Section 16
Recombination & Generation
16.2 Derivation of SRH formula (Shockley, Reed, Hall)
16.2.1 Trap Assisted Recombination Rates

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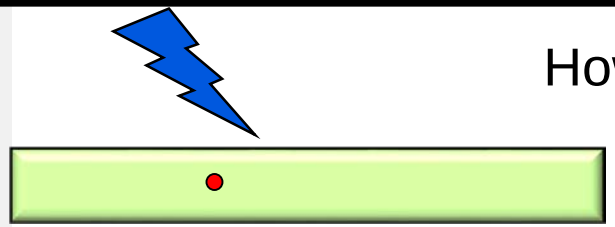
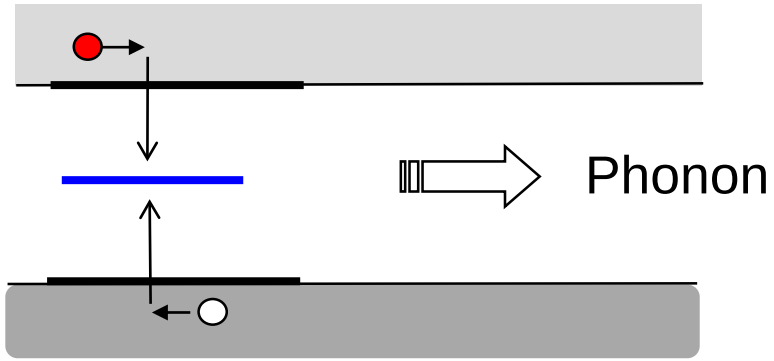
School of Electrical and Computer Engineering

Section 16
Recombination & Generation



How does the system go BACK to equilibrium?

$$\sigma_n = \pi r_0^{\,2}$$



- 16.1 Capture coefficient & Capture Cross Section
- 16.2 Derivation of SRH formula (Shockley, Reed, Hall)
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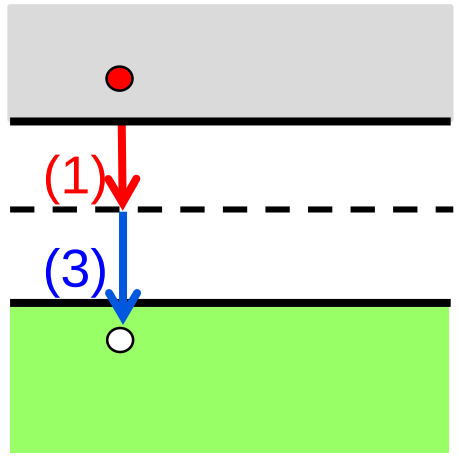
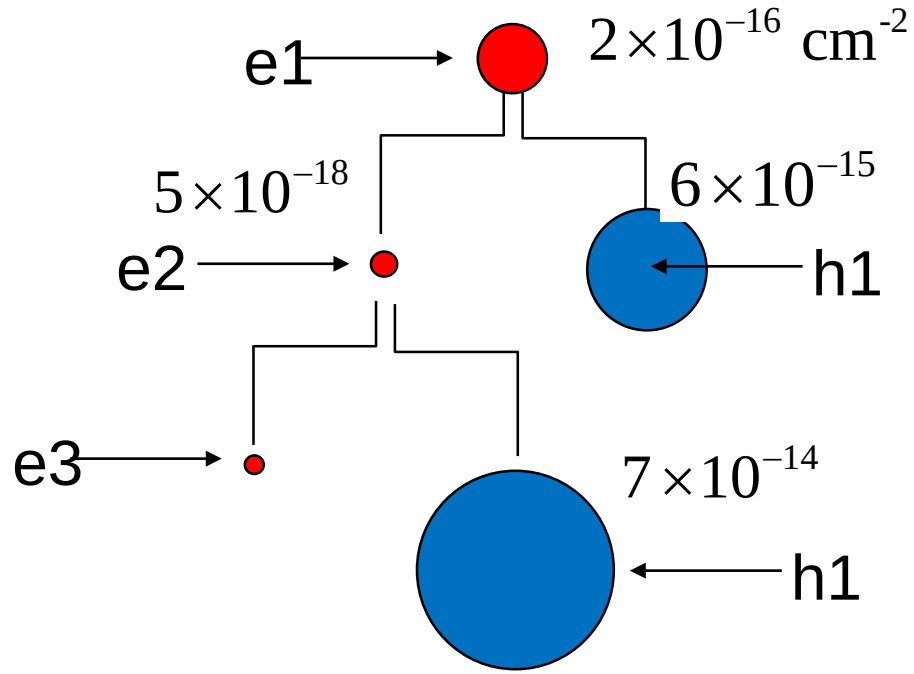
  - »16.2.3 Steady State Trap Population
  - »16.2.4 Recombination-Generation Rate





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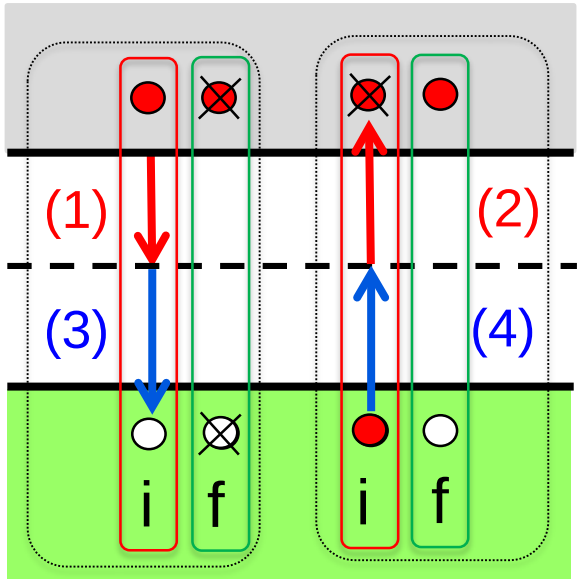
Derivation of Shockley-Read-Hall (SRH) Recombination

Overall Process

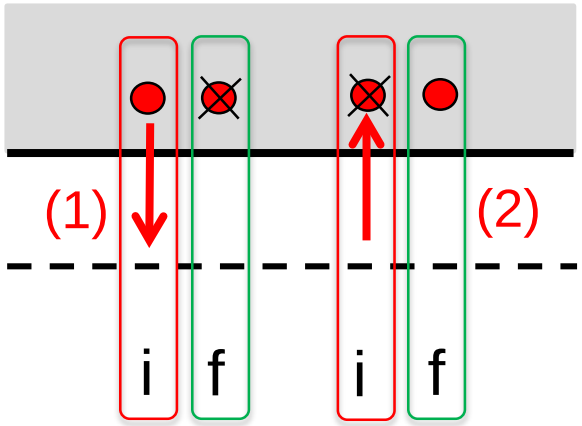


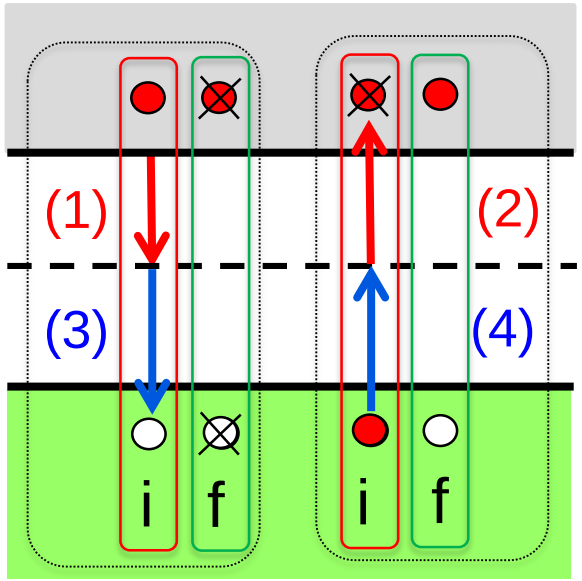
(1) one electron reduced from C-band
(3) One hole reduced from V-band

