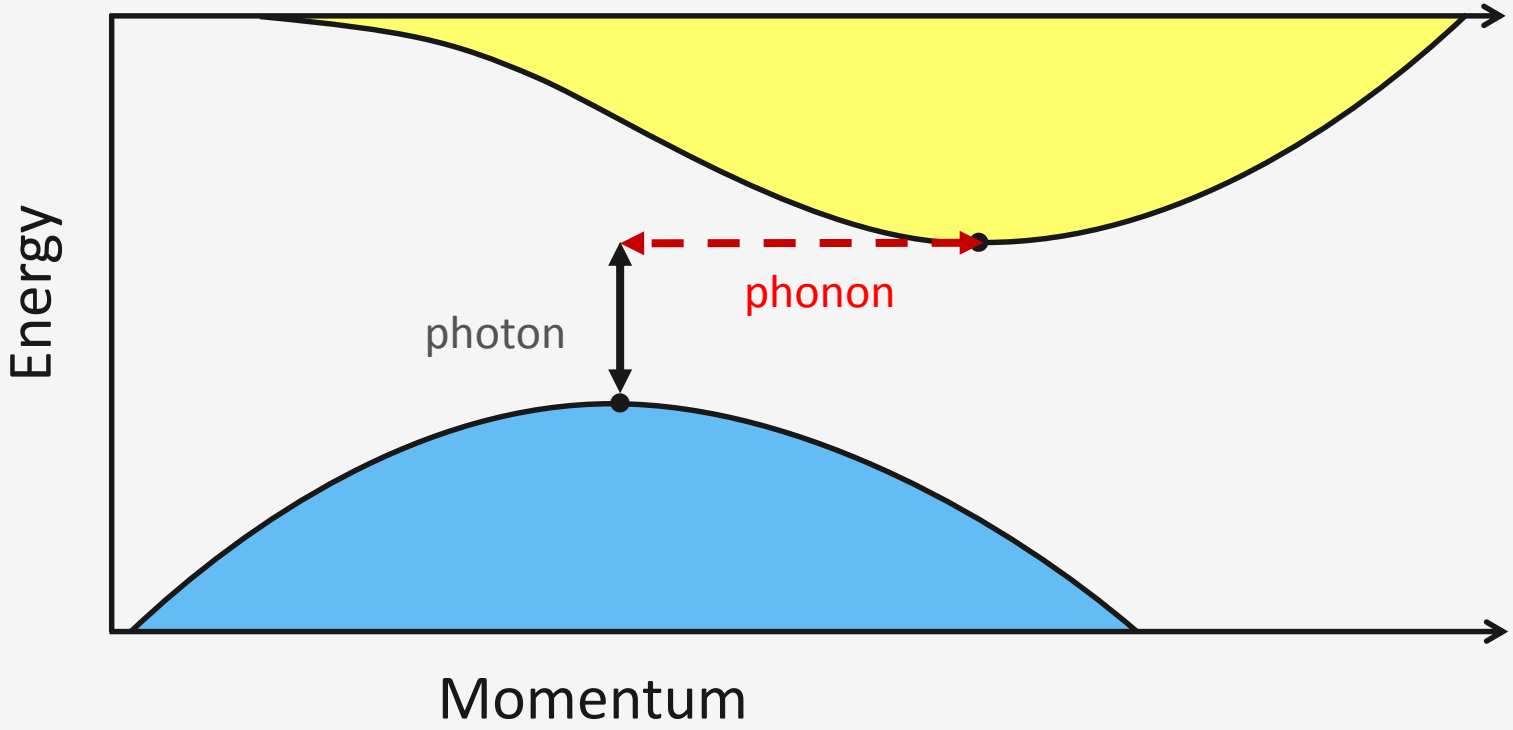
$$R_{electron} = kn^2p \qquad t_{e,Aug} \mu \frac{p}{R} = \frac{1}{kn^2}$$

