

Section 16 Recombination & Generation

16.5 Nature of interface states

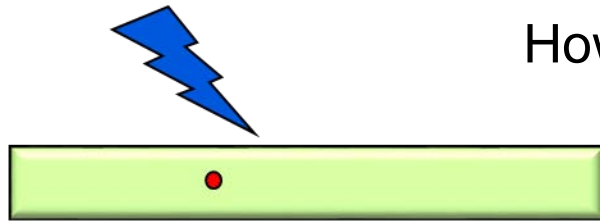
Gerhard Klimeck
gekco@purdue.edu



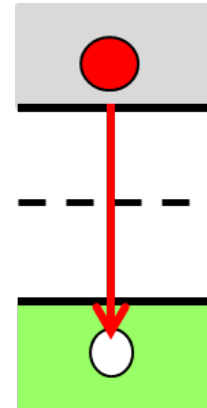
School of Electrical and
Computer Engineering

Section 16

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How does the system go BACK to equilibrium?



$$\tau_n = \frac{1}{c_n N_T} \quad \tau_p = \frac{1}{c_p N_T}$$

$$n_1 = n_i g_D e^{\beta(E_T - E_i)}$$

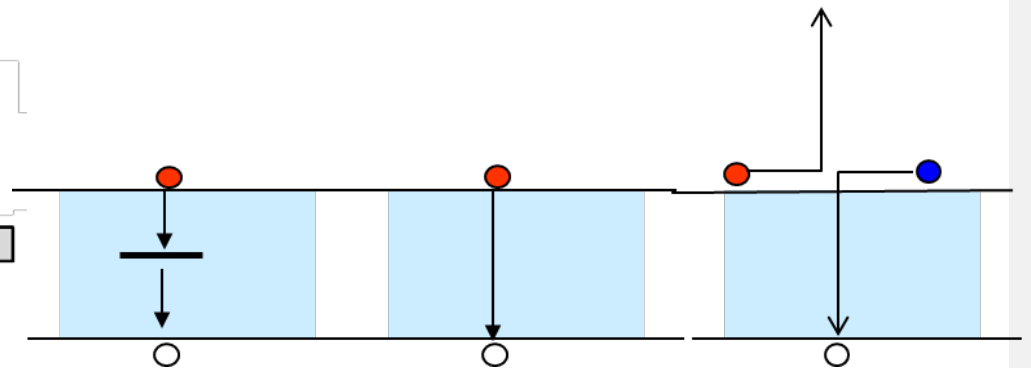
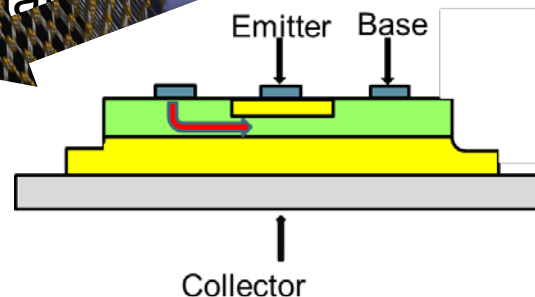
$$p_1 = n_i g_D^{-1} e^{\beta(E_i - E_T)}$$

$$R = \frac{pn - n_i^2}{\tau_p(n + n_1) + \tau_n(p + p_1)}$$

$$R = \frac{\Delta n}{\tau_n}$$

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- 16.1 Capture coefficient & Capture Cross Section
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- 16.3 Application of SRH formula for special cases
 - » Low level, high-level injection, depletion region
- 16.4 Direct and Auger recombination
- 16.5 Nature of interface states
- 16.6
- 16.7