(4) one hole created in V-band
(2) one electron created in C-band

Conduction Band Processes

Overall Process





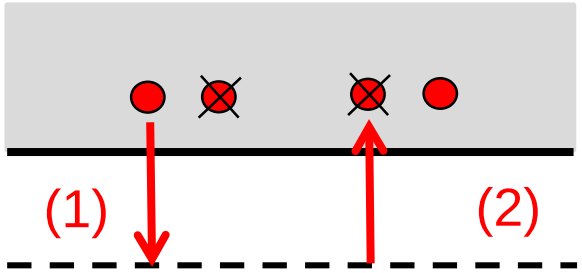
(1) one electron reduced from C-band
(2) one electron created in C-band

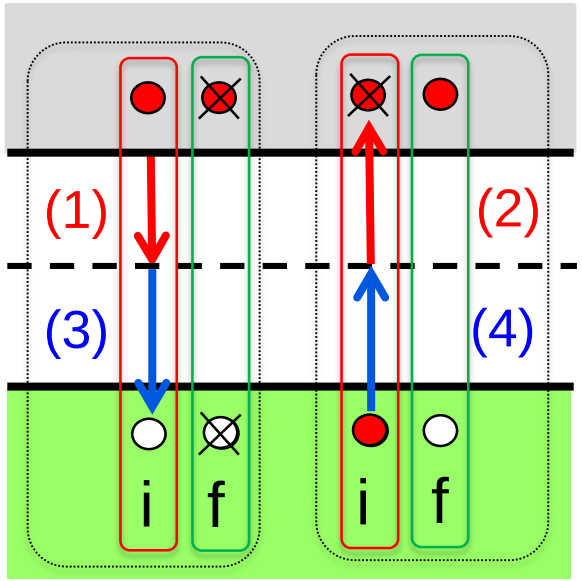
(1) one electron reduced from C-band
(3) One hole reduced from V-band

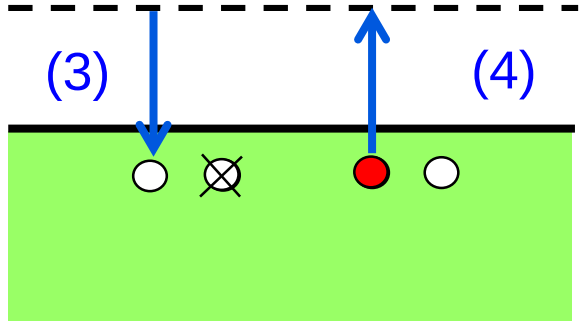
(4) one hole created in V-band
(2) one electron created in C-band

Valence Band Processes

Overall Process







(1) one electron reduced from C-band
(2) one electron created in C-band

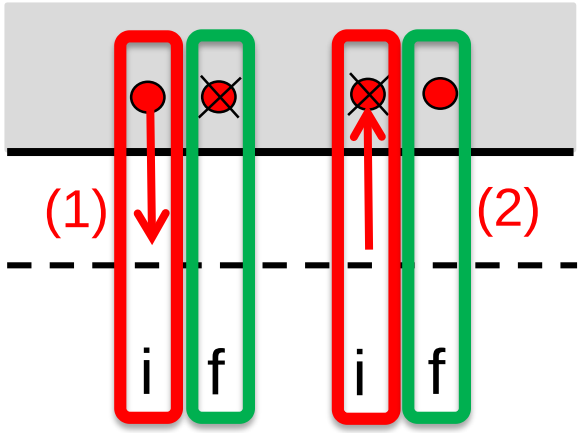
(3) One hole reduced from V-band
(4) one hole created in V-band

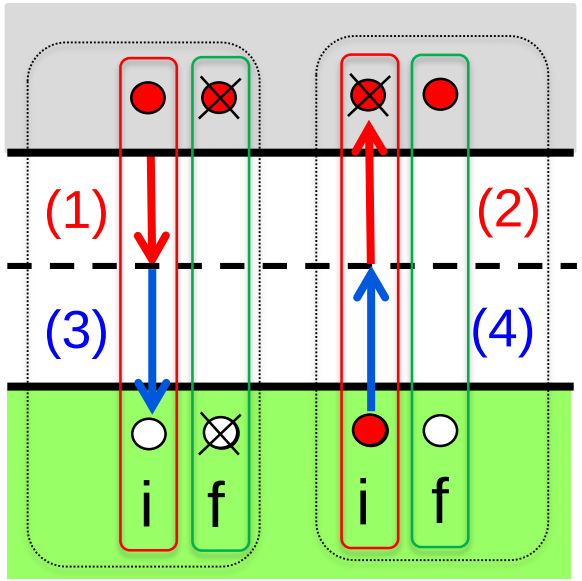
(1) one electron reduced from C-band
(3) One hole reduced from V-band

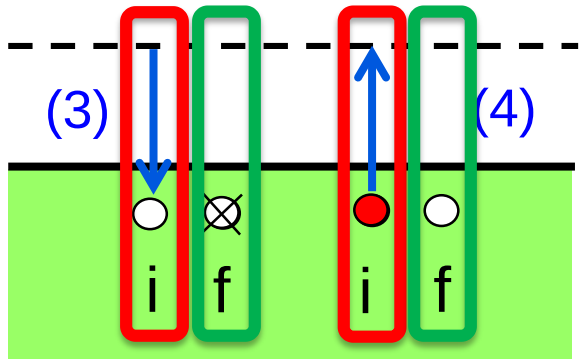
(4) one hole created in V-band
(2) one electron created in C-band