$$R_{hole} = kp^2n \qquad t_{h,Aug} \mu \frac{n}{R} = \frac{1}{kp^2}$$

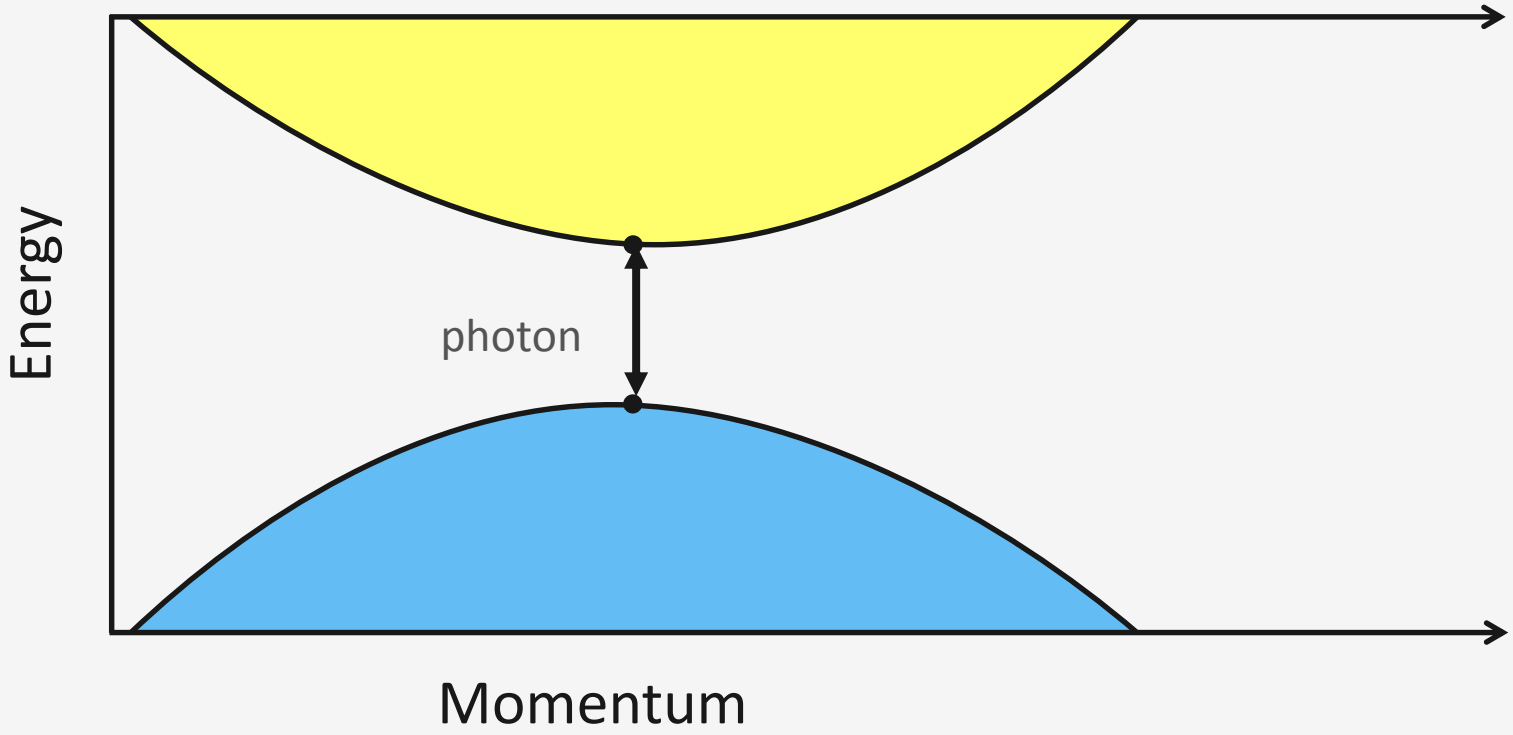
Charge Carrier Recombination