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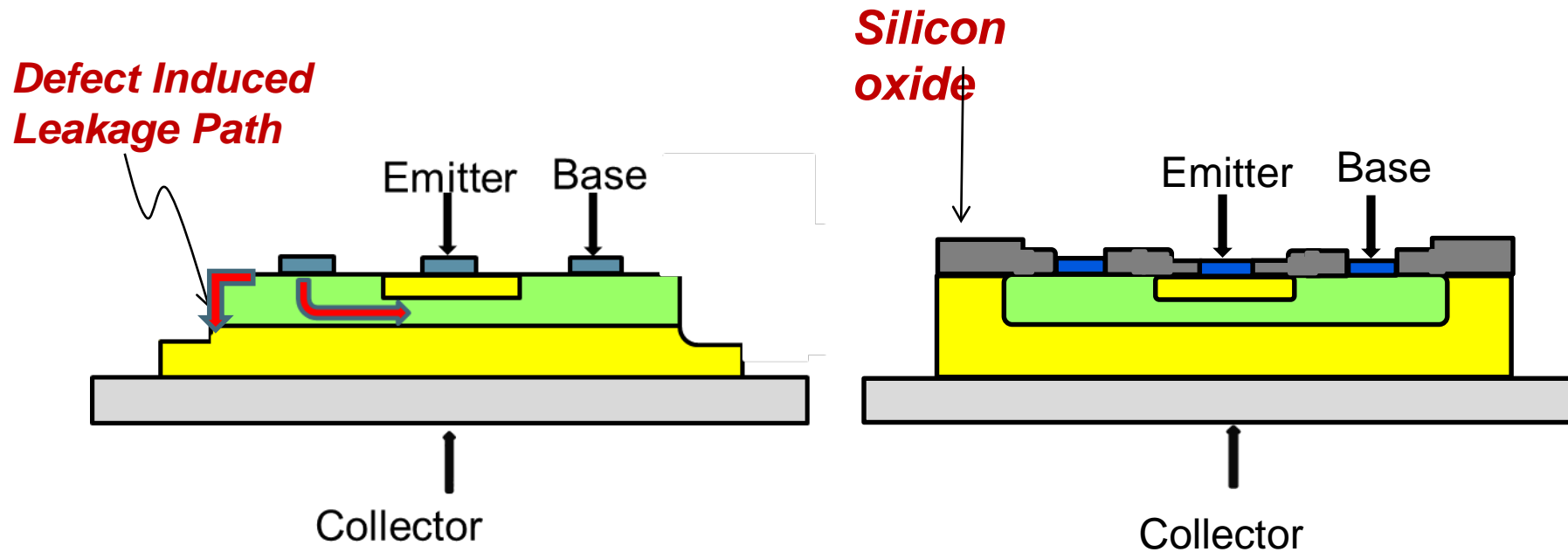
Surface states: Little bit of history

MOSFET patented as concept in 1930s – not implemented due to interface states

Bipolar Junction Transistor had Surface Interface States

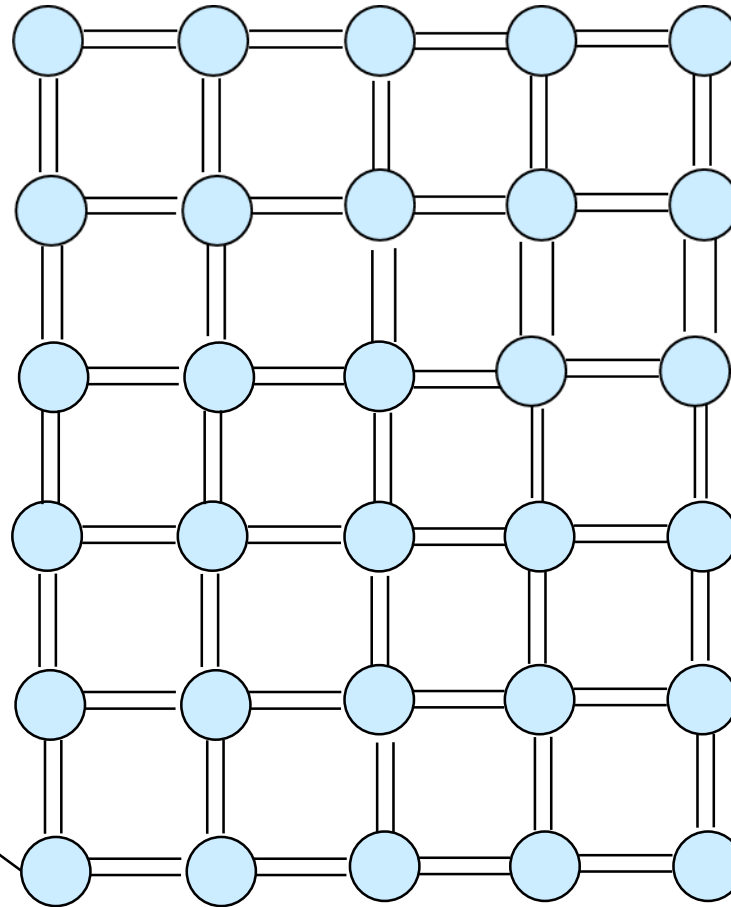
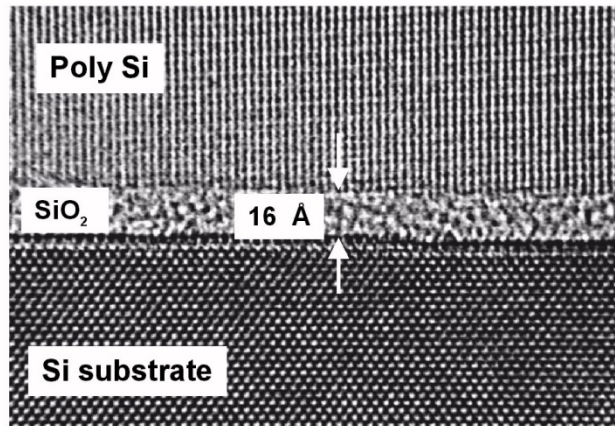
Original Bell Labs transistor never went into production

