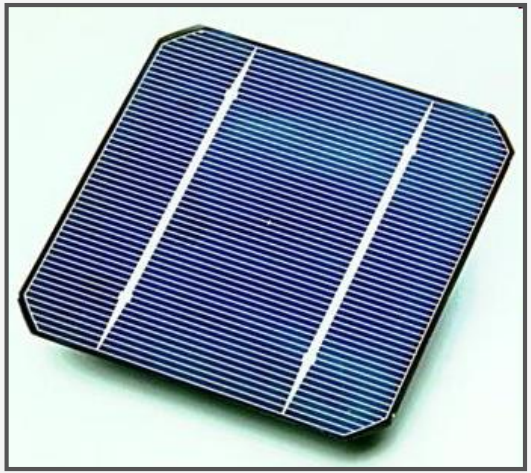
PV Technology Based on Crystalline Silicon Wafers

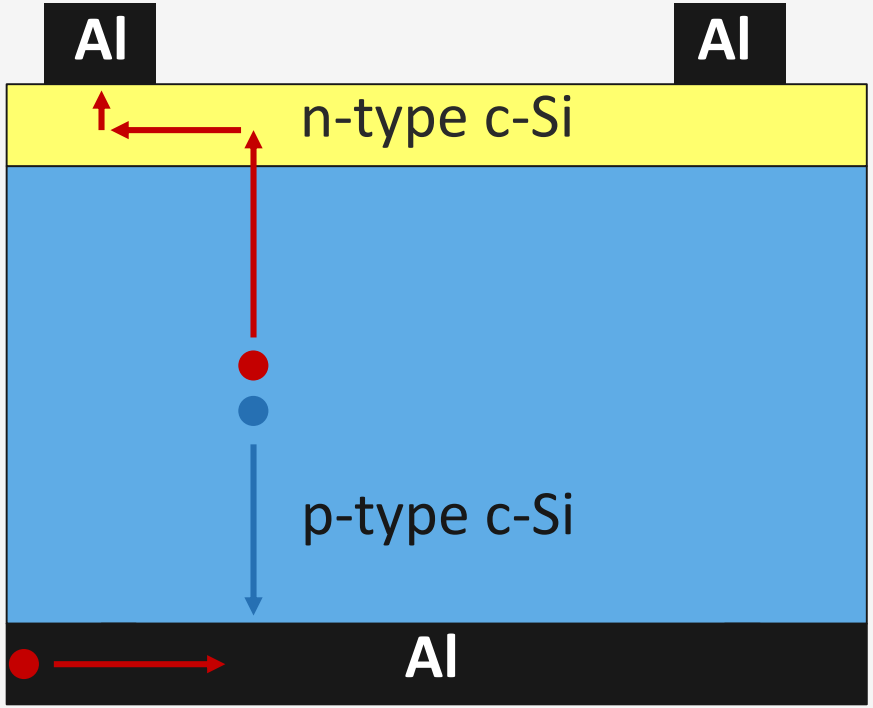
Design Rules of Crystalline Silicon

Week 4.3

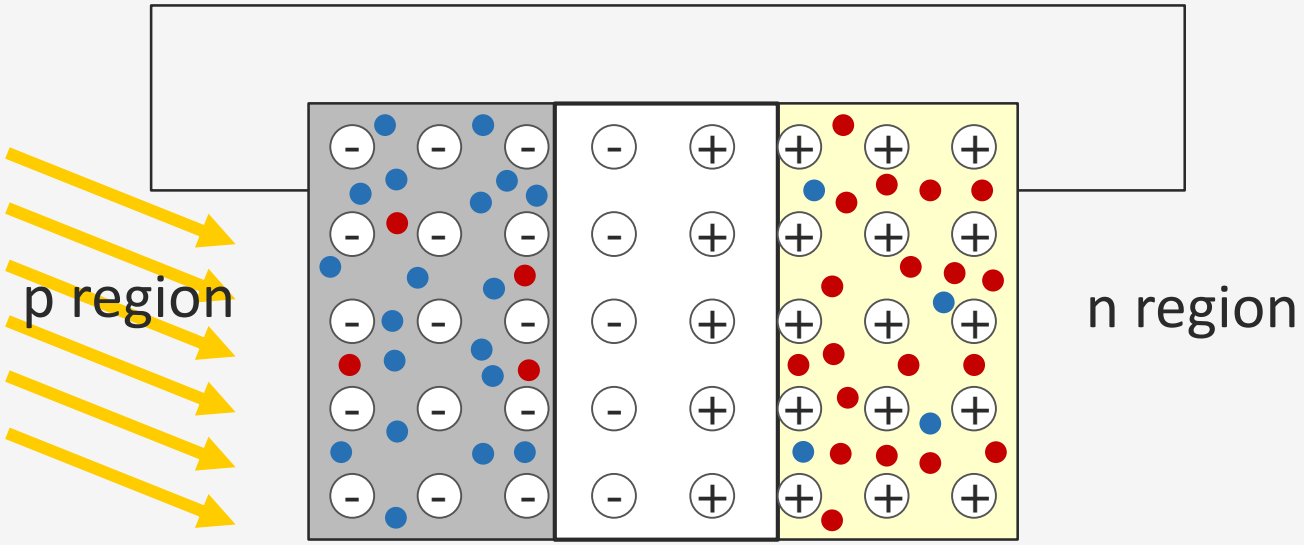
Arno Smets

Introduction

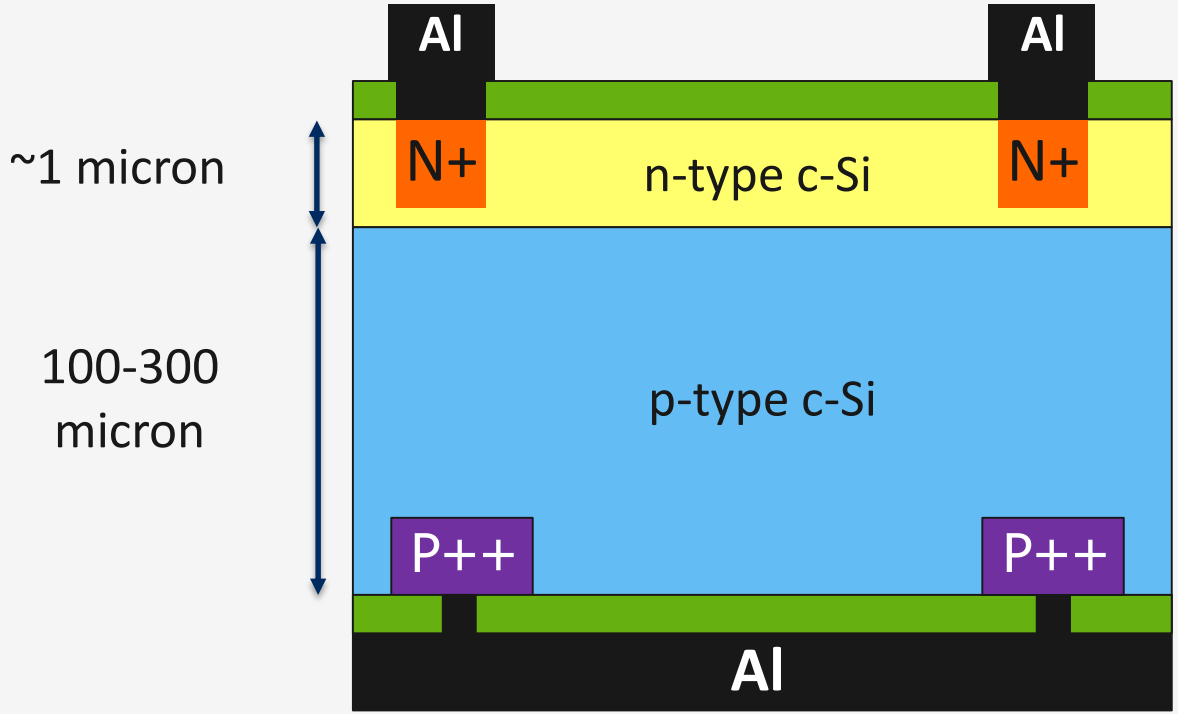




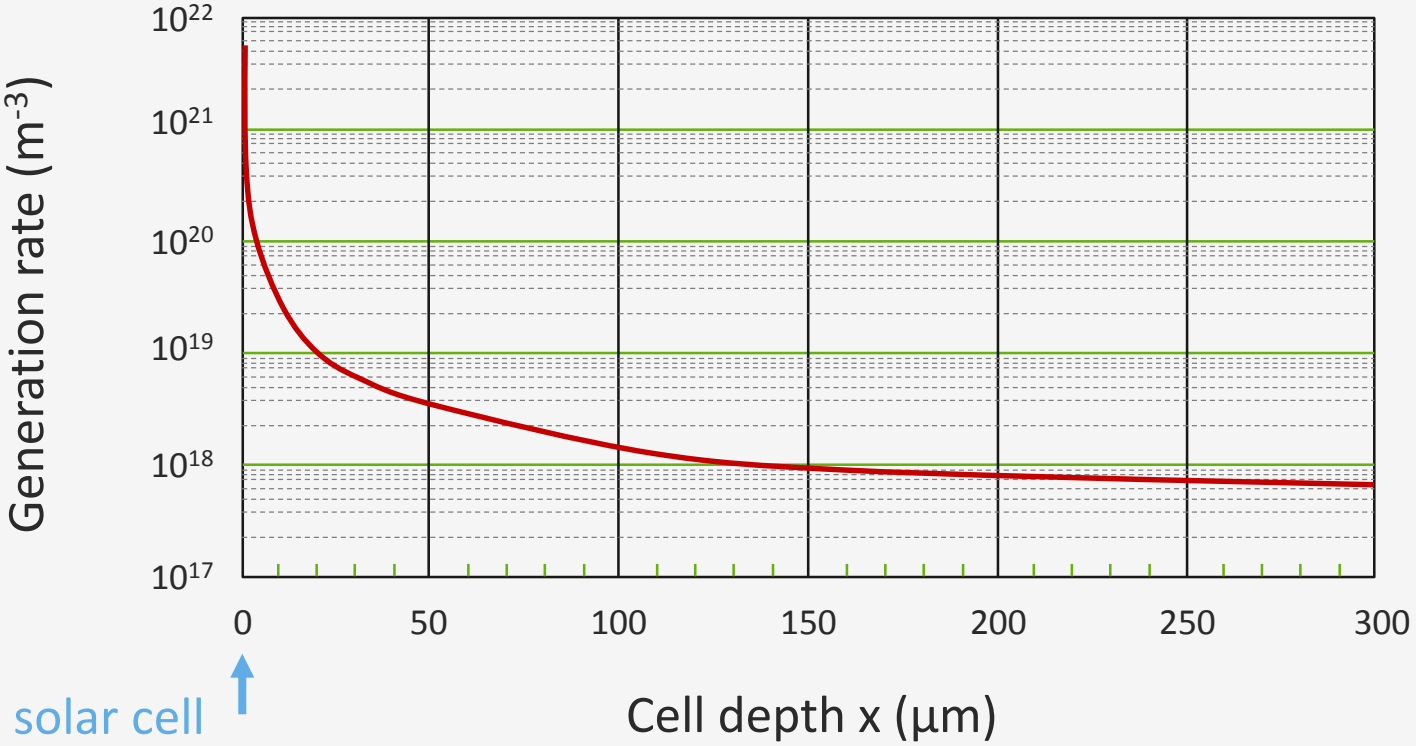
Semiconductor Junction – under illumination