Need a Definition of Initial and Final States

Overall Process







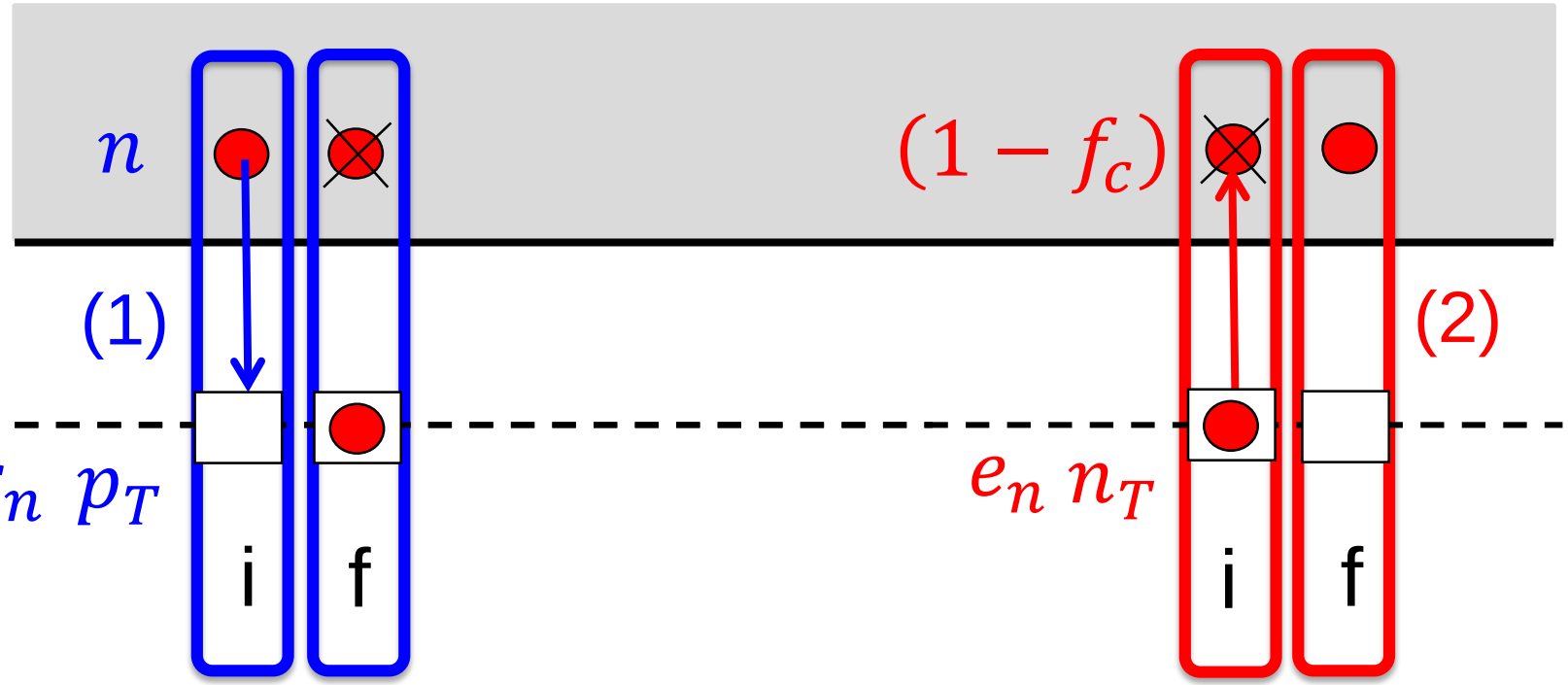
(1) one electron reduced from C-band
(2) one electron created in C-band

(3) One hole reduced from V-band
(4) one hole created in V-band

(1) one electron reduced from C-band
(3) One hole reduced from V-band

(4) one hole created in V-band
(2) one electron created in C-band

Focus on Electron Processes



(1) one electron reduced from C-band

p_T hole-filled (empty) traps

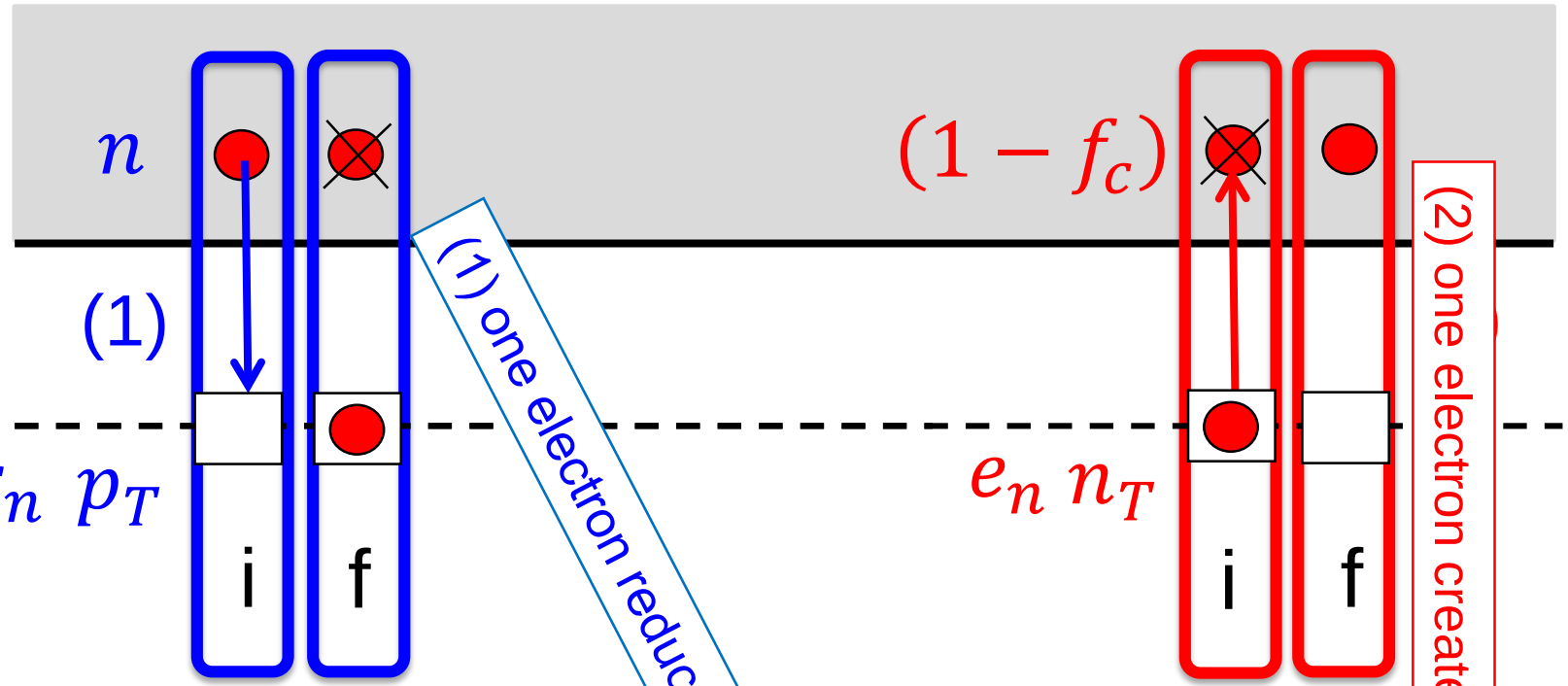
c_n electron capture coef.

(2) one electron created in C-band

n_T electron-filled traps

e_n electron emission coef.

Focus on Electron Processes



p_T hole-filled (empty) traps

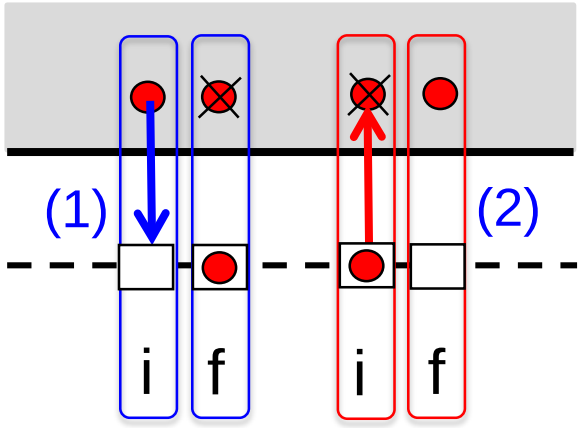
c_n electron capture coef.

n_T electron-filled traps

e_n electron emission coef.

$$\left.\frac{\partial n}{\partial t}\right|_{1,2} = -c_n n p_T + e_n n_T (1 - f_c)$$

Focus on Hole Processes



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p_T hole-filled (empty) traps

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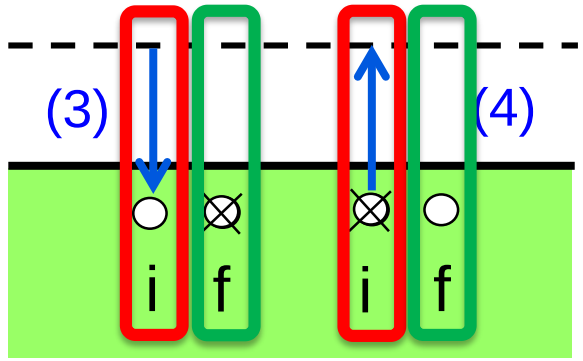
e_n electron emission coef.