Jean Hoerni's diagram of Mesa and planar transistors (1961)



One of the fundamental advances in semiconductor history

Atomic configuration of Bulk States



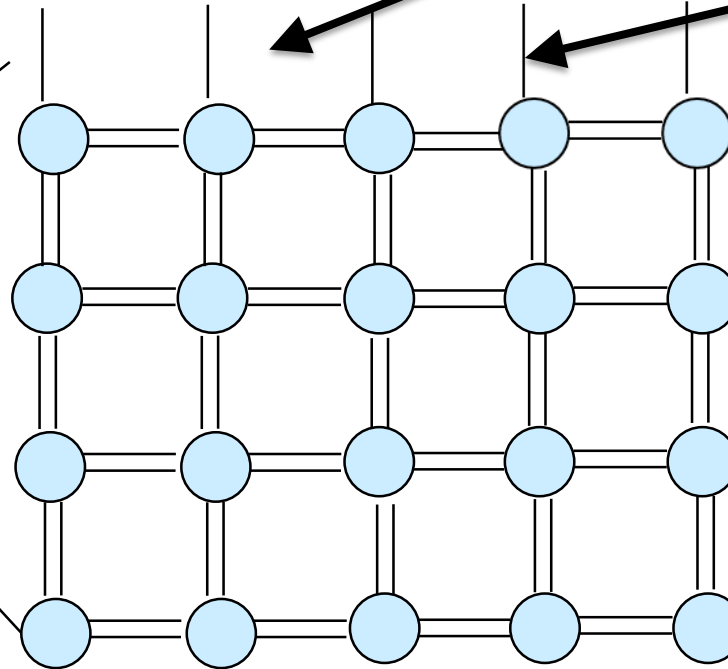
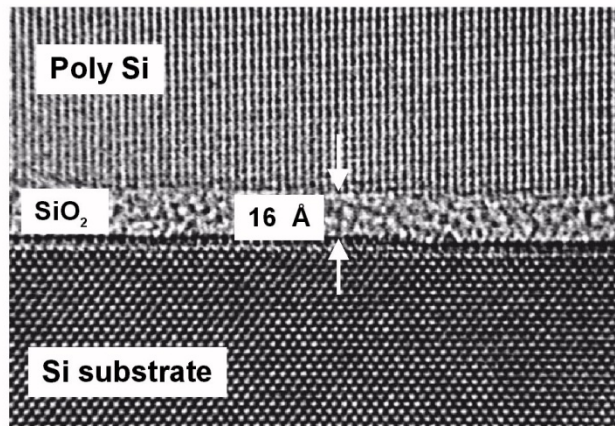
Atomic configuration of Surface States

Trapping and de-trapping at interface changes electrostatics

Threshold fluctuates (turn-ON/OFF characteristics)