p-type c-Si wafer based solar cell



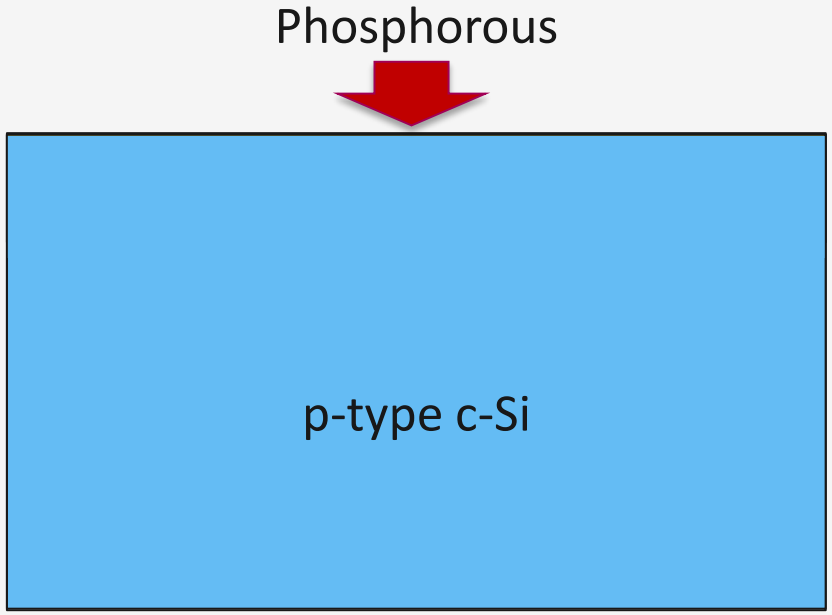
Absorption coefficient



Solid State Diffusion

Flux = D dn/dx

In furnace at high temperatures



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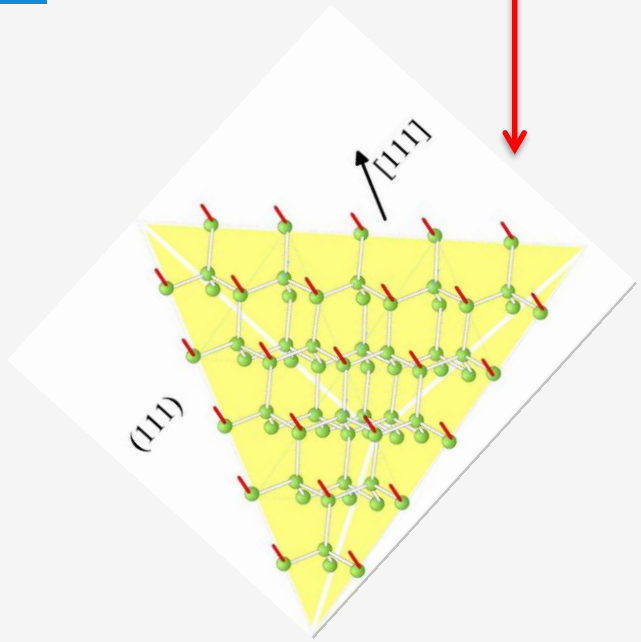

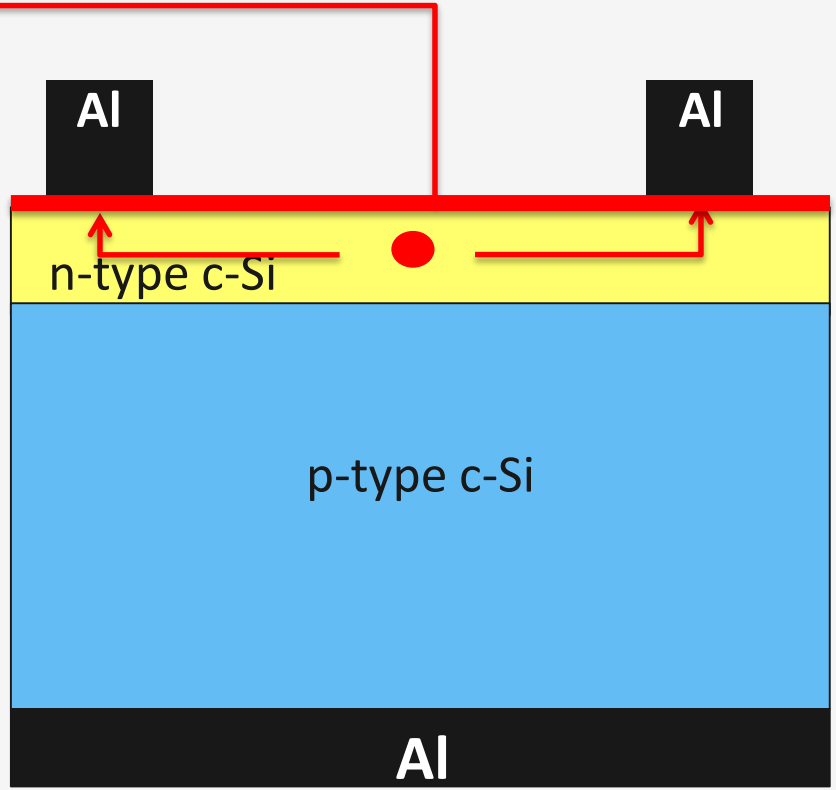

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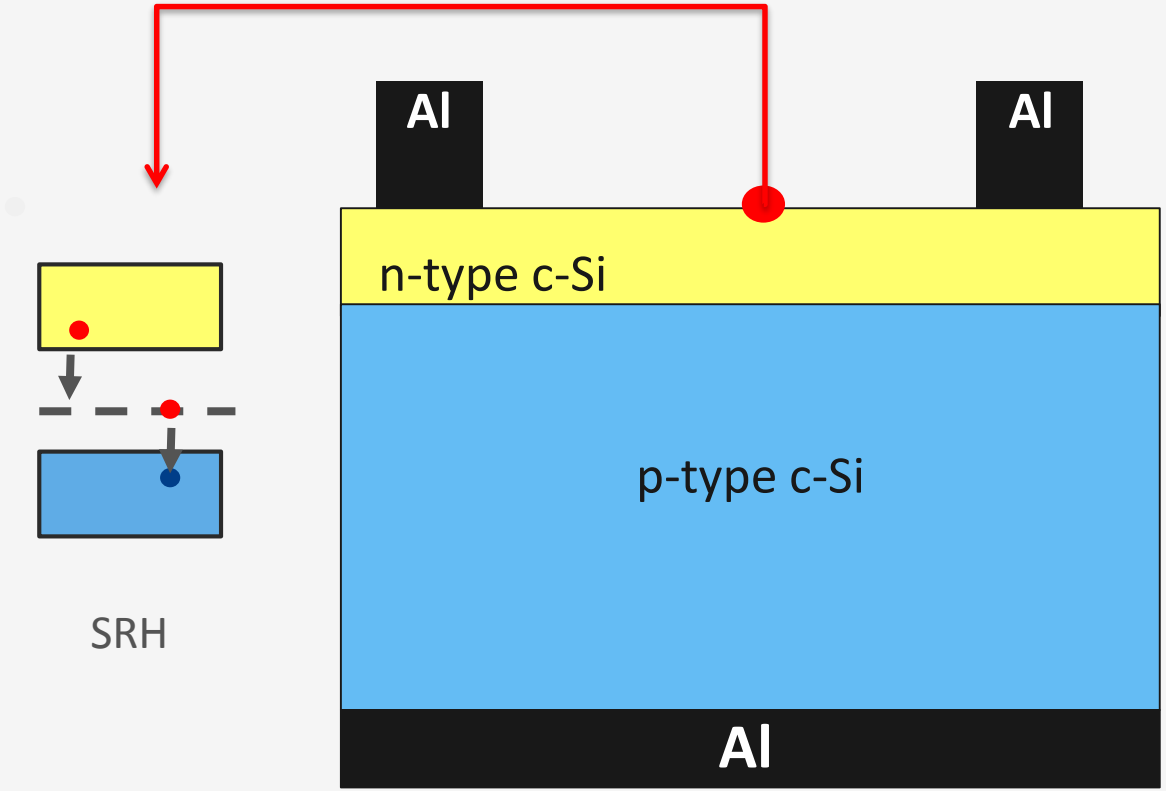