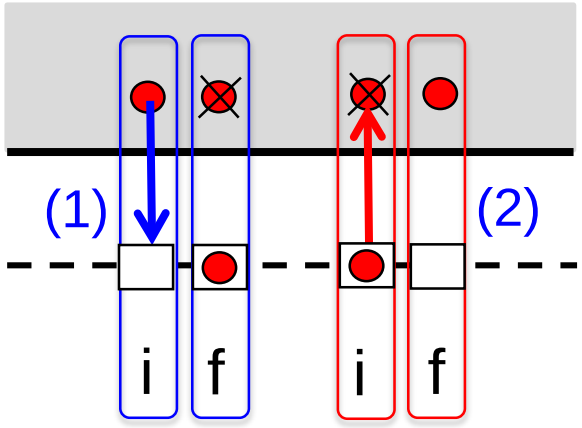
$$\left.\frac{\partial n}{\partial t}\right|_{1,2} = -c_n n p_T + e_n n_T (1 - f_c)$$



(3) One hole reduced from V-band

(4) one hole created in V-band

Focus on Hole Processes



n_T electron-filled traps

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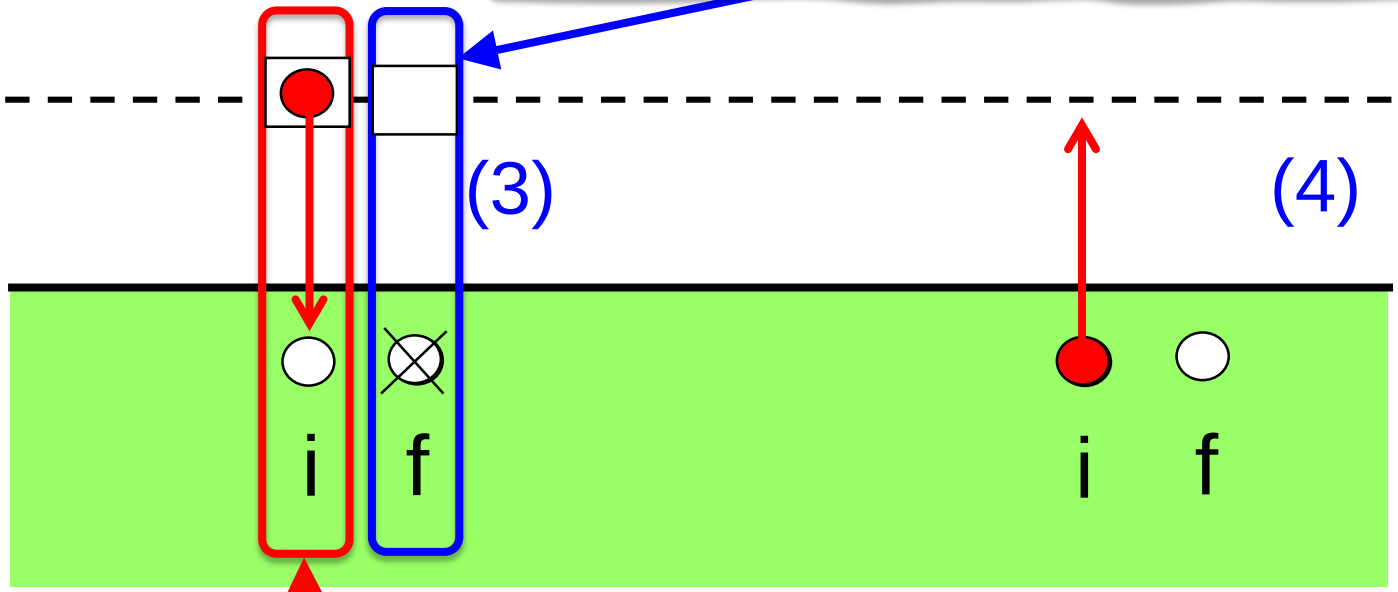
c_n electron capture coef.

e_n electron emission coef.

$$\left.\frac{\partial n}{\partial t}\right|_{1,2} = -c_n n p_T + e_n n_T (1 - f_c)$$