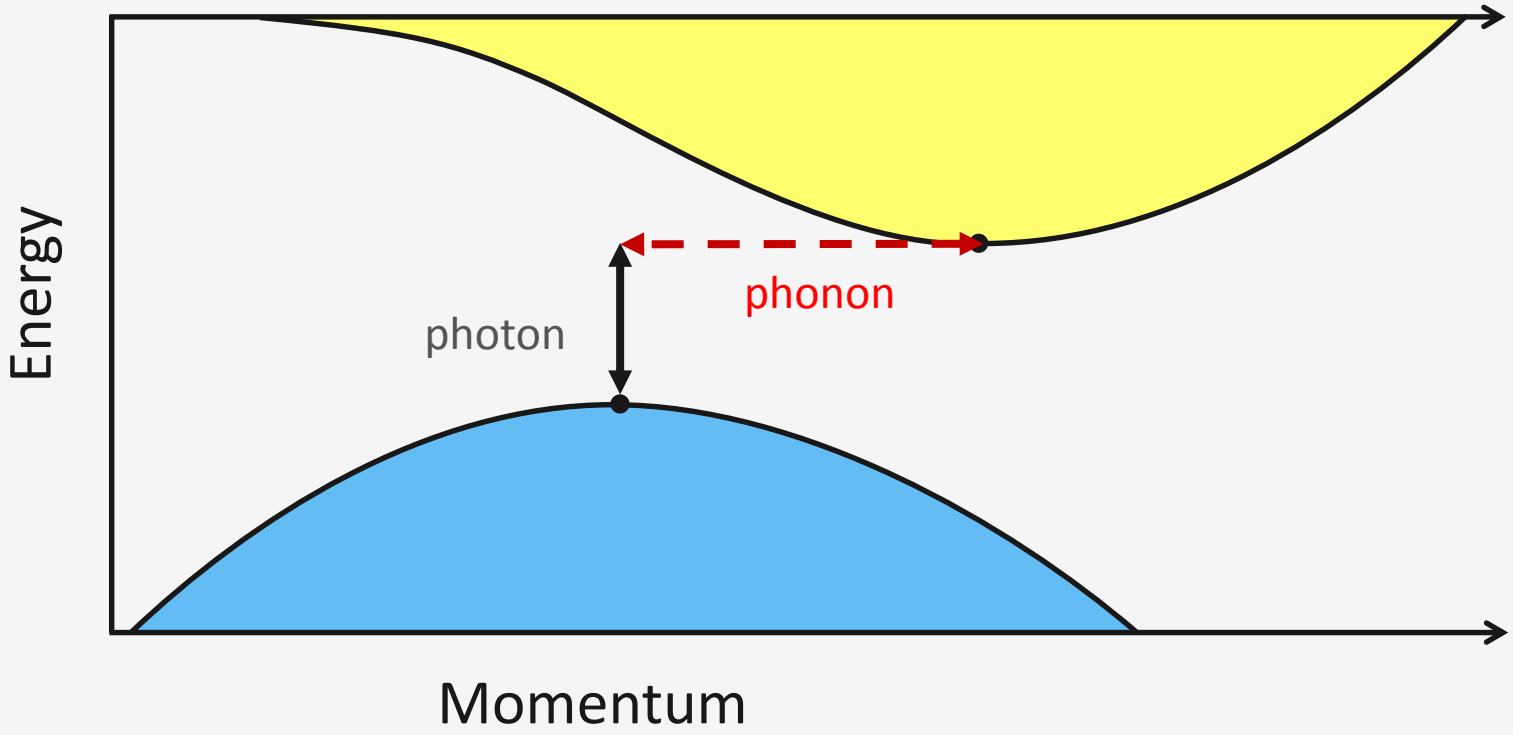
Indirect band gap



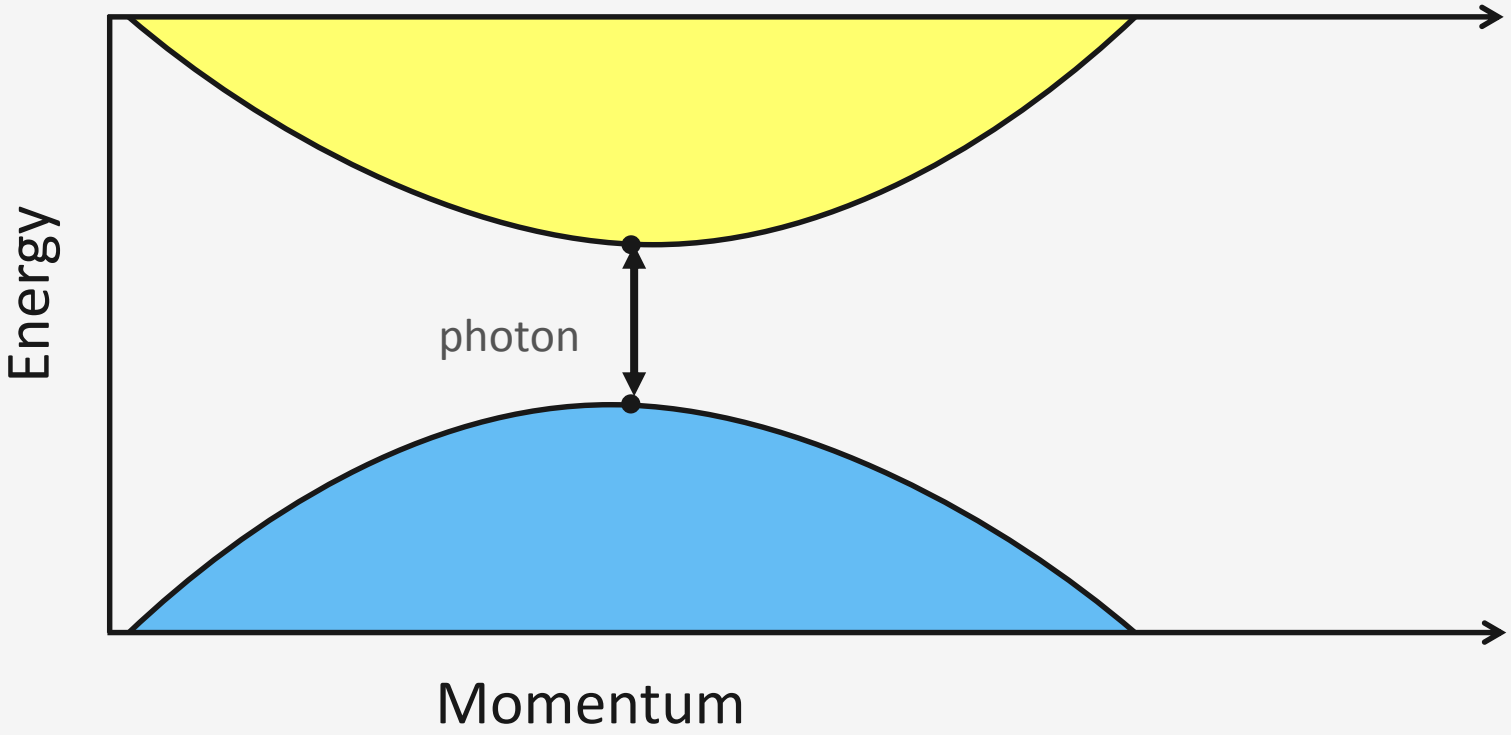
Direct band gap