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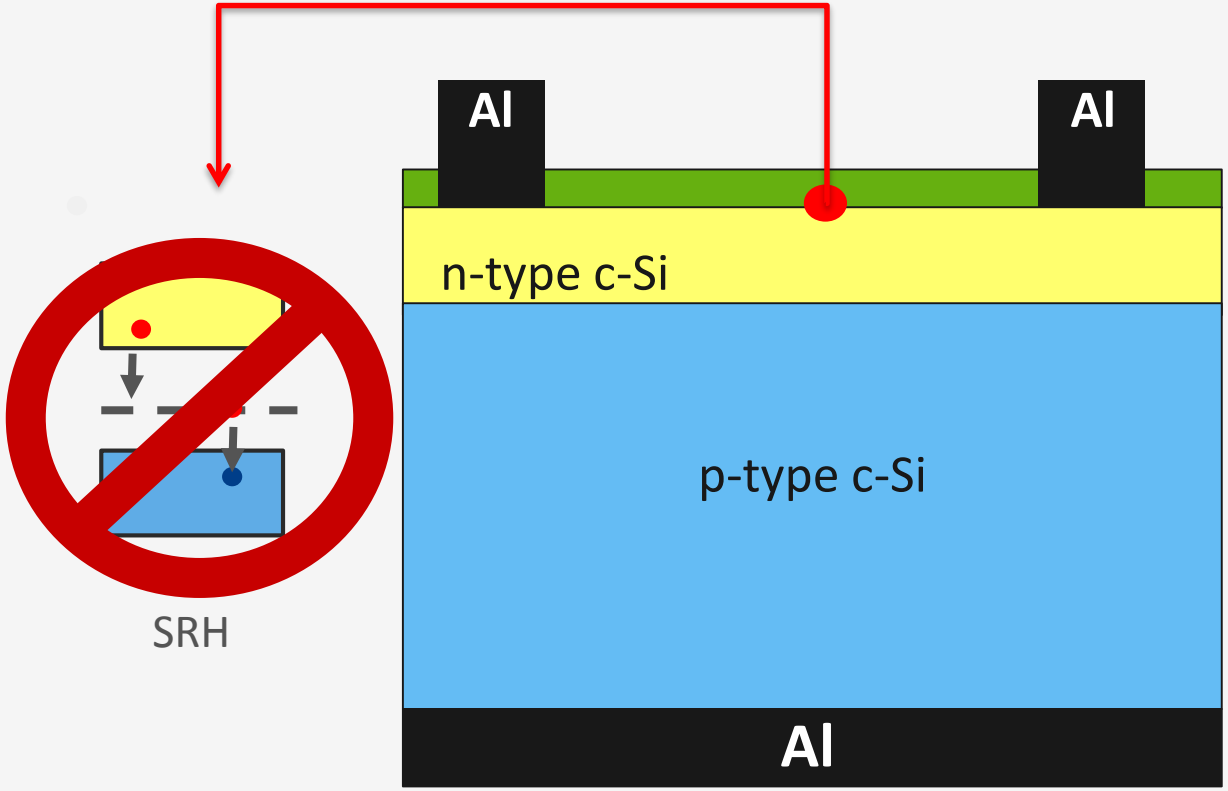
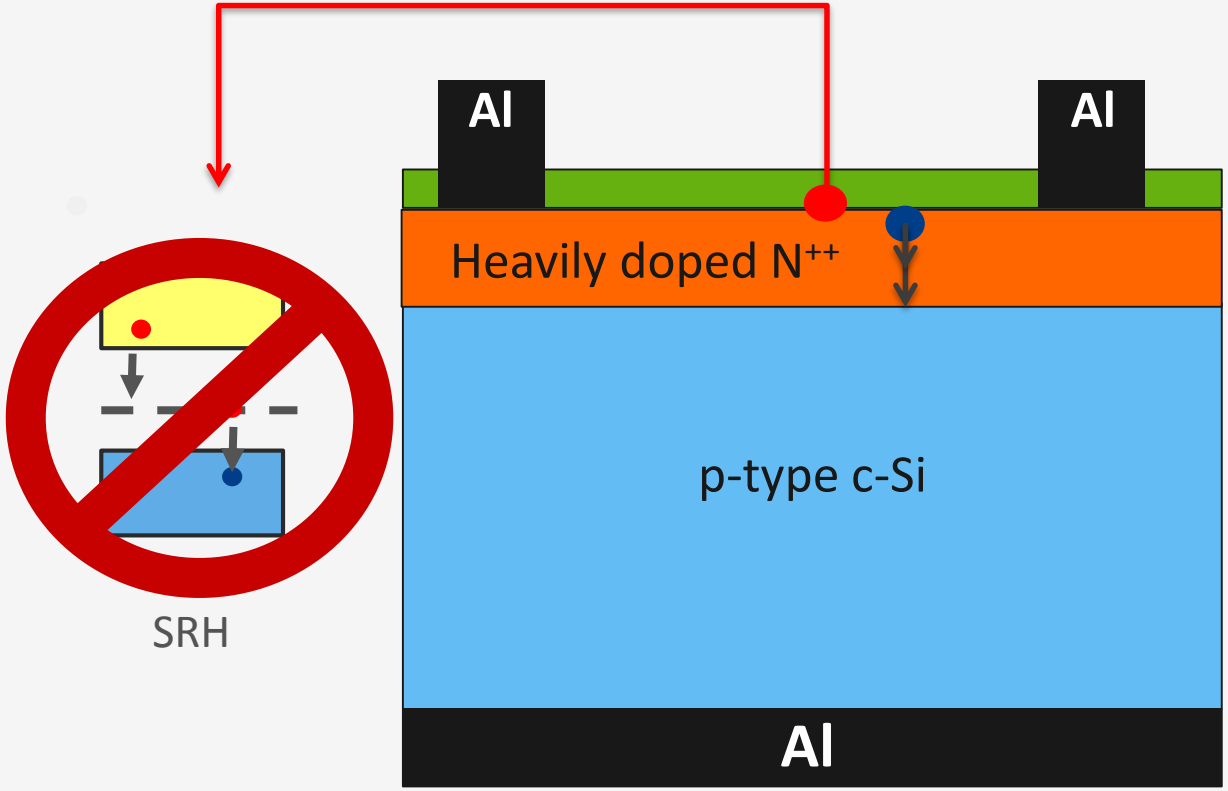
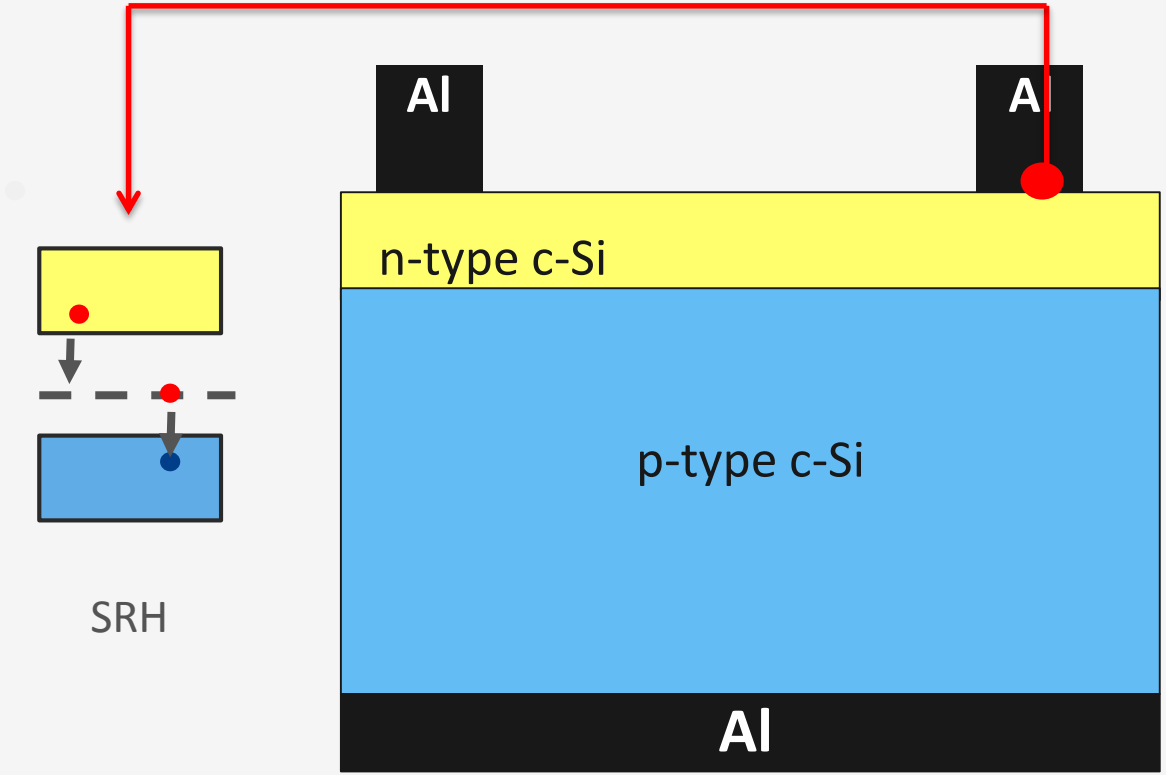