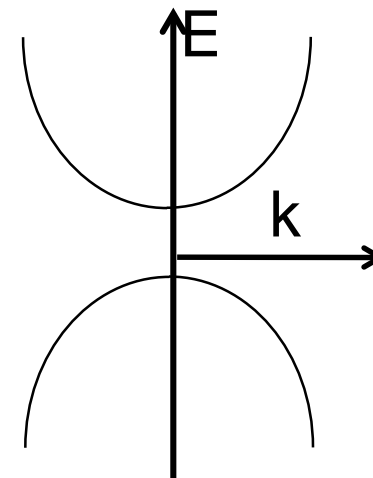
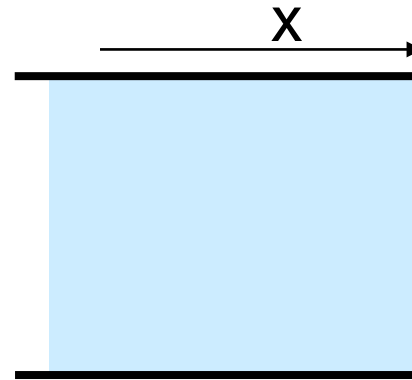
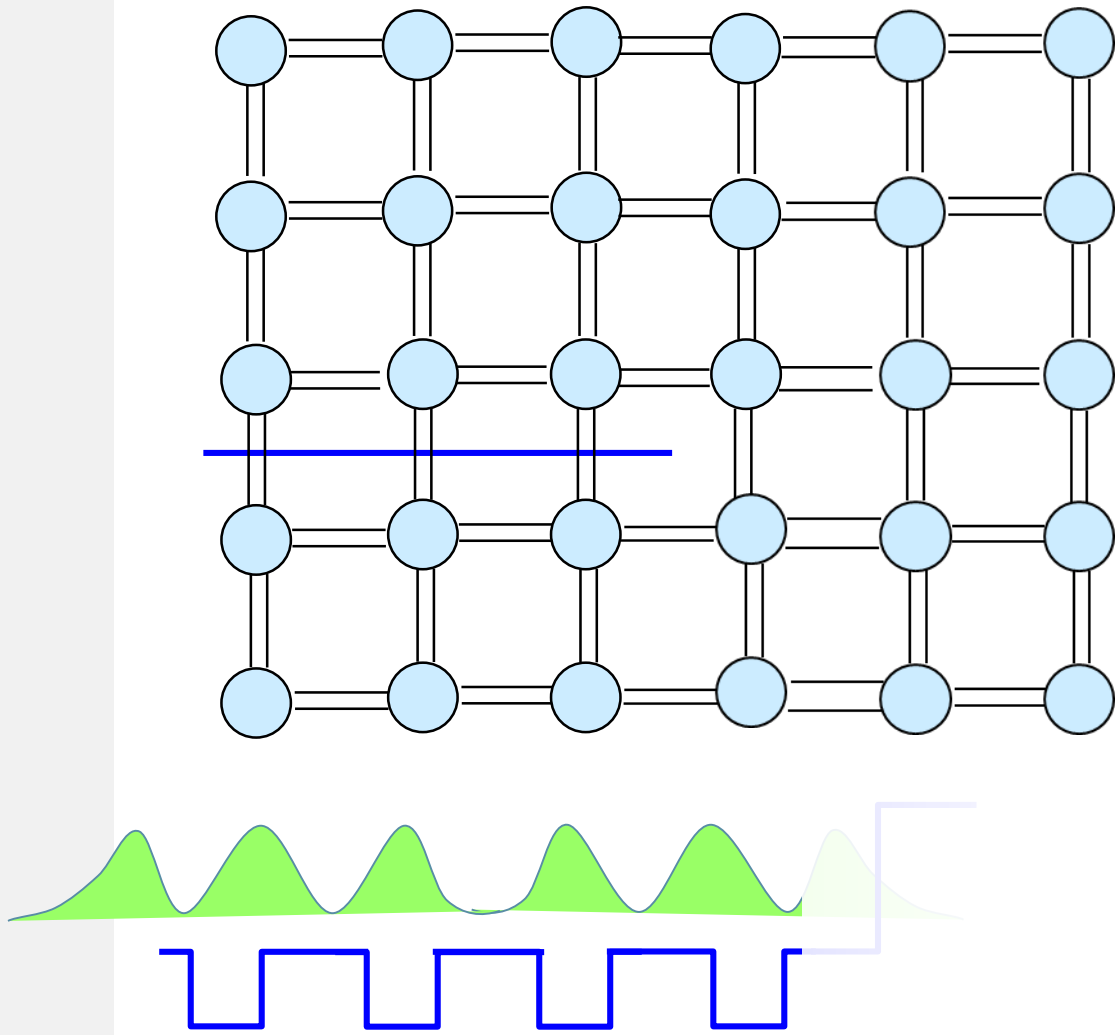
*Free electron will
bind to dangling bond*