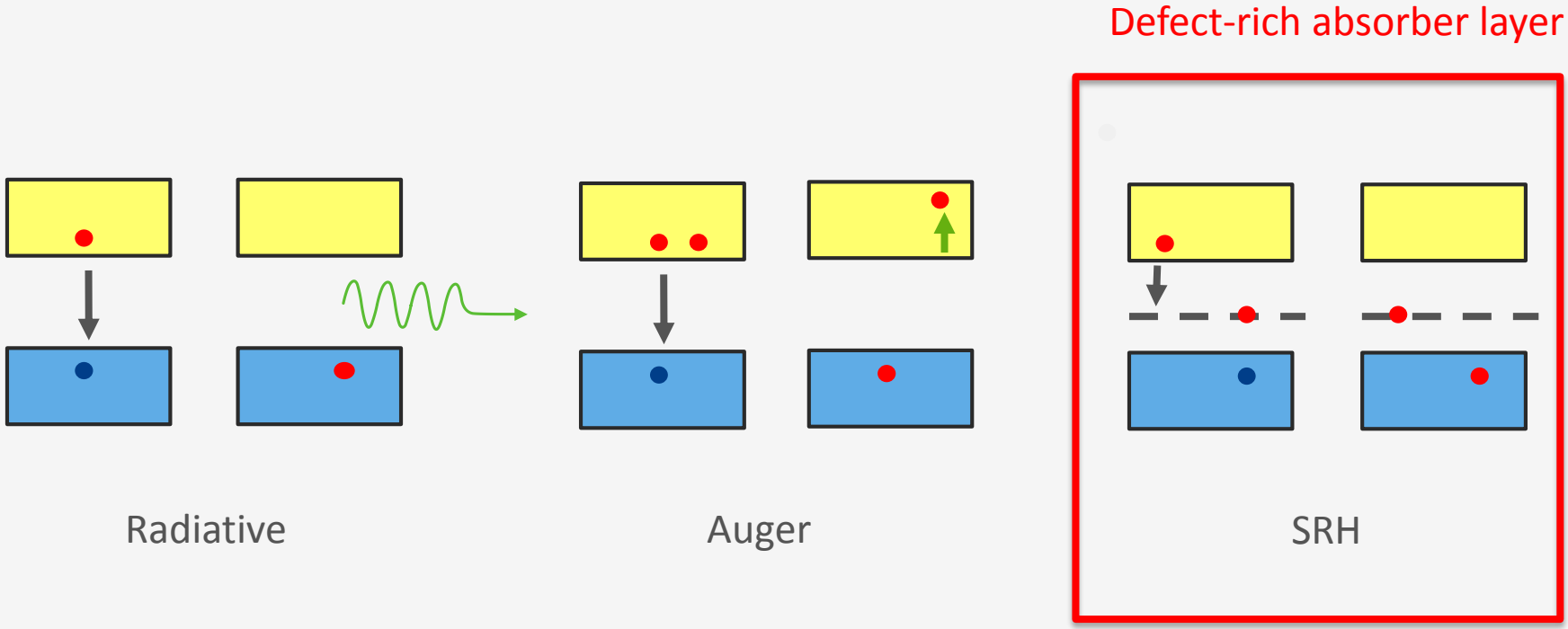
Indirect band gap: c-Si



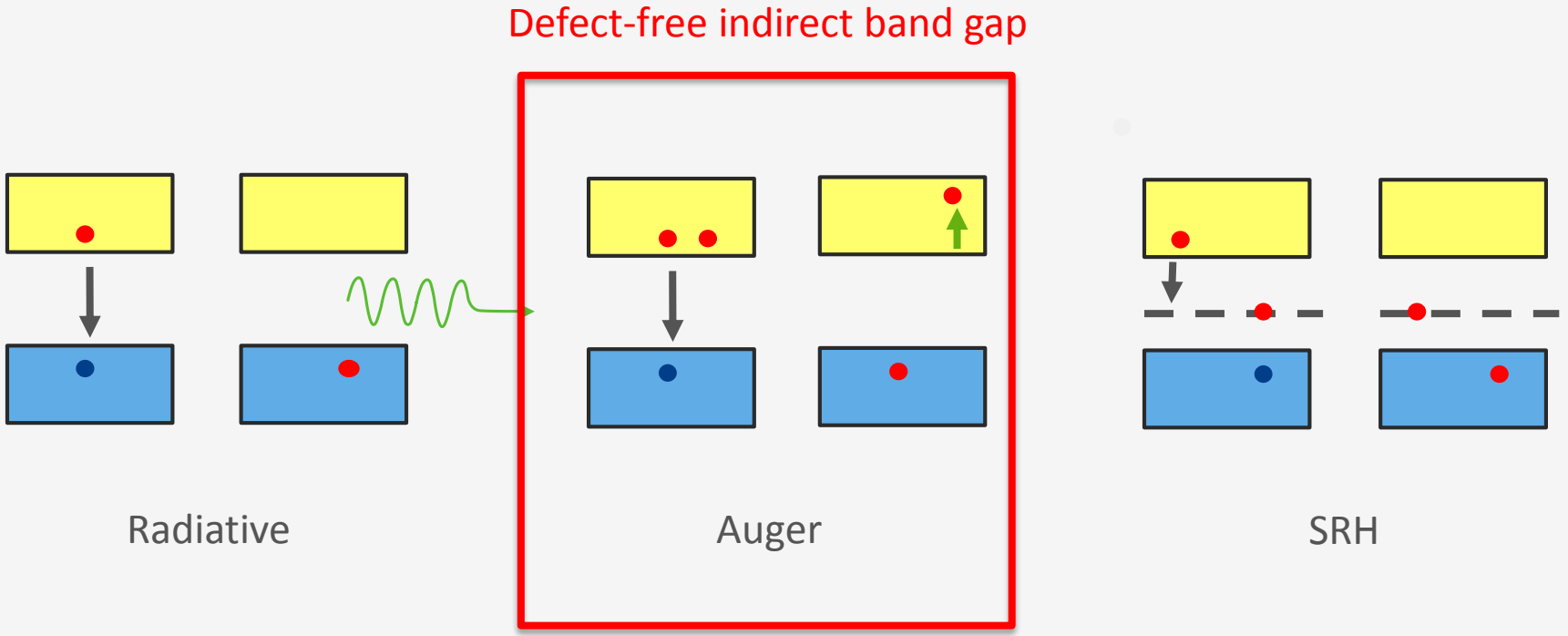
Direct band gap: GaAs