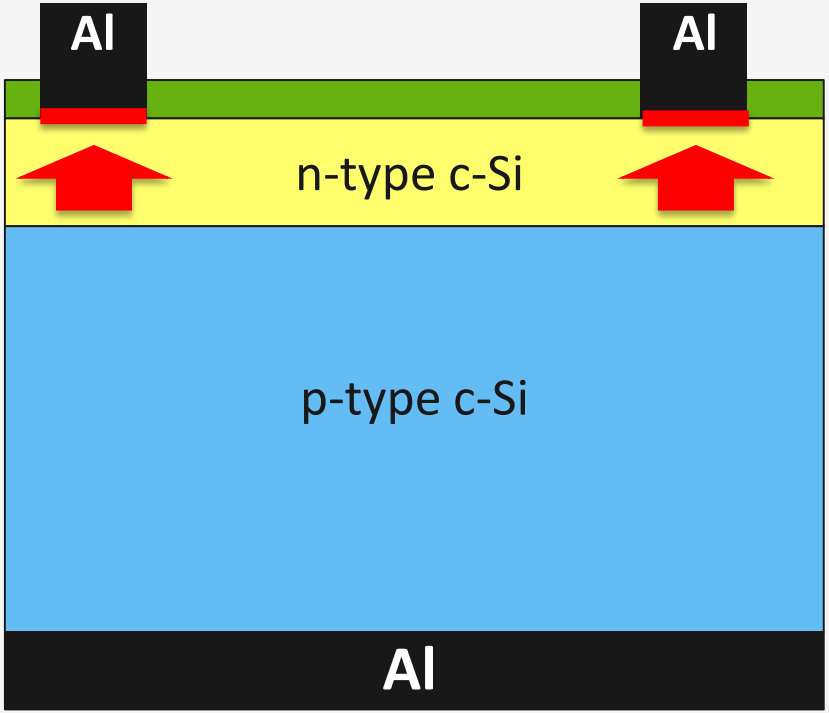
p-type c-Si wafer based solar cell



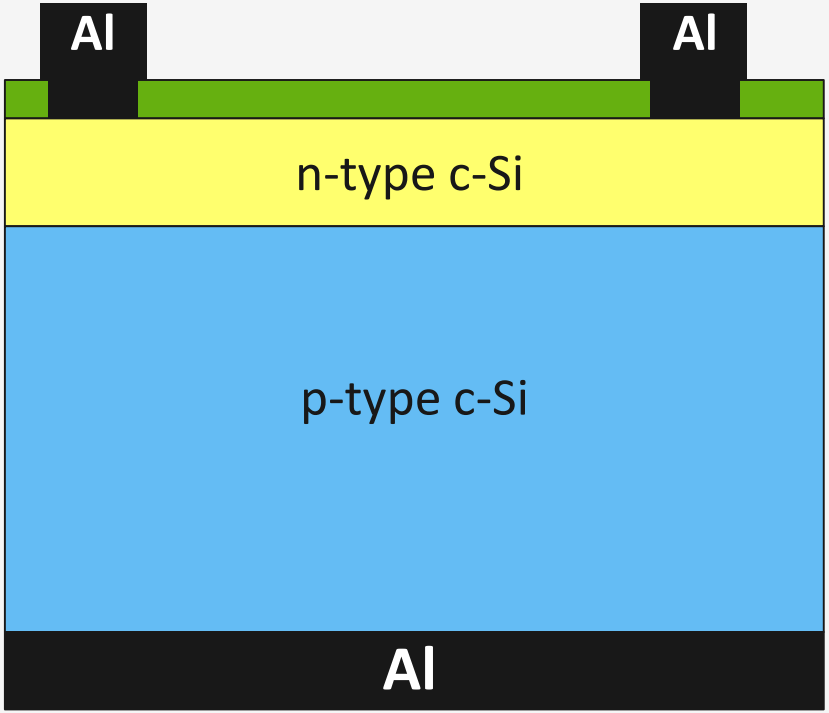
p-type c-Si wafer based solar cell



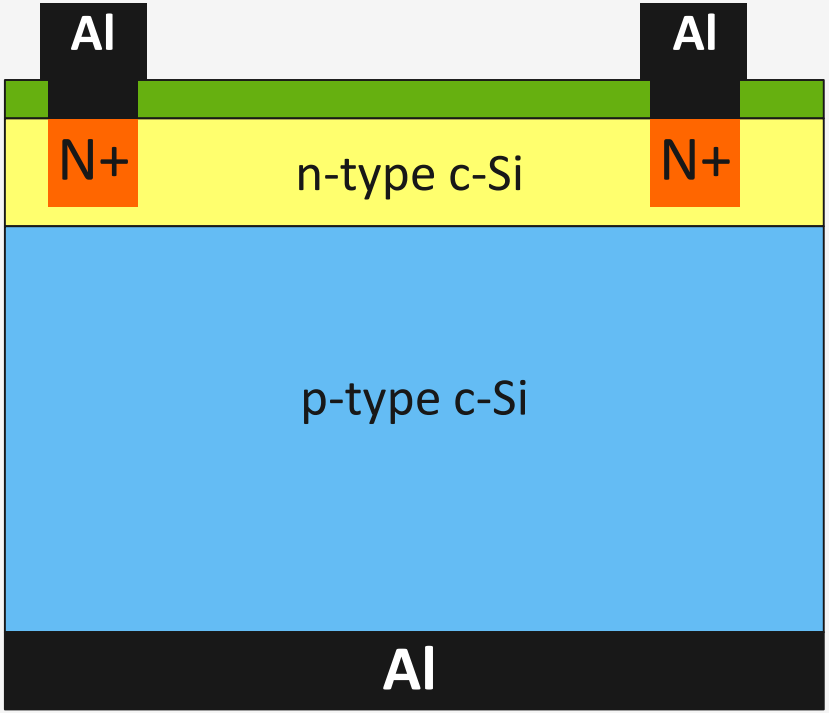
p-type c-Si wafer based solar cell



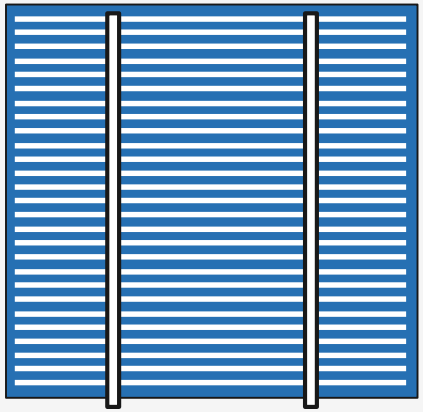
p-type c-Si wafer based solar cell