We want a trap+hole-focused view

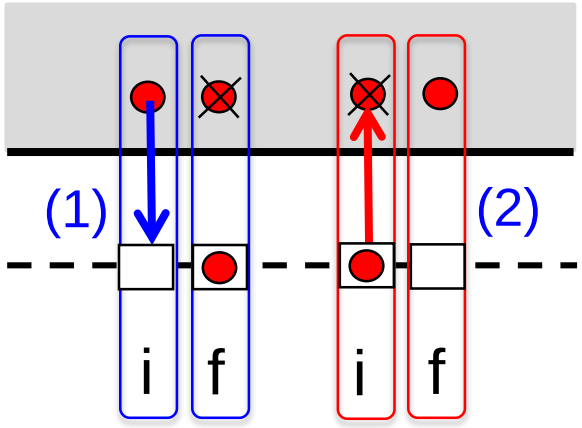


(3) One hole reduced from V-band

(4) one hole created in V-band

This is an electron-focused view

Focus on Hole Processes



n_T electron-filled traps

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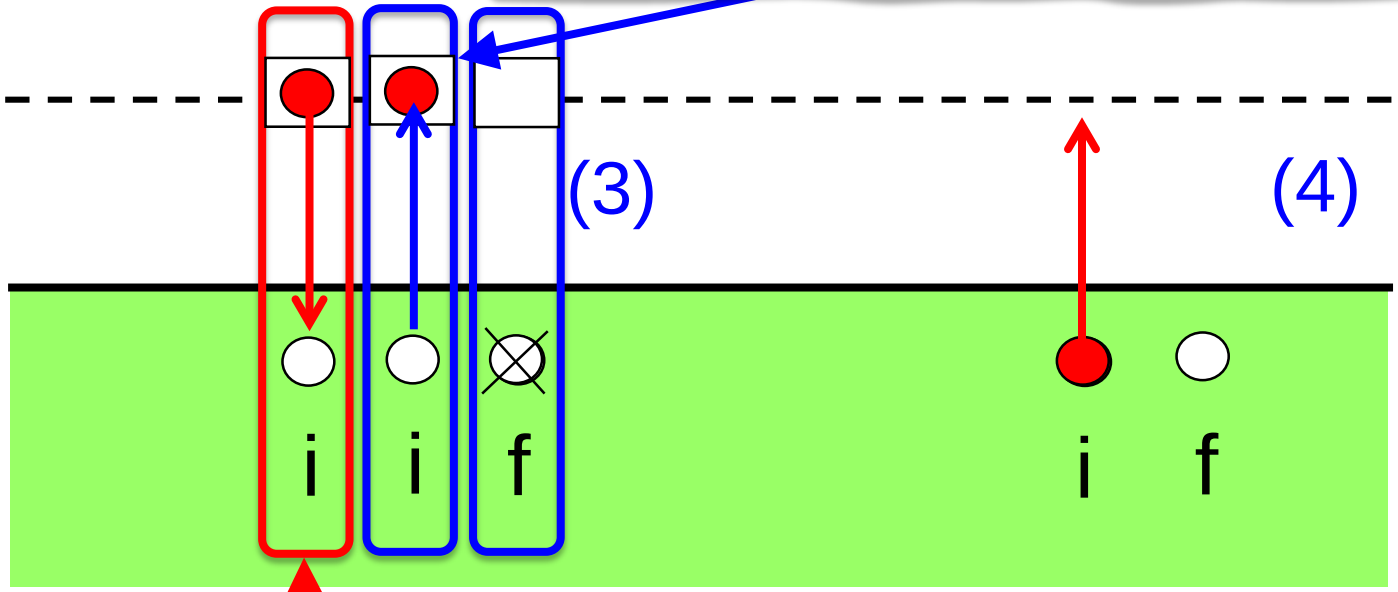
$$\left.\frac{\partial n}{\partial t}\right|_{1,2} = -c_n n p_T + e_n n_T (1 - f_c)$$

We want a trap+hole-focused view

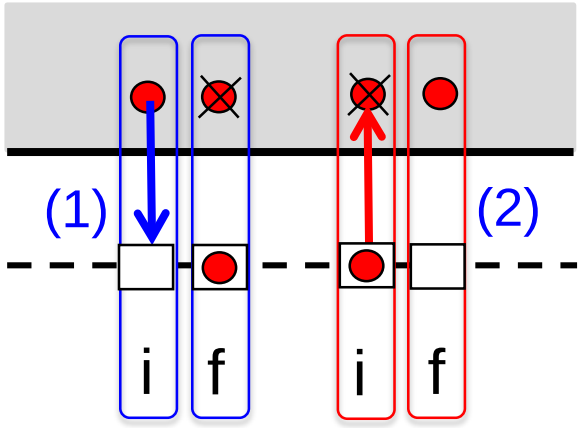


(3) One hole reduced from V-band

(4) one hole created in V-band

This is an electron-focused view

Focus on Hole Processes



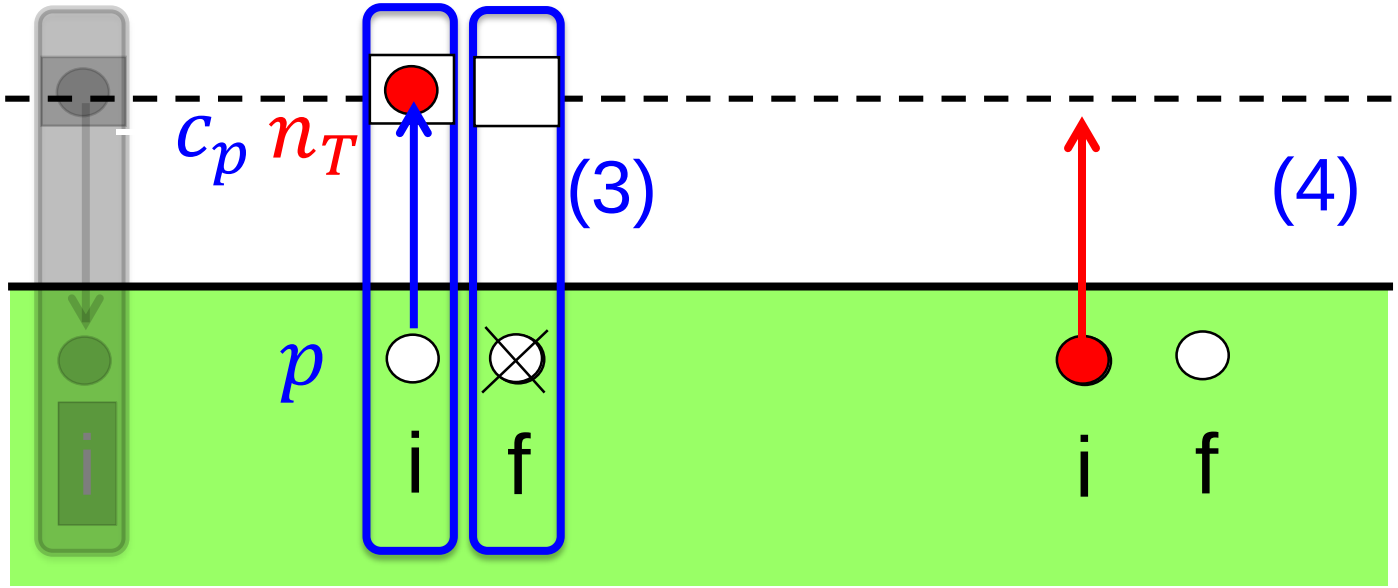
n_T electron-filled traps

p_T hole-filled (empty) traps

c_n electron capture coef.

c_p hole capture coef.

e_n electron emission coef.