*Single bonds
Dangling Bonds*

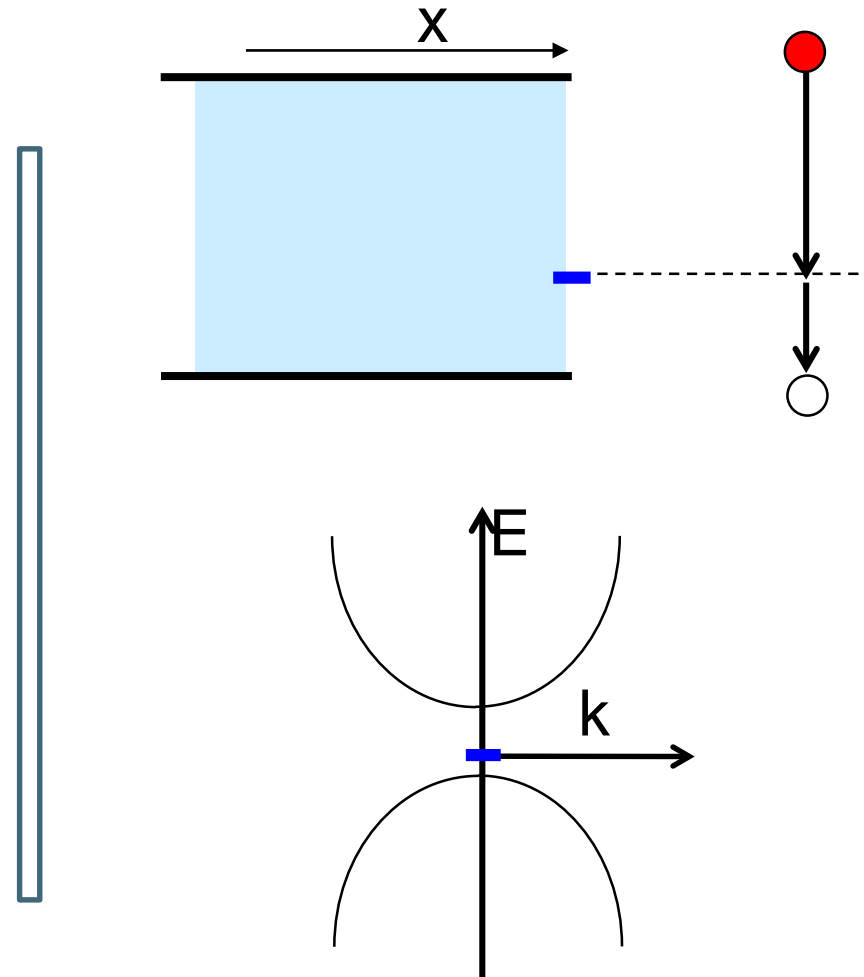
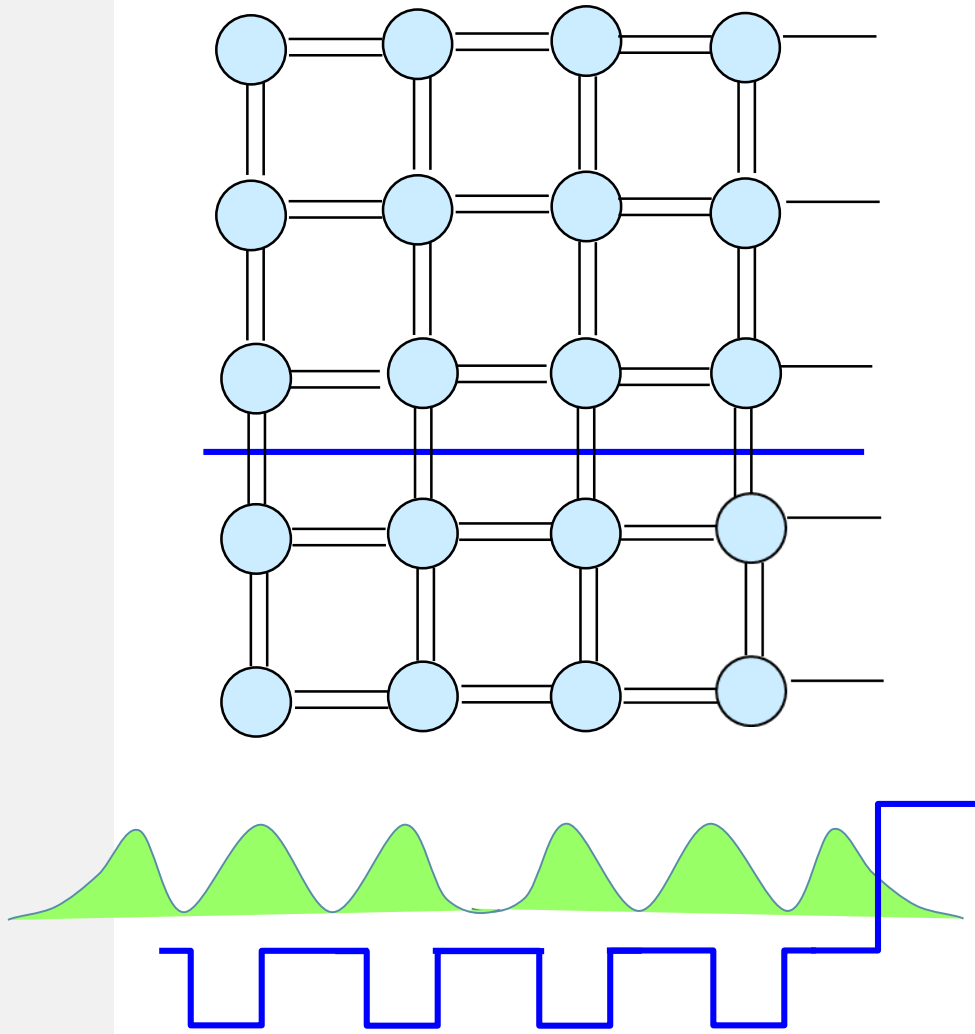