Band gap utilization: .....the V_{oc} is limited by

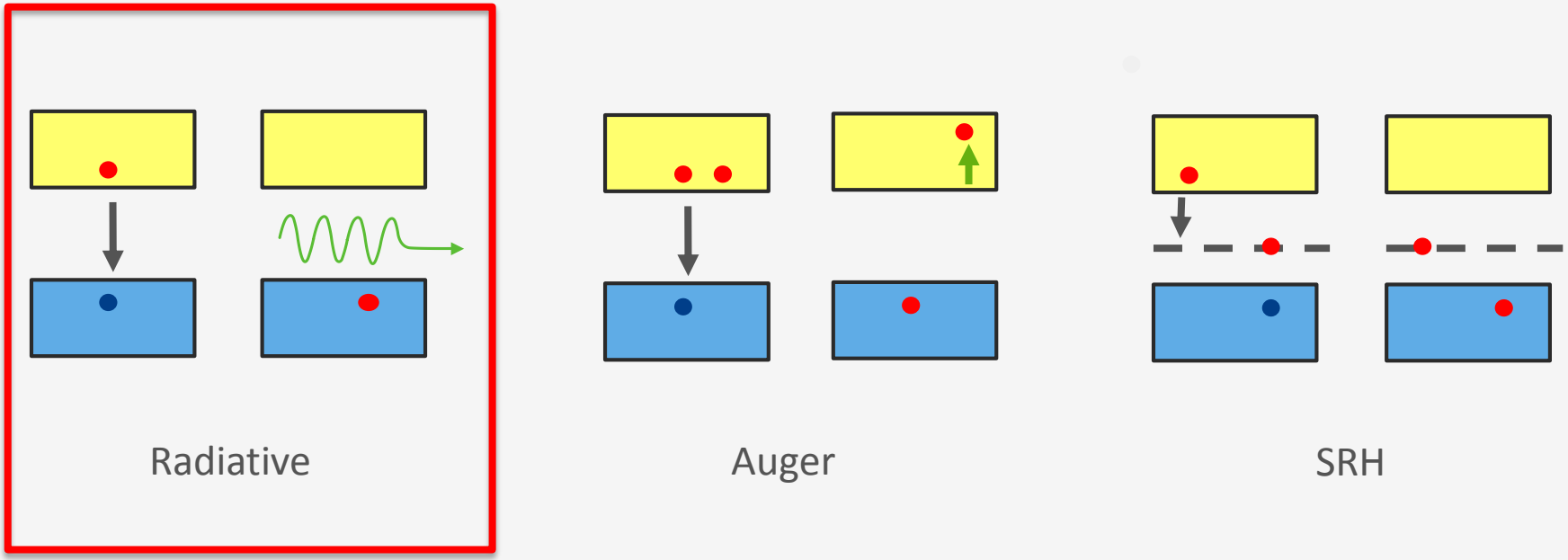


Band gap utilization: .....the V_{oc} is limited by