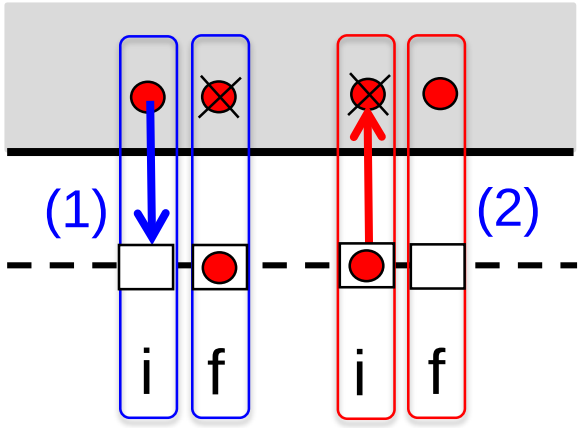
(3) One hole reduced from V-band

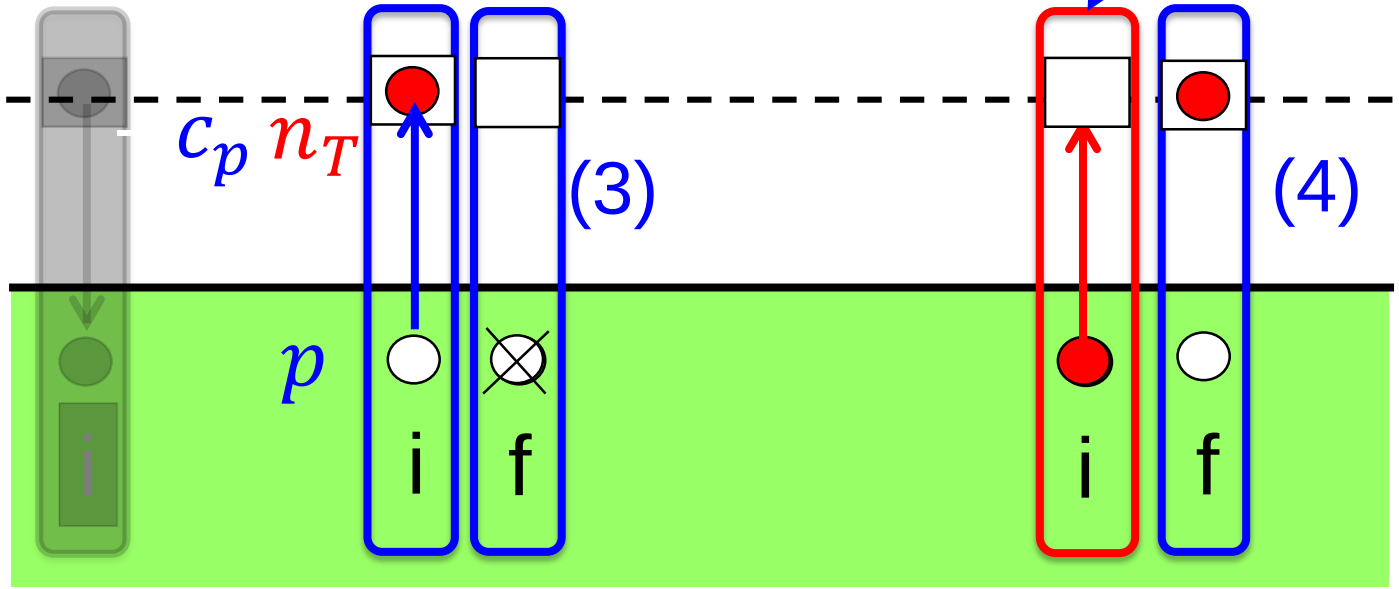
(4) one hole created in V-band

$$\left.\frac{\partial n}{\partial t}\right|_{1,2} = -c_n n p_T + e_n n_T (1 - f_c)$$

Focus on Hole Proc

We want a trap+hole-focused view





(3) One hole reduced from V-band

n_T electron-filled traps

p_T hole-filled (empty) traps

c_n electron capture coef.

c_p hole capture coef.

e_n electron emission coef.

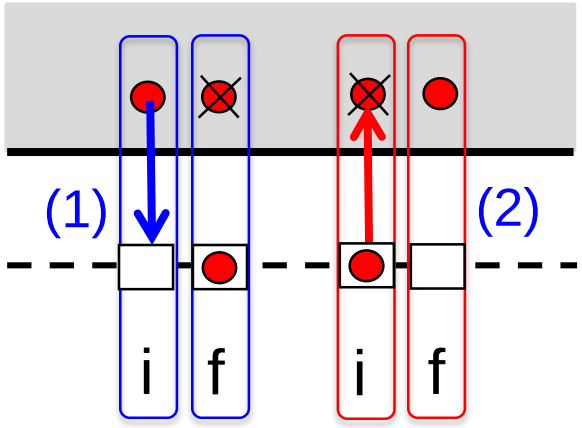
(4) one hole created in V-band

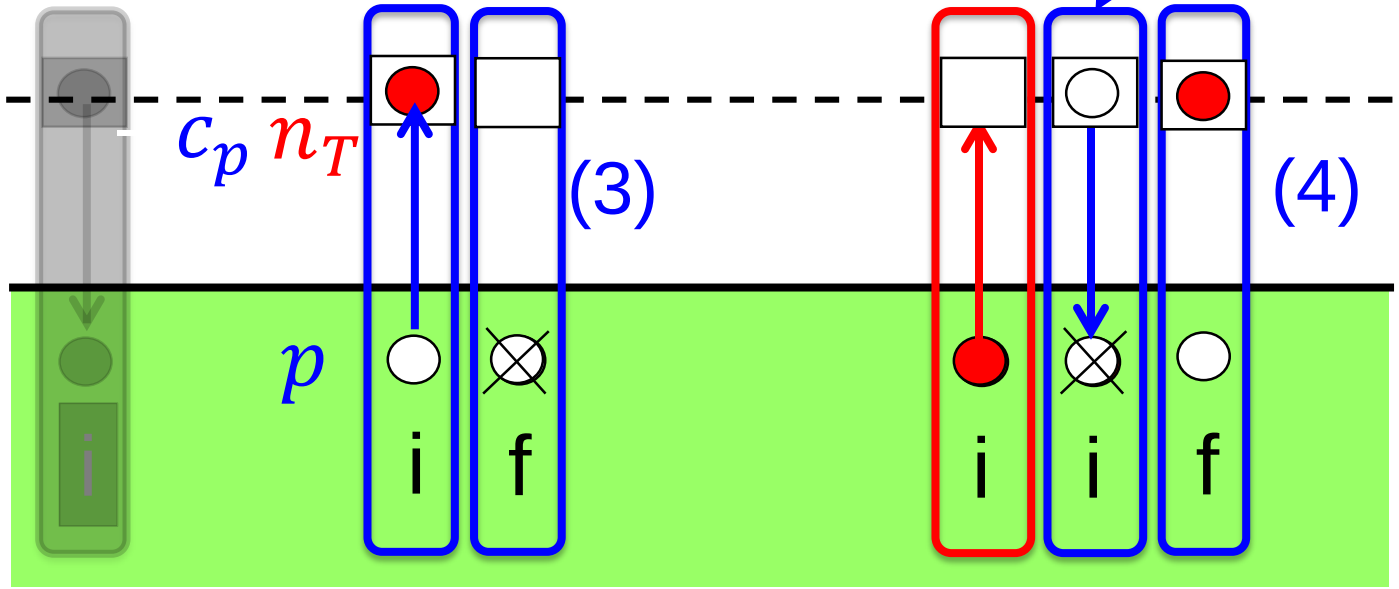
$$\left.\frac{\partial n}{\partial t}\right|_{1,2} = -c_n n p_T + e_n n_T (1 - f_c)$$

$$\left.\frac{\partial p}{\partial t}\right|_{3,4} = -c_p p n_T + e_p p_T f_v$$

Focus on Hole Proc

We want a trap+hole-focused view





(3) One hole reduced from V-band

(4) one hole created in V-band

n_T electron-filled traps

p_T hole-filled (empty) traps

c_n electron capture coef.

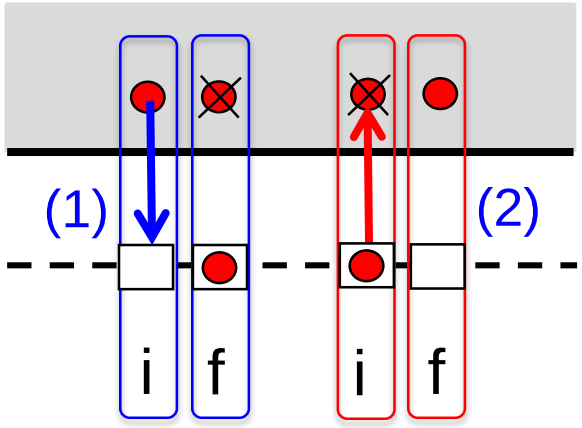
c_p hole capture coef.