Charge trapping needed to be solved for MOSFET => 1960s Fairchild

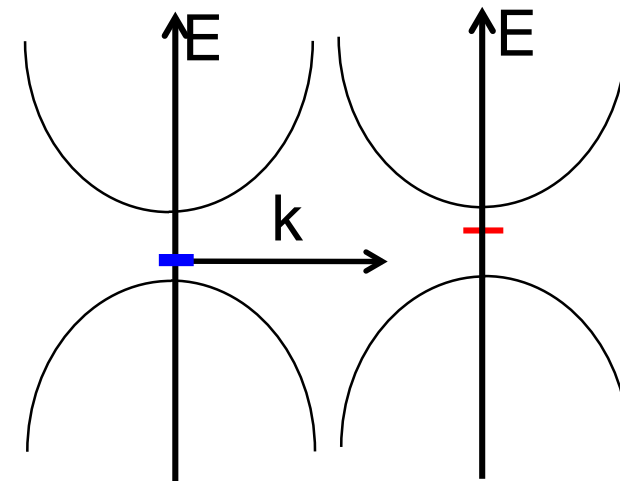
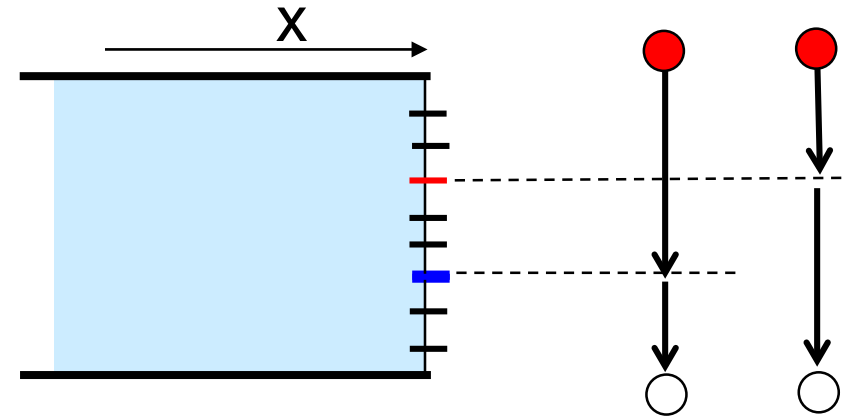
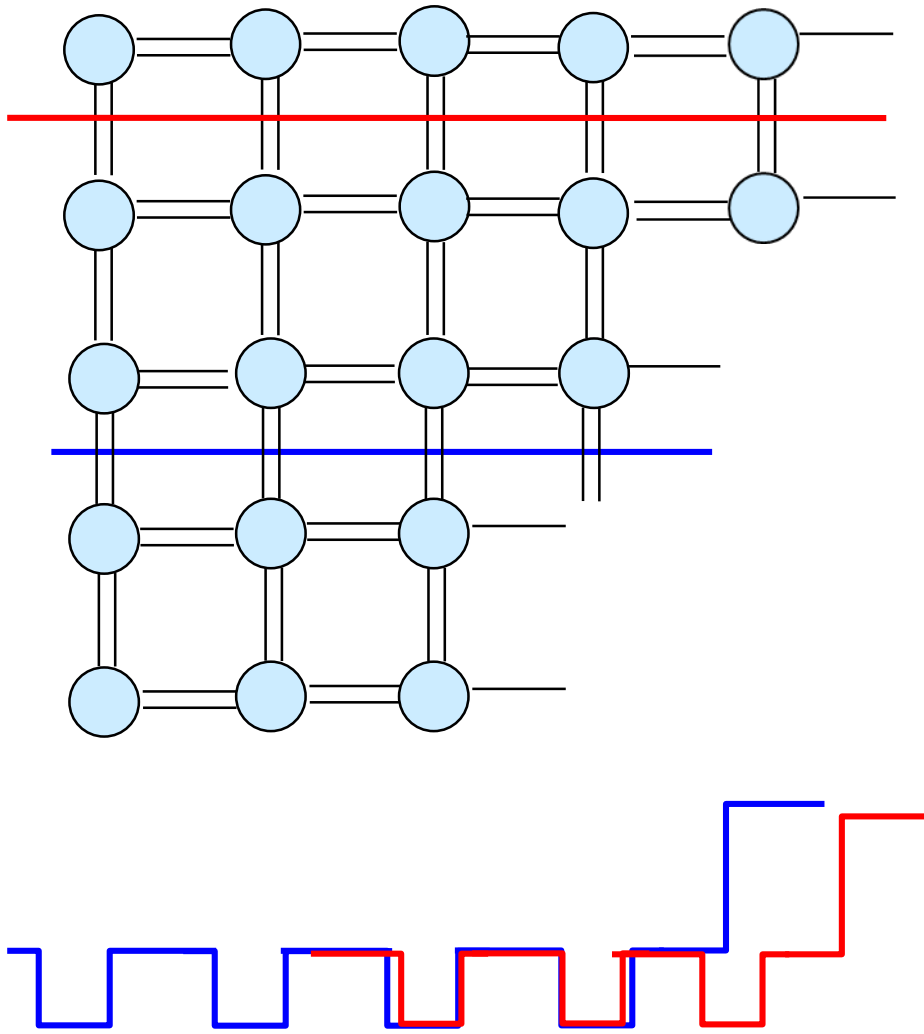
Bulk States - Infinite Periodic Potential No Consideration of Surfaces