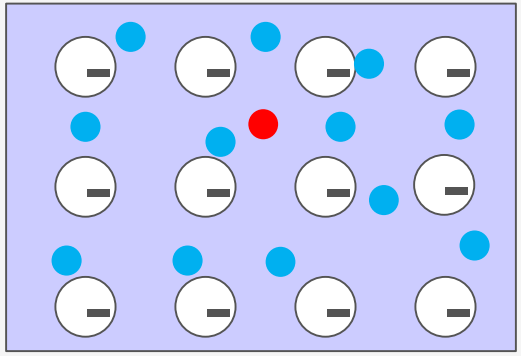


Band gap utilization: .....the V_{oc} is limited by

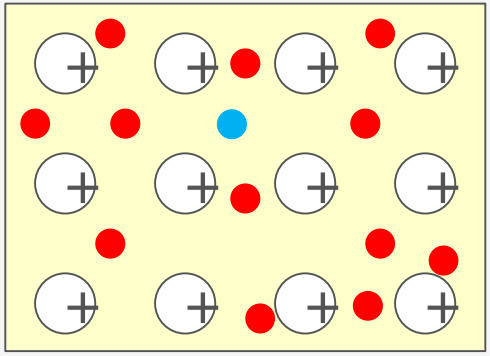
Defect-free direct band gap



Diffusion Length



p-doped



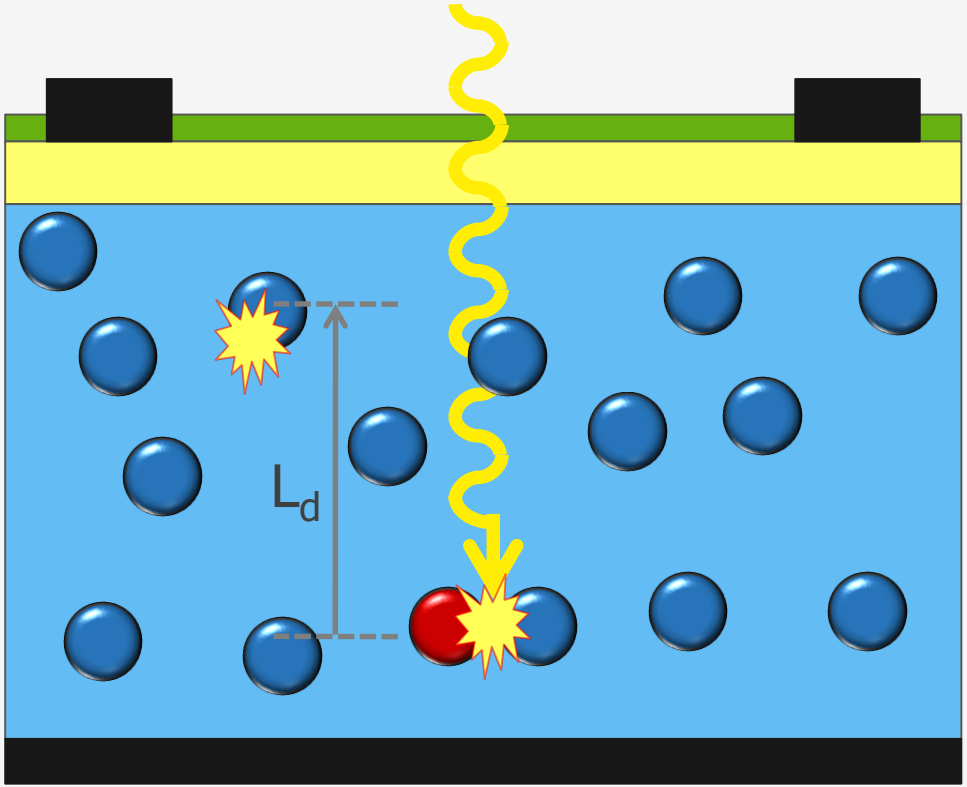
n-doped

Diffusion length:

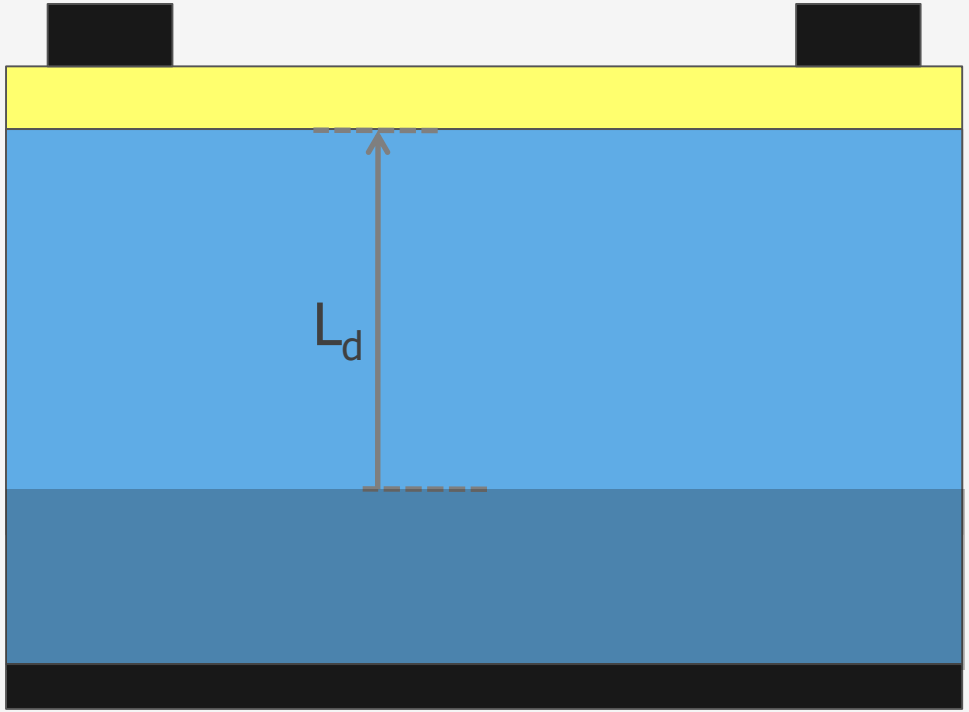
$$L_e = \sqrt{D_e t_e} < L_h$$

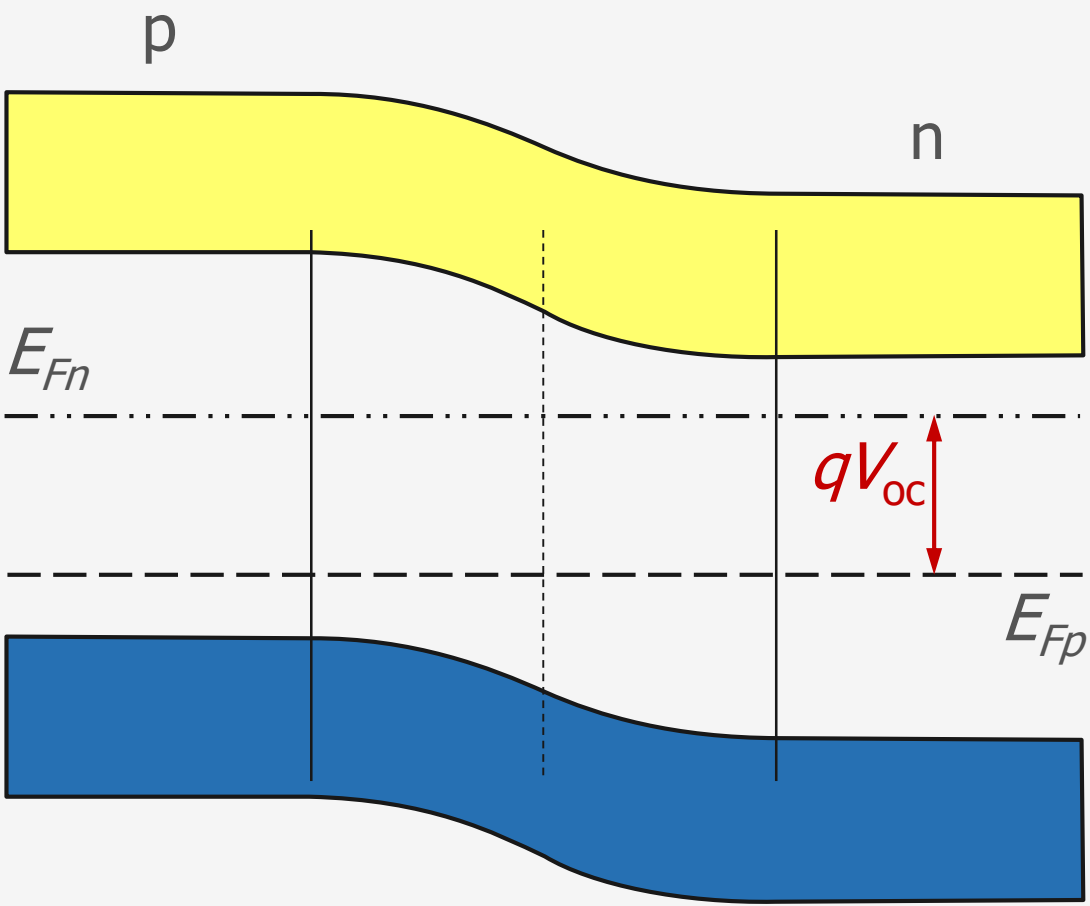
$$L_h = \sqrt{D_h \tau_h} < L_e$$

Minority carrier diffusion length



Relation between diffusion length and typical thickness of solar cells




p
n
E_{Fn}
qV_{oc}
E_{Fp}