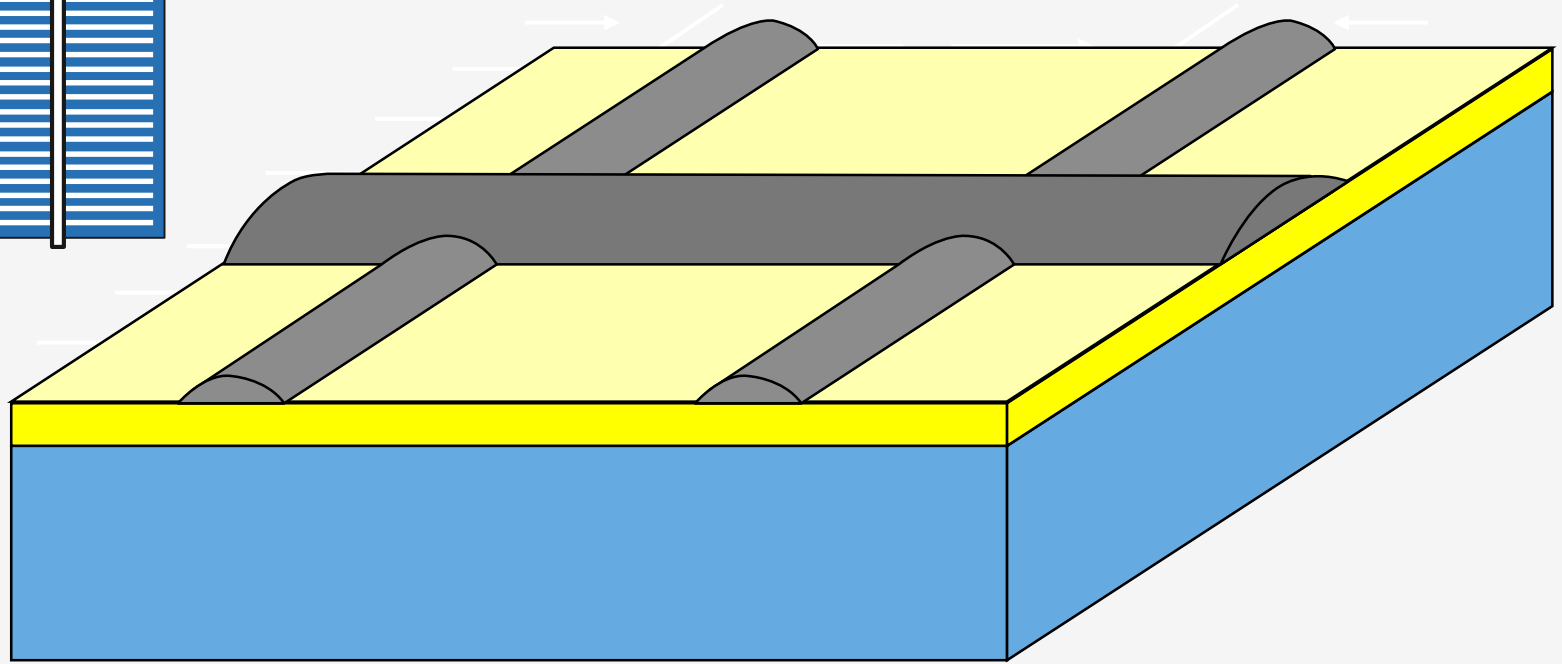
p-type c-Si wafer based solar cell



Metal contact grid at the front



Busbars



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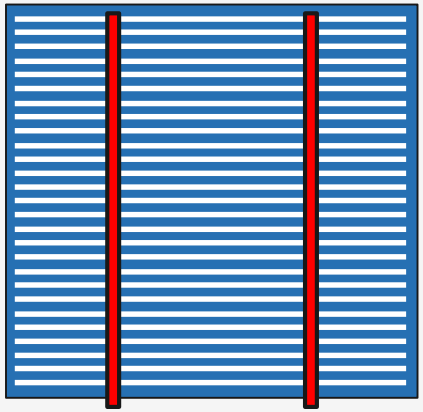
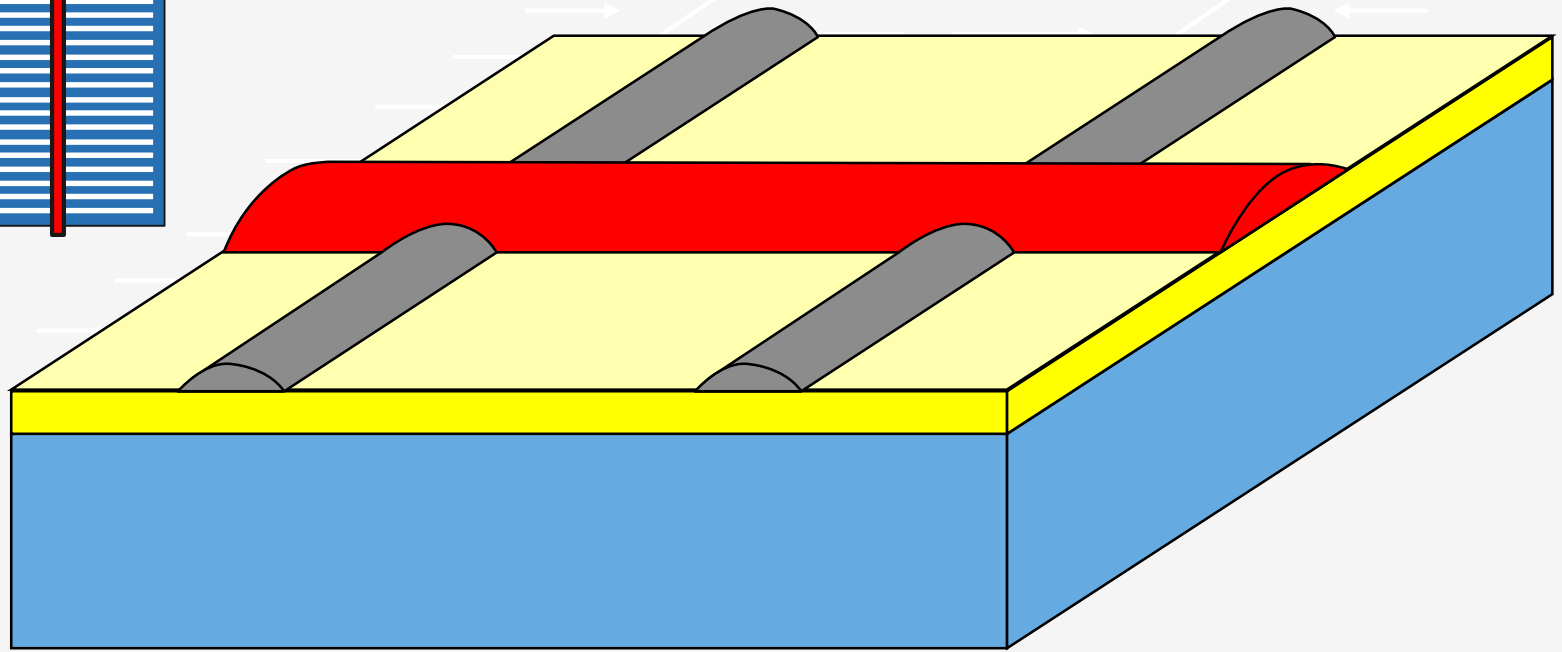
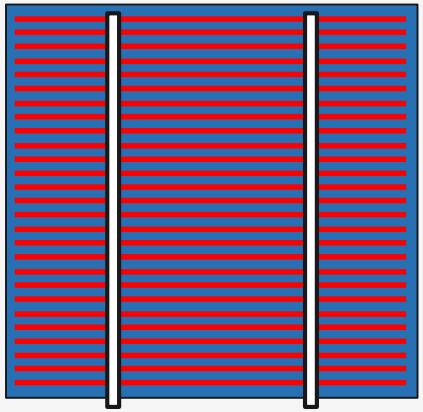
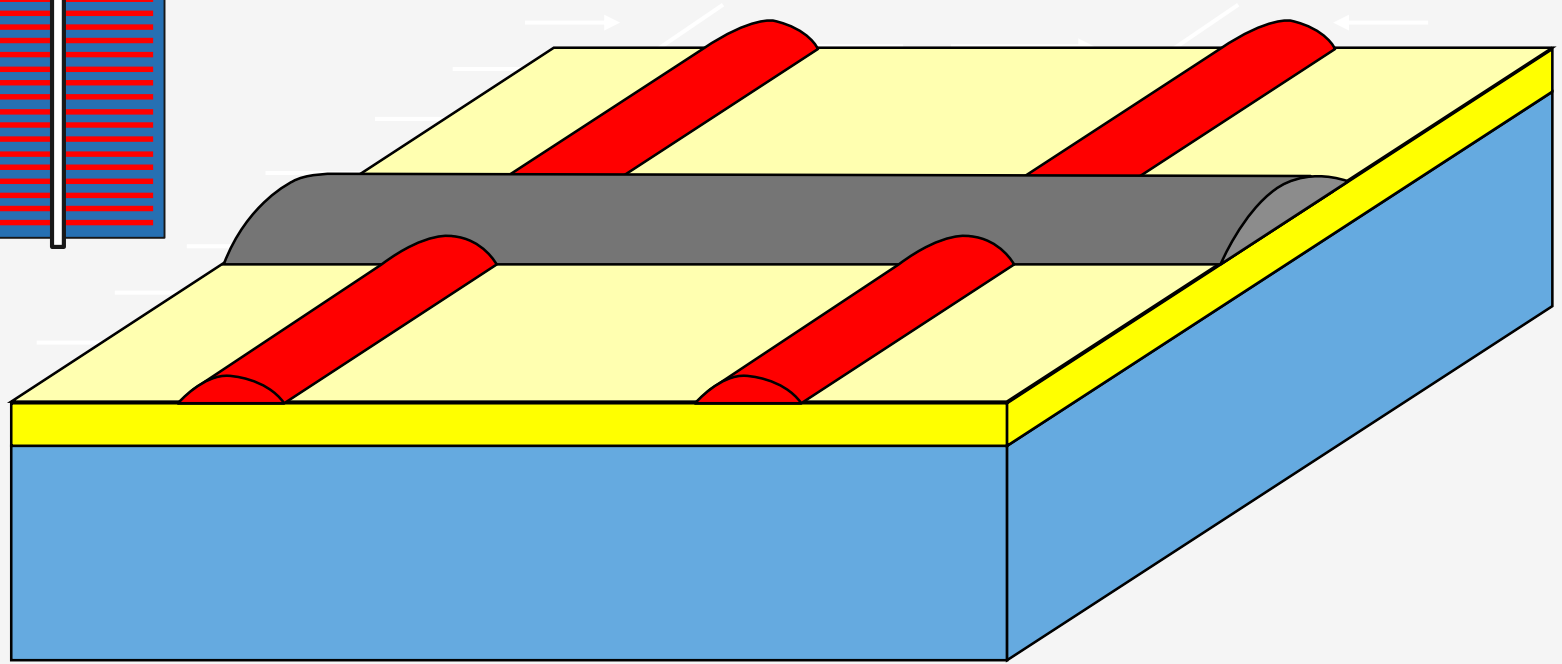