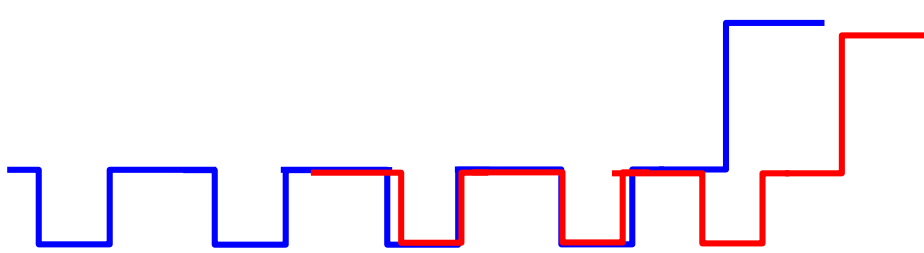
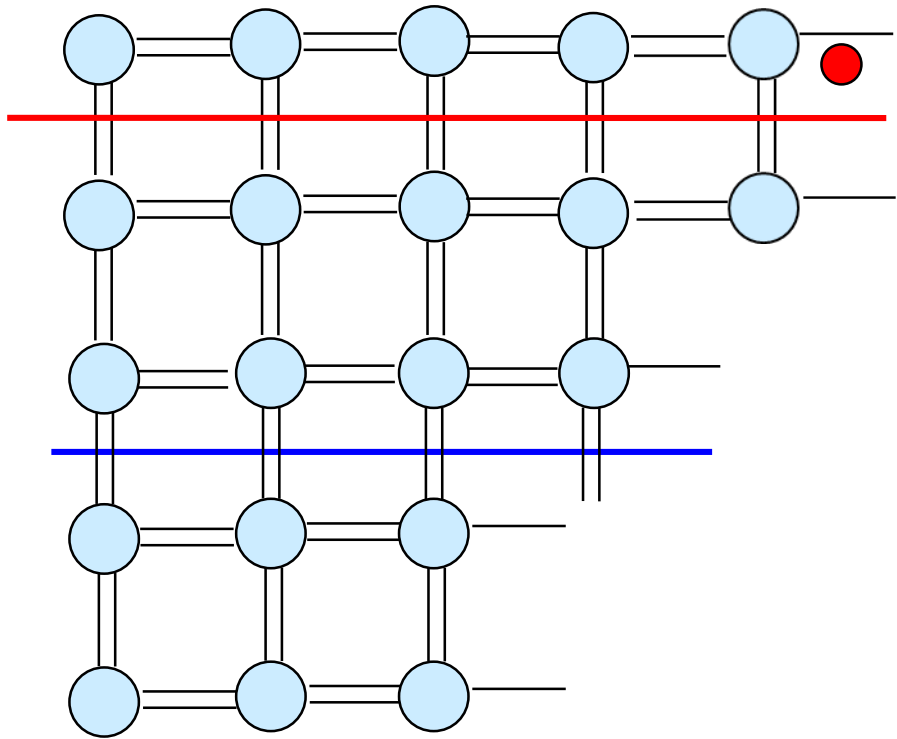
Surface States