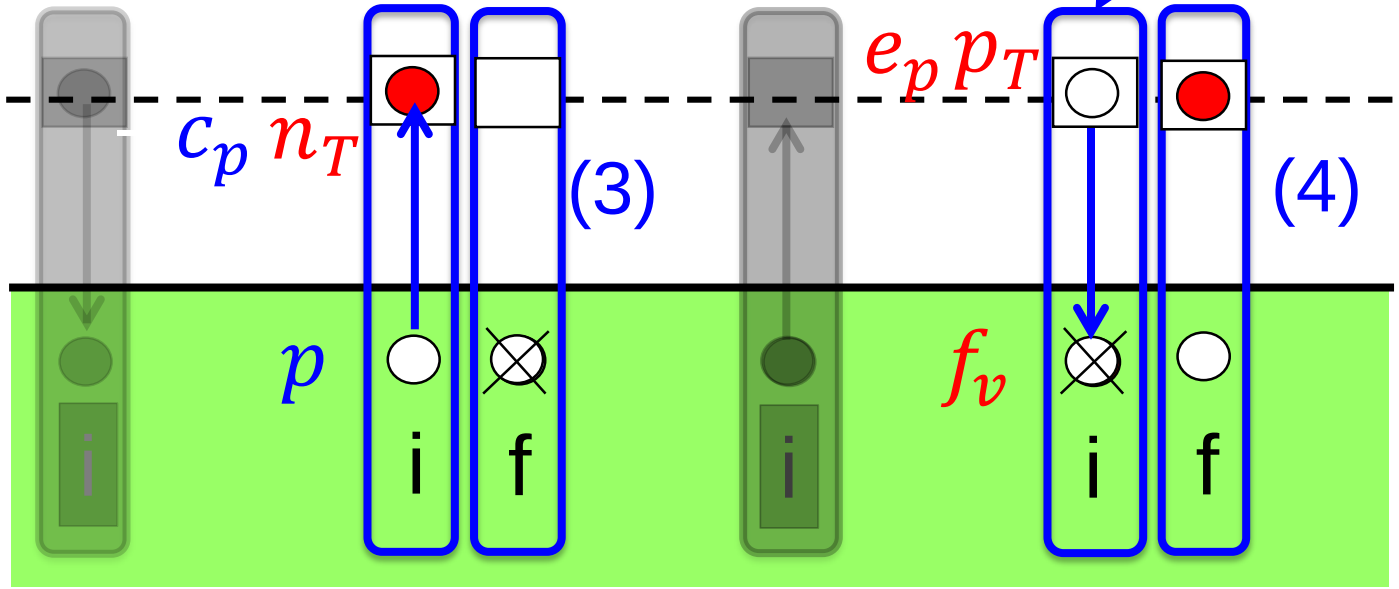
e_n electron emission coef.

$$\left.\frac{\partial n}{\partial t}\right|_{1,2} = -c_n n p_T + e_n n_T (1 - f_c)$$

Focus on Hole Proc

We want a trap+hole-focused view





(3) One hole reduced from V-band

(4) one hole created in V-band

n_T electron-filled traps

p_T hole-filled (empty) traps

c_n electron capture coef.

c_p hole capture coef.

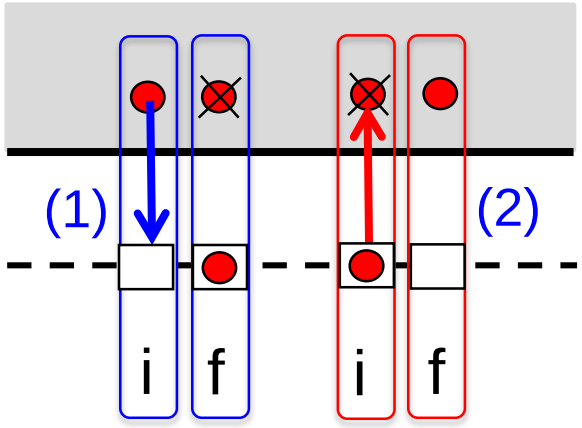
e_n electron emission coef.

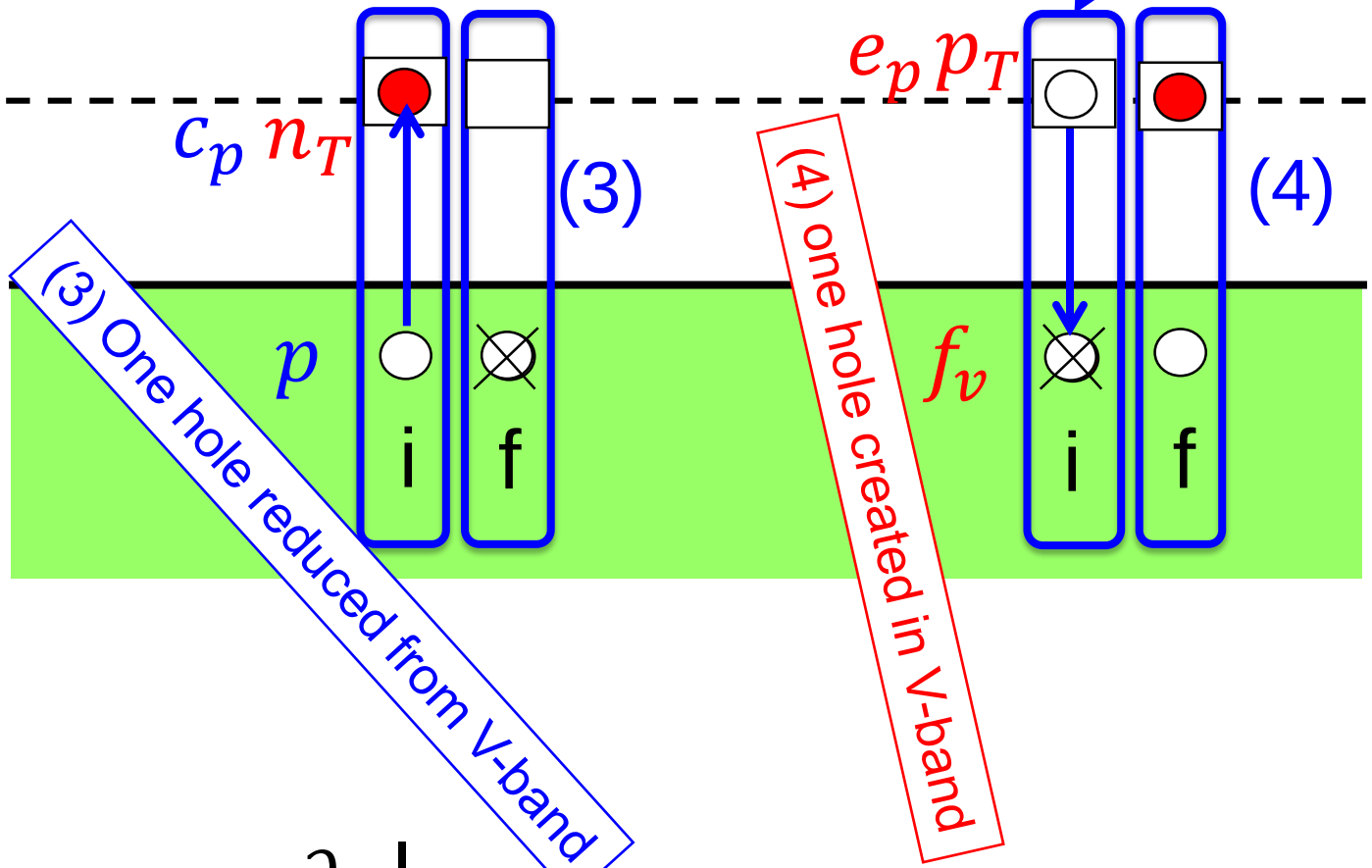
e_p hole emission coef.