Busbars



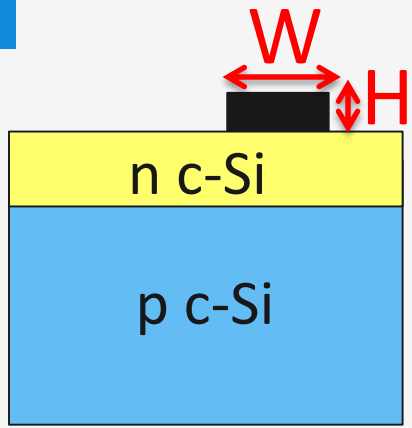
Metal contact grid at the front

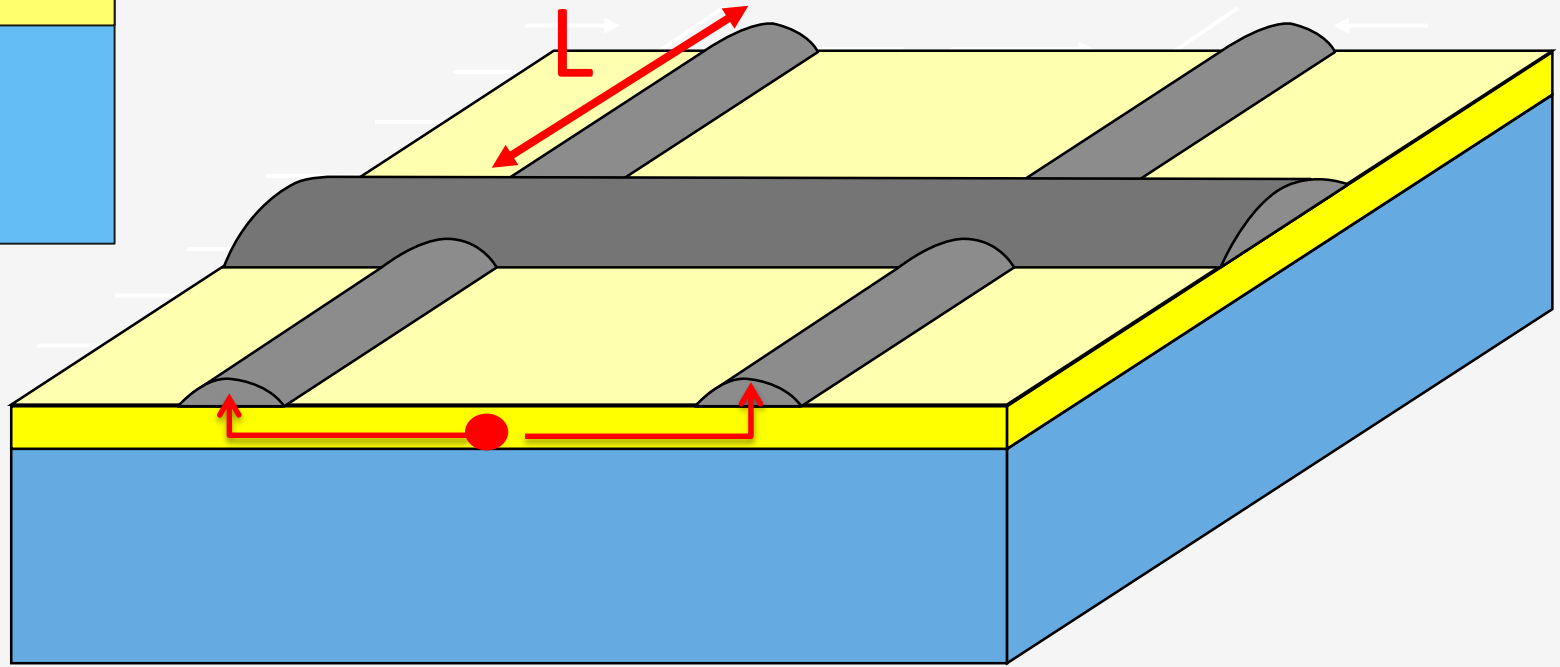




Metal contact grid at the front

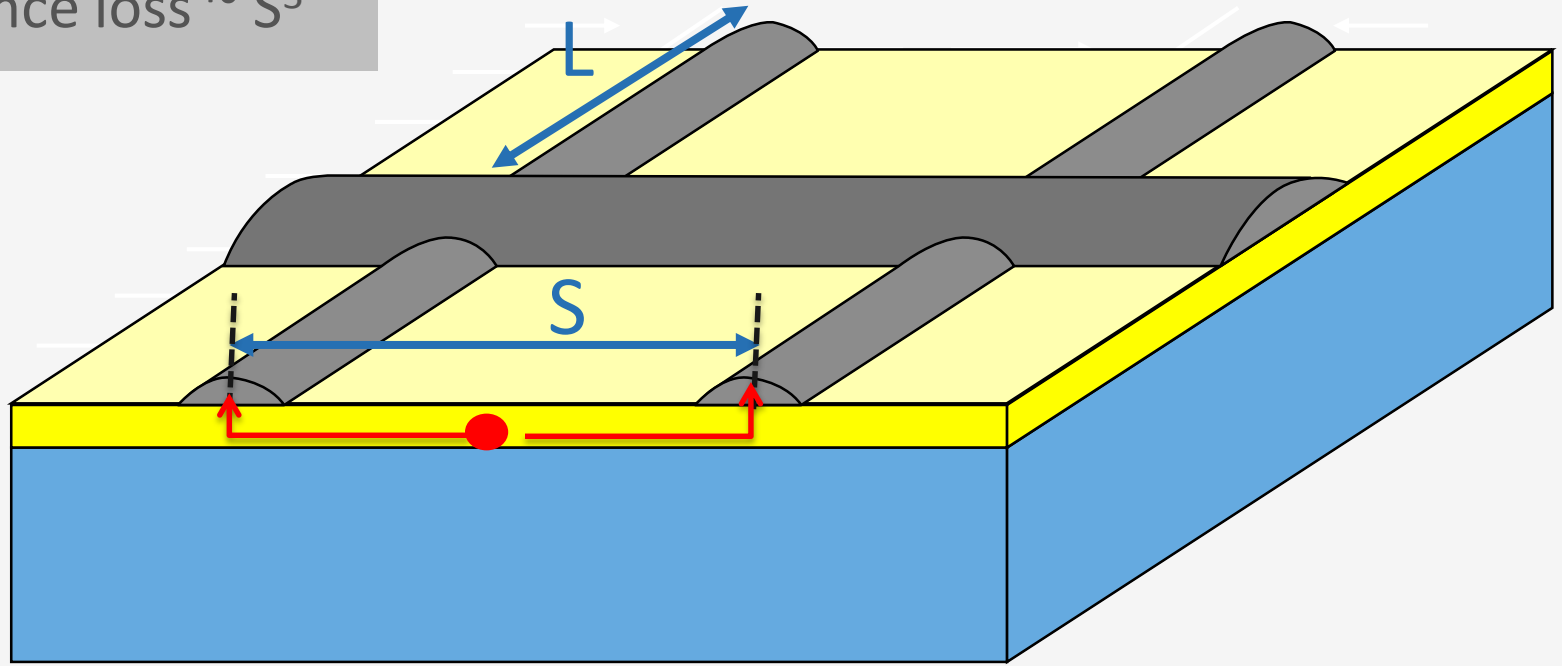
$$R = \rho \cdot \frac{L}{W \cdot H}$$





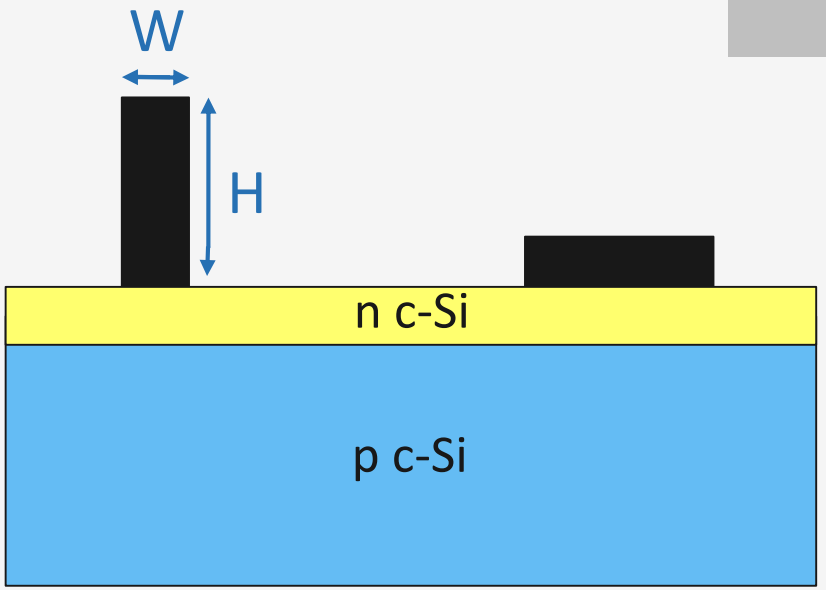
Metal contact grid at the front

Resistance loss ~ S^3

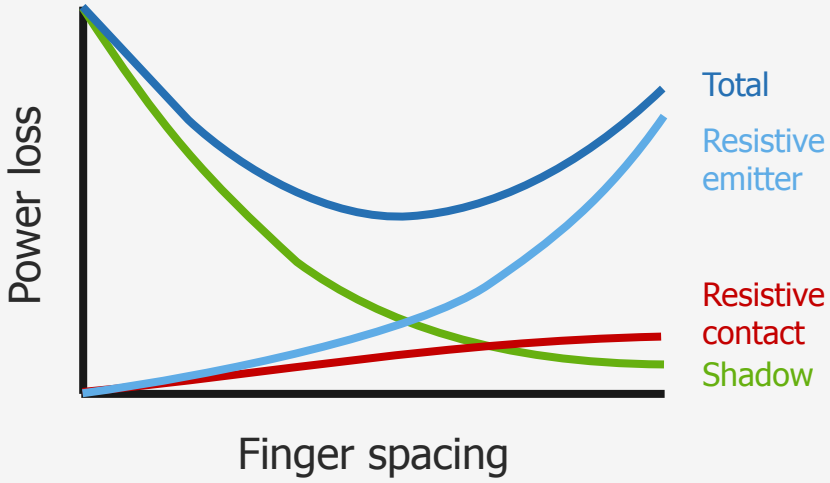


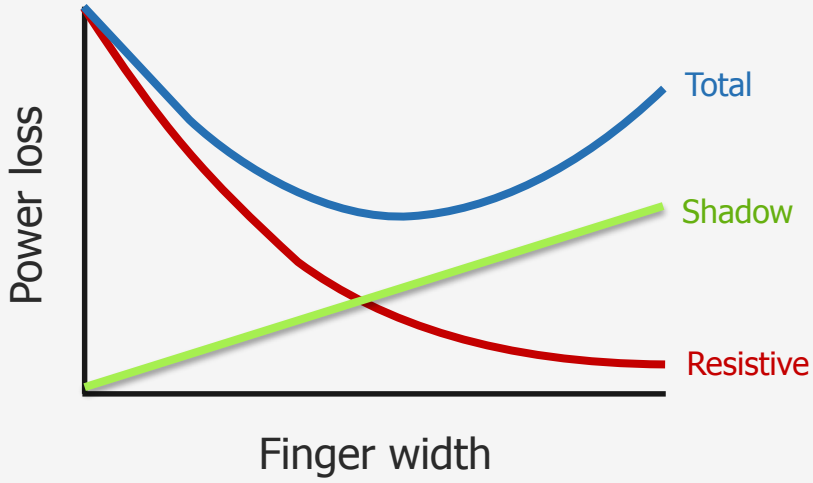
Shading by contacts

$$R = \rho \cdot \frac{L}{W \cdot H}$$

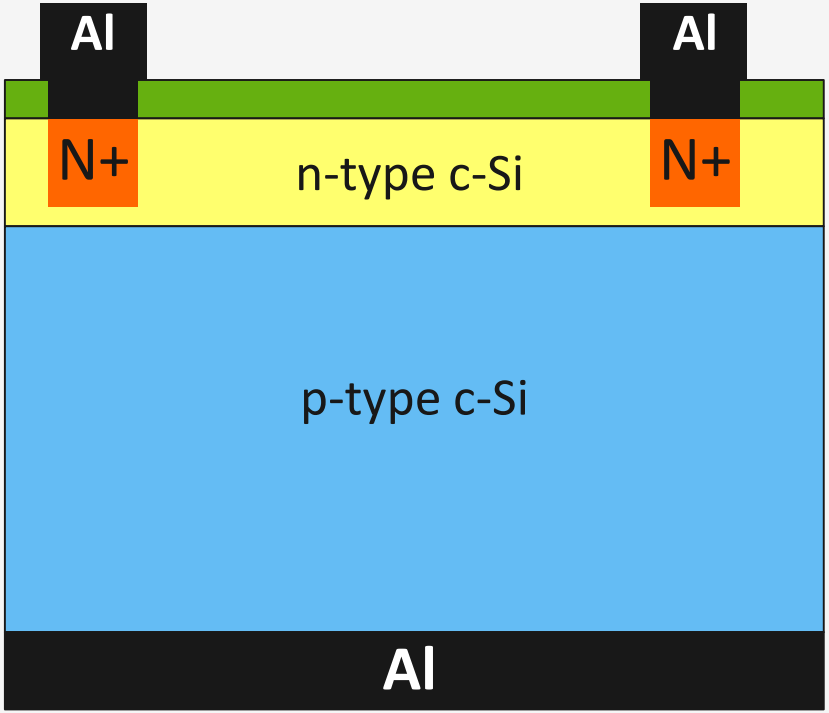


Improving aspect ratio = W/H