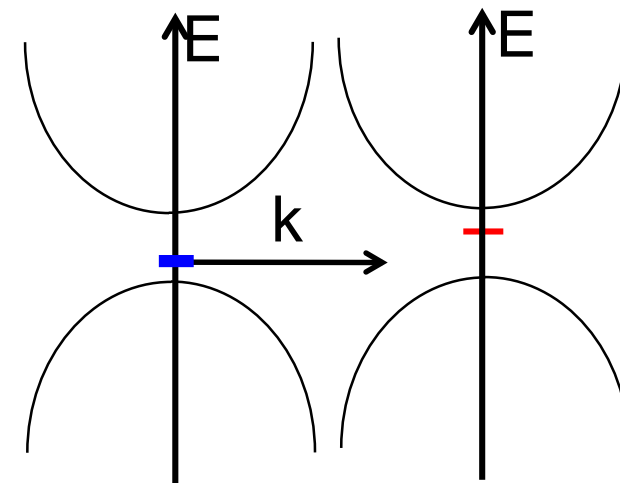
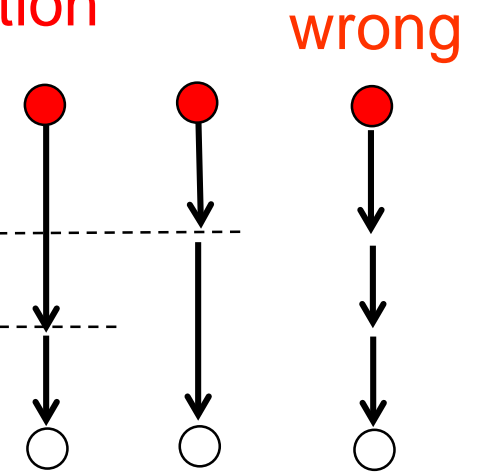
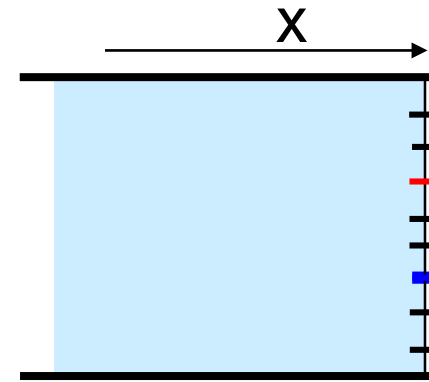
Rough and 3D-Surfaces



Surface States So Not "Connect" Energetically

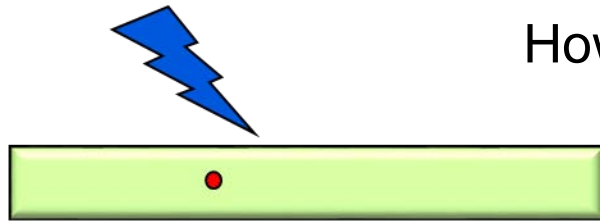


Filling process of dangling bonds important for SRH derivation



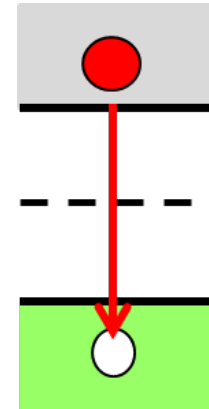
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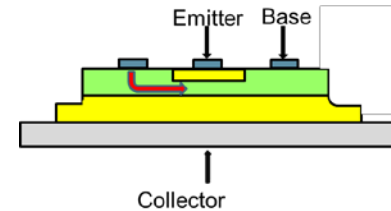
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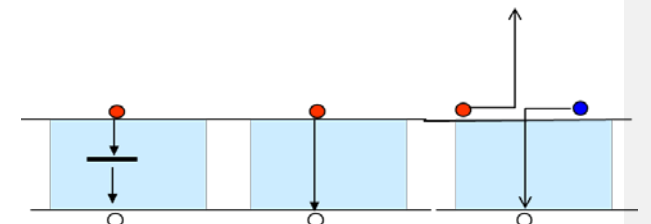
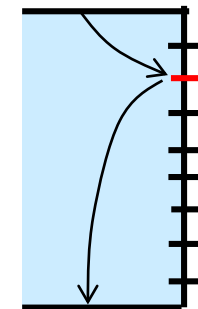
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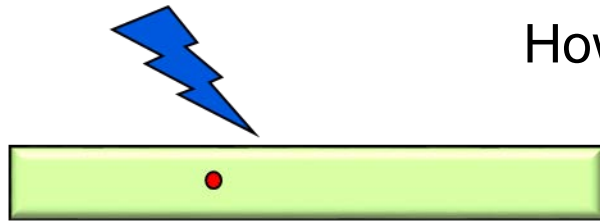
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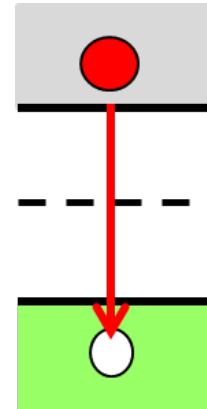
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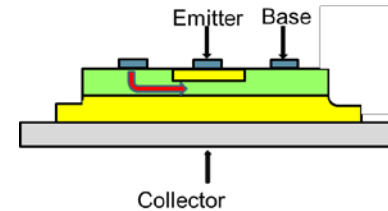
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