$$\left.\frac{\partial n}{\partial t}\right|_{1,2} = -c_n n p_T + e_n n_T (1 - f_c)$$

Focus on Hole Proc

We want a trap+hole-focused view





n_T electron-filled traps

p_T hole-filled (empty) traps

c_n electron capture coef.

c_p hole capture coef.

e_n electron emission coef.

e_p hole emission coef.

$$\left.\frac{\partial n}{\partial t}\right|_{1,2} = -c_n n p_T + e_n n_T (1 - f_c)$$

$$\left.\frac{\partial p}{\partial t}\right|_{3,4} = -c_p p n_T + e_p p_T f_v$$

Trap Assisted Recombination

n_T electron-filled traps

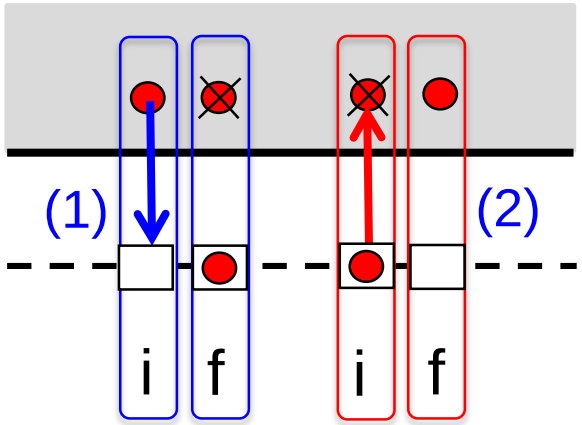
p_T hole-filled (empty) traps

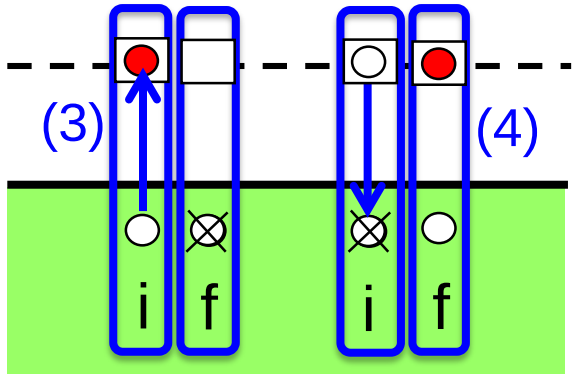
c_n electron capture coef.

c_p hole capture coef.

e_n electron emission coef.

e_p hole emission coef.





$$\left.\frac{\partial n}{\partial t}\right|_{1,2} = -c_n n p_T + e_n n_T (1 - f_c)$$

$$\left.\frac{\partial p}{\partial t}\right|_{3,4} = -c_p p n_T + e_p p_T f_v$$

Section 16.2.2
Trap Assisted Recombination Rates

n_T electron-filled traps

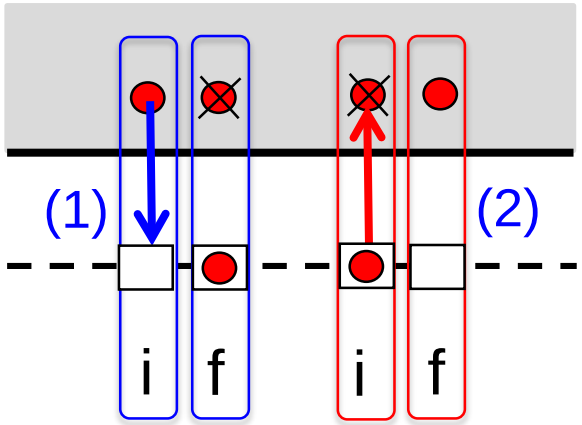
p_T hole-filled (empty) traps

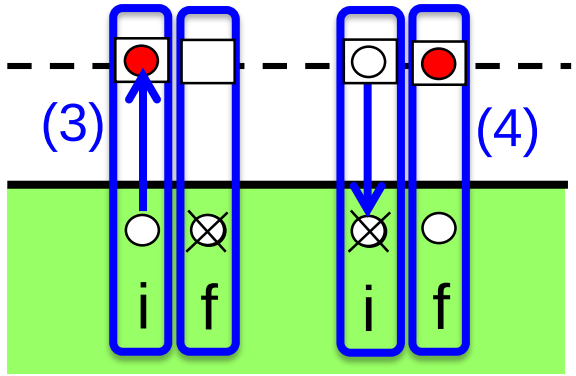
c_n electron capture coef.

c_p hole capture coef.

e_n electron emission coef.

e_p hole emission coef.





$$\left.\frac{\partial n}{\partial t}\right|_{1,2} = -c_n n p_T + e_n n_T (1 - f_c) \qquad \left.\frac{\partial p}{\partial t}\right|_{3,4} = -c_p p n_T + e_p p_T f_v$$

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  - » 16.2.1 Trap Assisted Recombination Rates 

  - » 16.2.2 Capture and emission relationship (n_1 and p_1)
  - » 16.2.3 Steady State Trap Population
  - » 16.2.4 Recombination-Generation Rate

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Section 16.2.2
Capture and emission relationship (n1 and p1)

n_T electron-filled traps

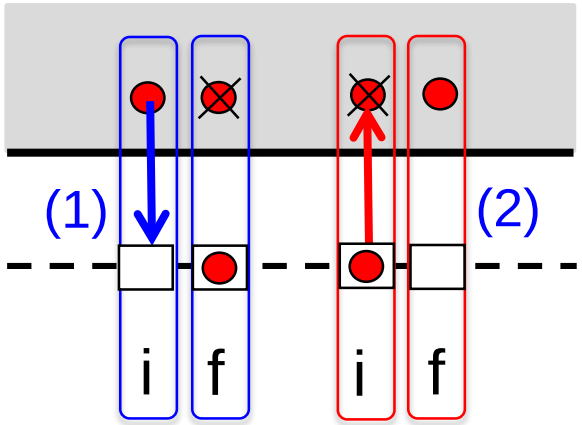
p_T hole-filled (empty) traps

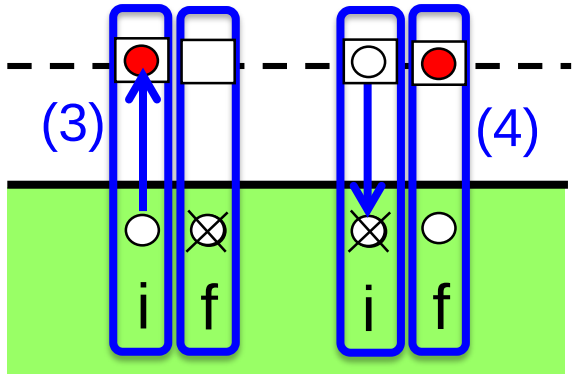
c_n electron capture coef.

c_p hole capture coef.

e_n electron emission coef.

e_p hole emission coef.





$$\left.\frac{\partial n}{\partial t}\right|_{1,2} = -c_n n p_T + e_n n_T (1 - f_c)$$

$$\left.\frac{\partial p}{\partial t}\right|_{3,4} = -c_p p n_T + e_p p_T f_v$$

Vid

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  - » 16.2.4 Recombination-Generation Rate

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