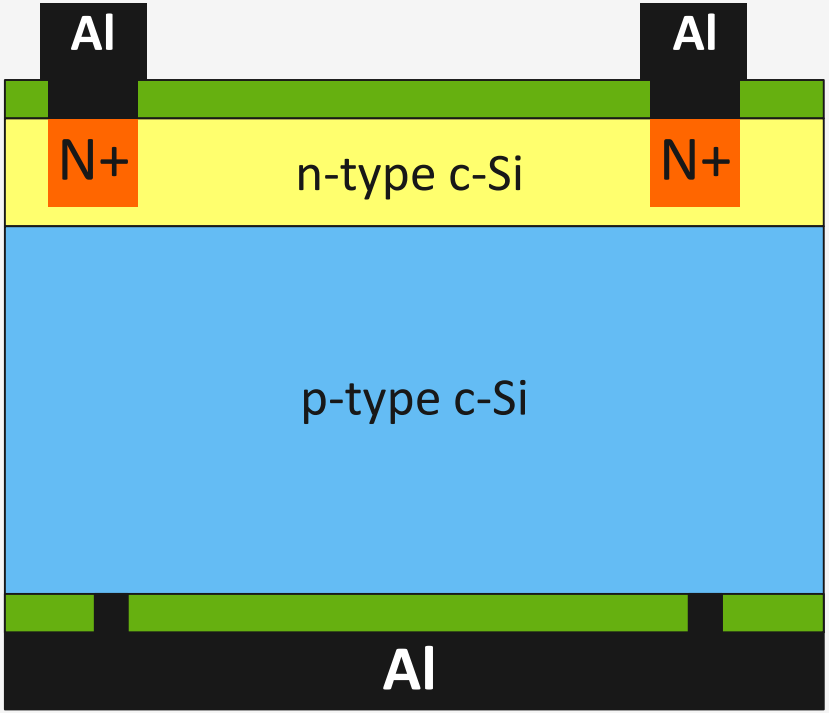

Power loss
Total
Resistive emitter
Resistive contact
Shadow
Finger spacing


Power loss
Total
Shadow
Resistive
Finger width

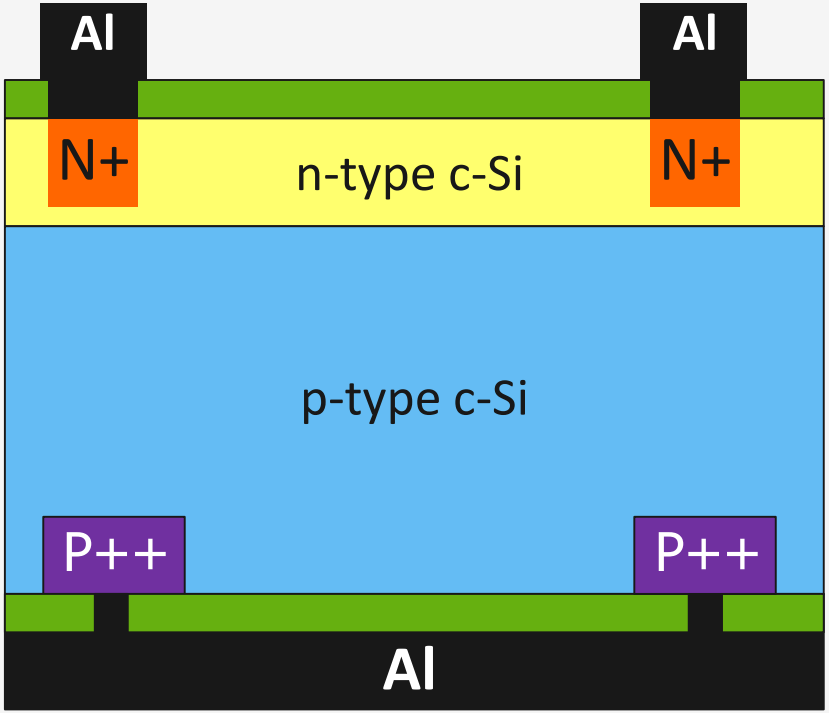
p-type c-Si wafer based solar cell



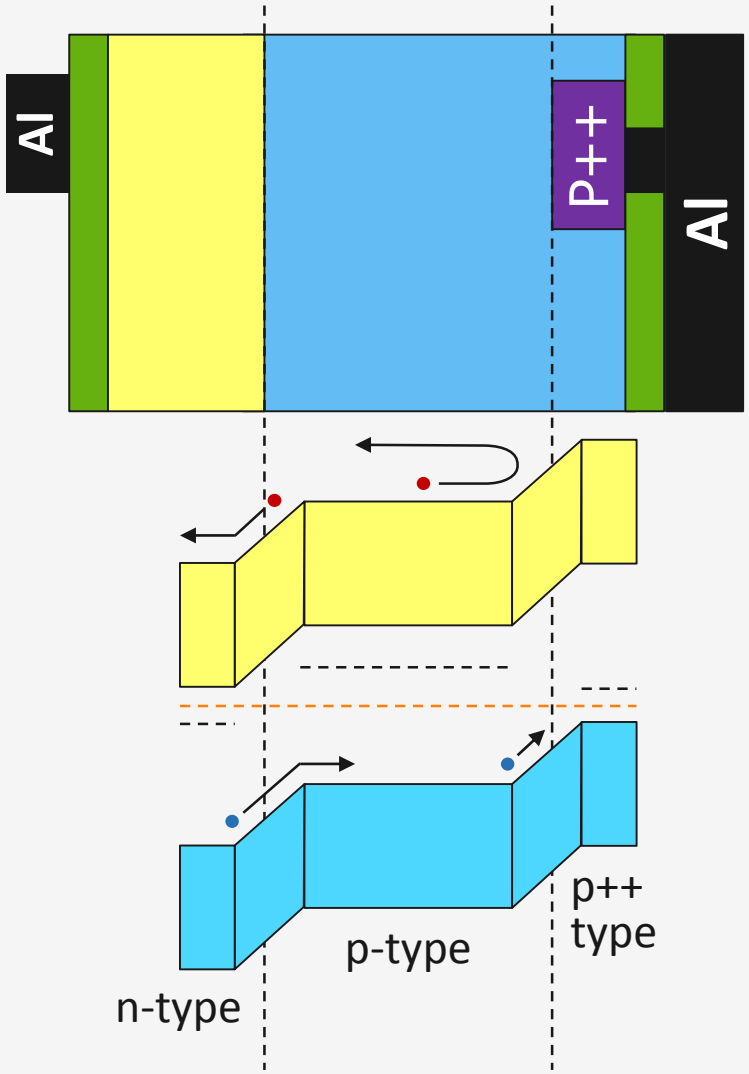
Point contacts



Back Surface Field (BSF)

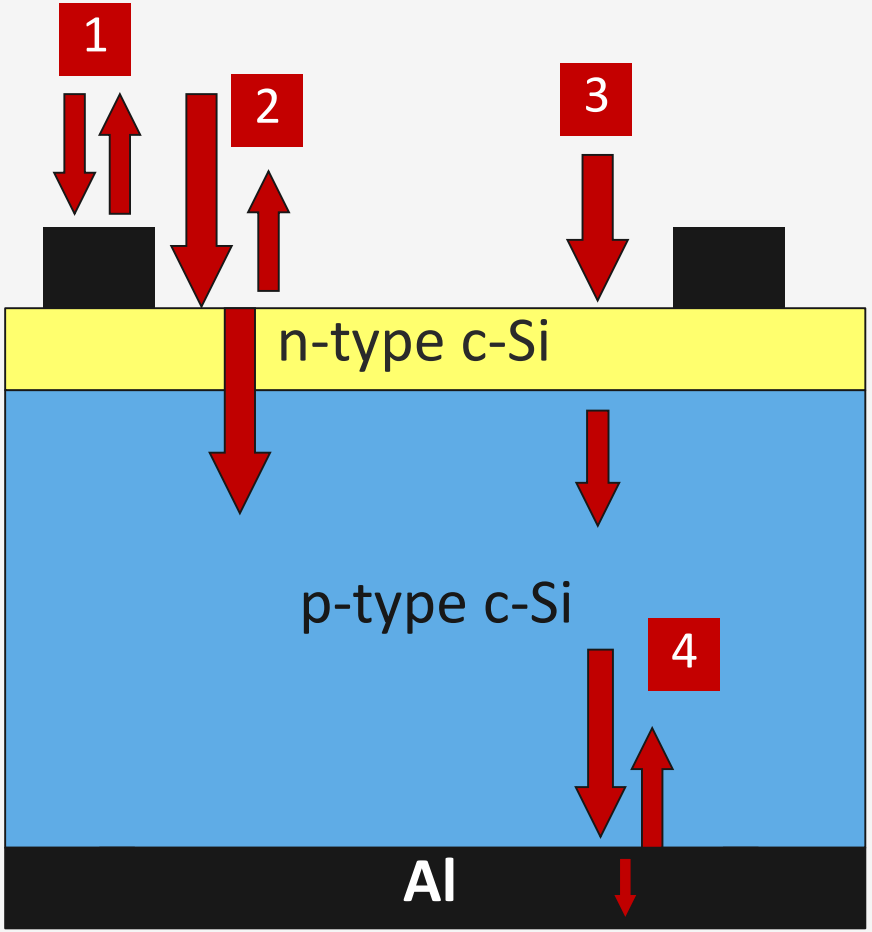


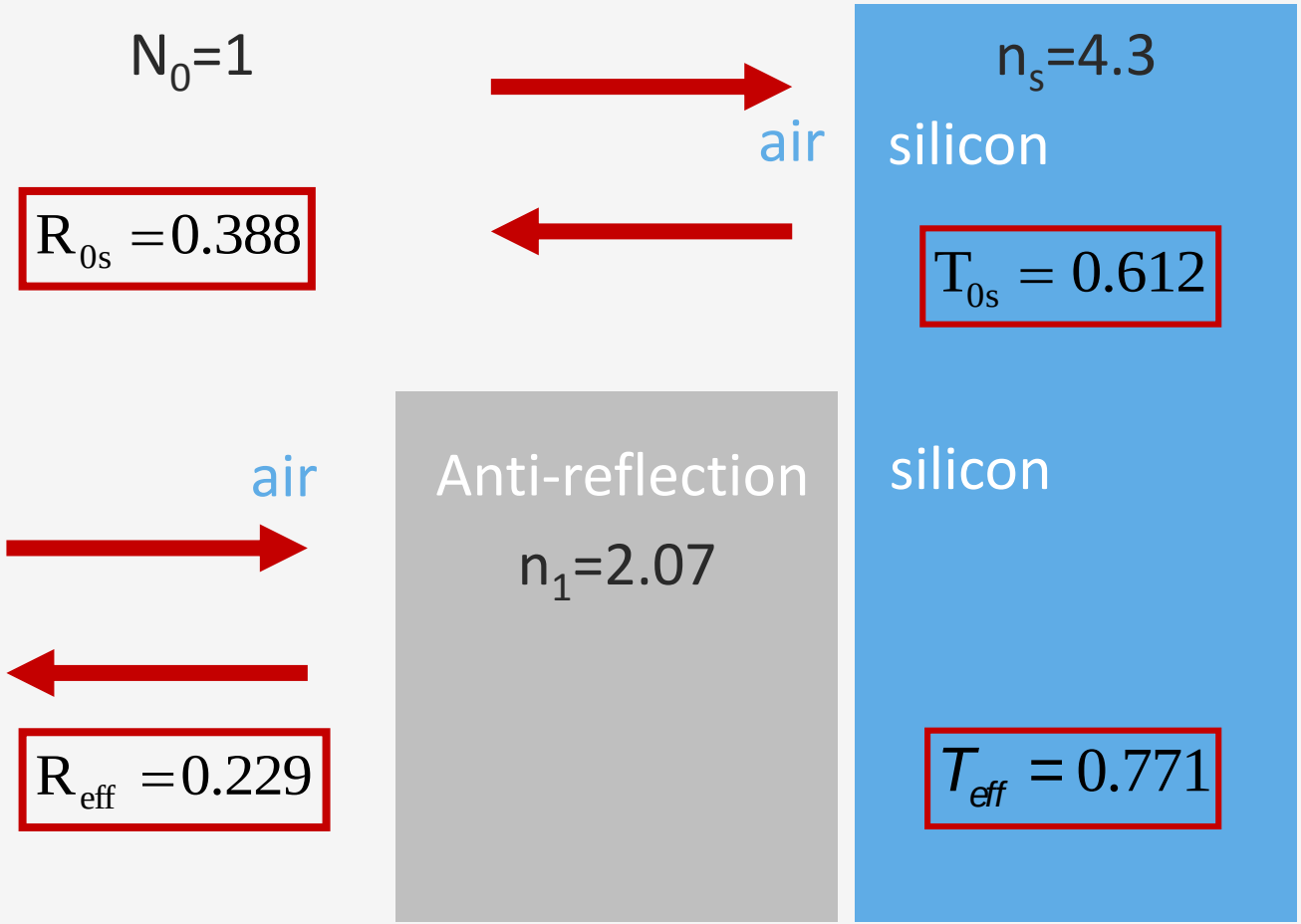
BSF



Optical losses

1. Shading
2. Reflection front window layer
3. Absorption in PV inactive layers
4. Absorption or Transmission at back reflector



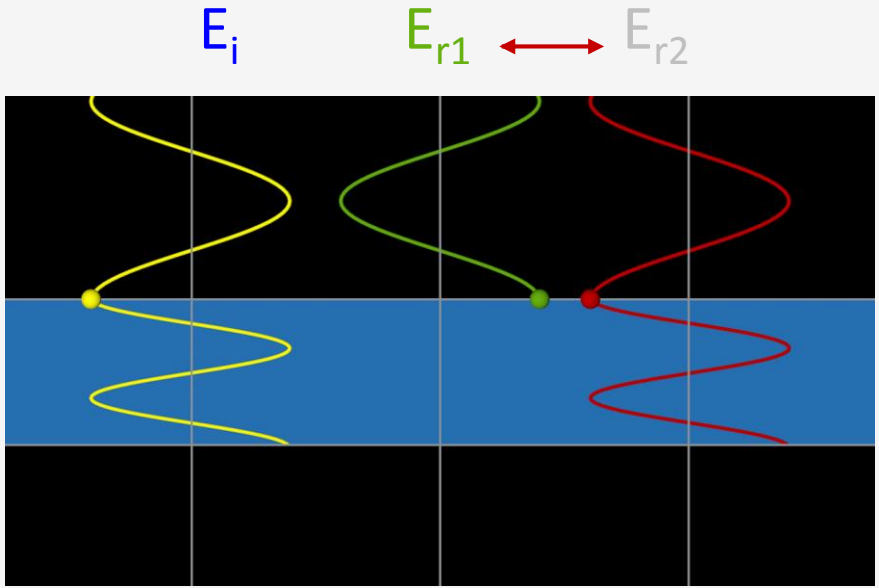

N_0=1
n_s=4.3
air
silicon
$R_{0s} = 0.388$
$T_{0s} = 0.612$
air
Anti-reflection
n_1=2.07
silicon
$R_{eff} = 0.229$
$T_{eff} = 0.771$

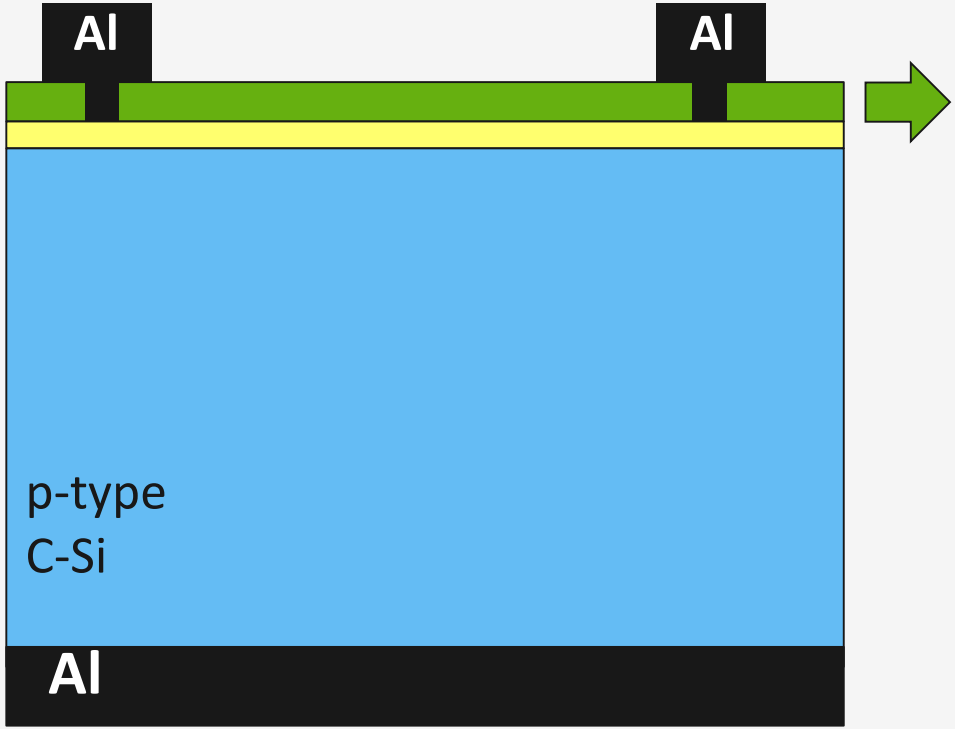
Interference: the anti-reflection coating

Destructive interference

$\Delta\phi=\pi$

$$d = \frac{\lambda}{4n_2}$$





$$d = \frac{\lambda}{4n_2}$$

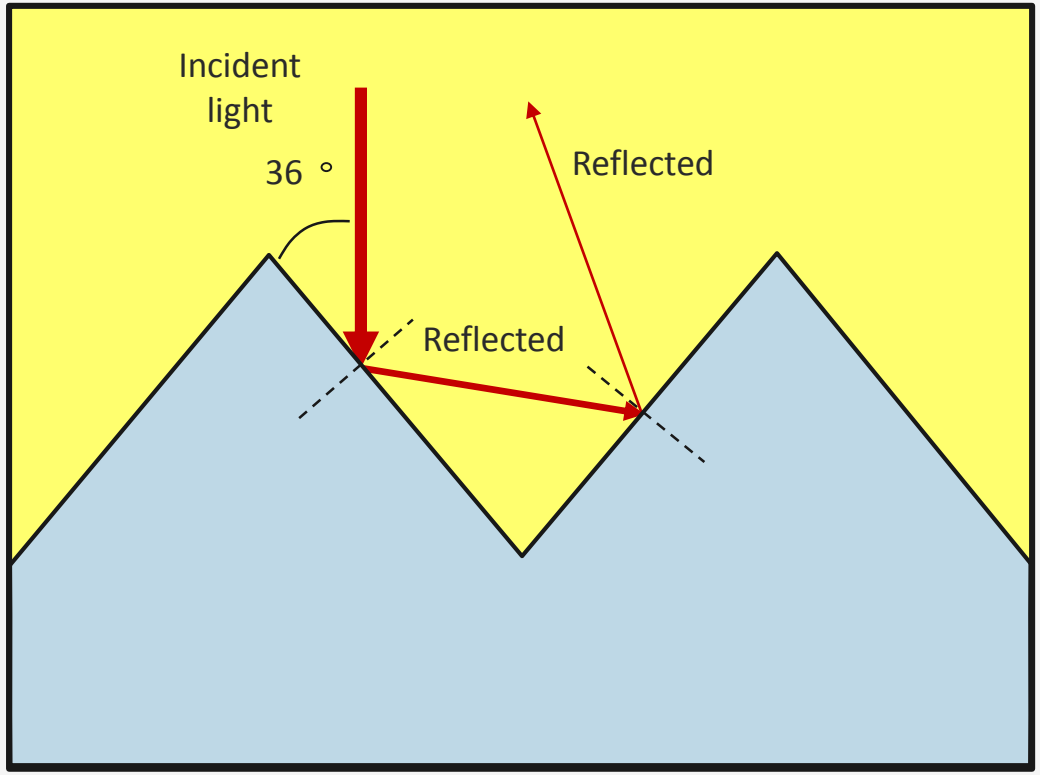
thickness ~60 nm
Optimized for
wavelengths
of 480-560 nm
(nd= ¼λ)

Reduction Front Reflection:

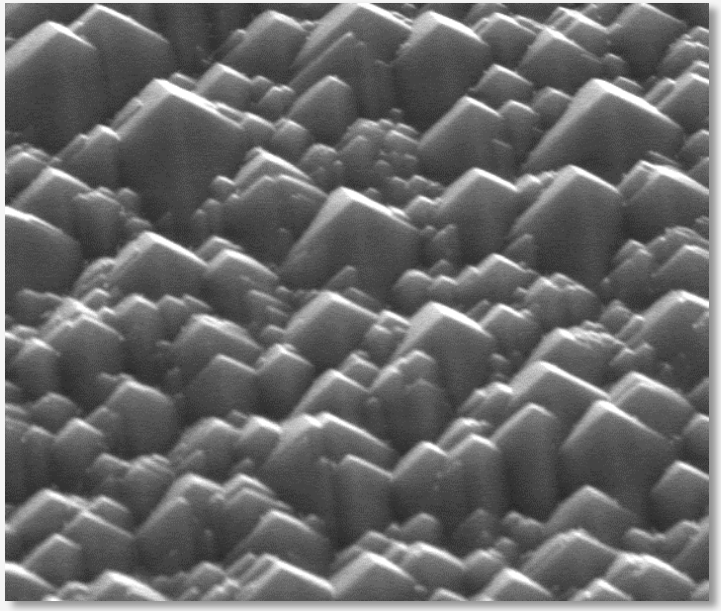
anti-reflection coating

Silicon Nitride (a-SiN).
Refractive index
n=2.0-2.2
Thickness ~60 nm

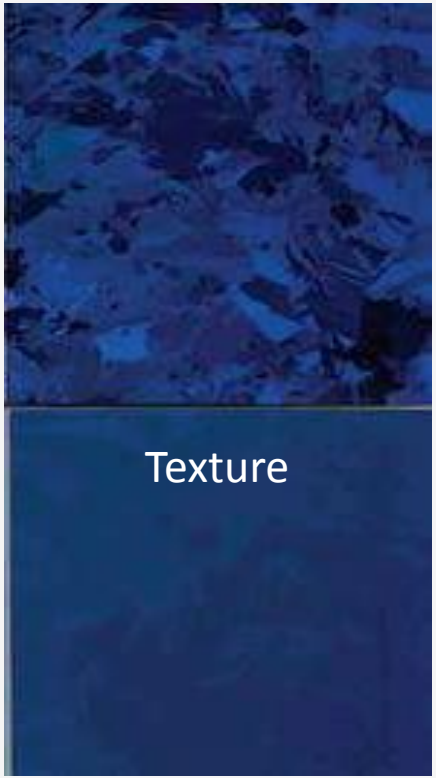
Macroscopic roughness (d>>λ)



Etching silicon wafers



Texturing front surface



Thank you for your attention!