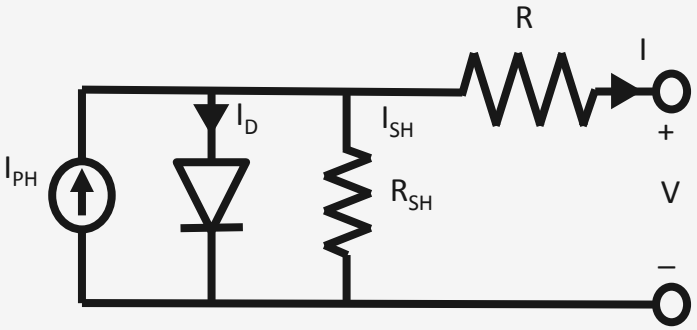
Solar Cell Operation, Performance and Design Rules

Solar Cell Operation

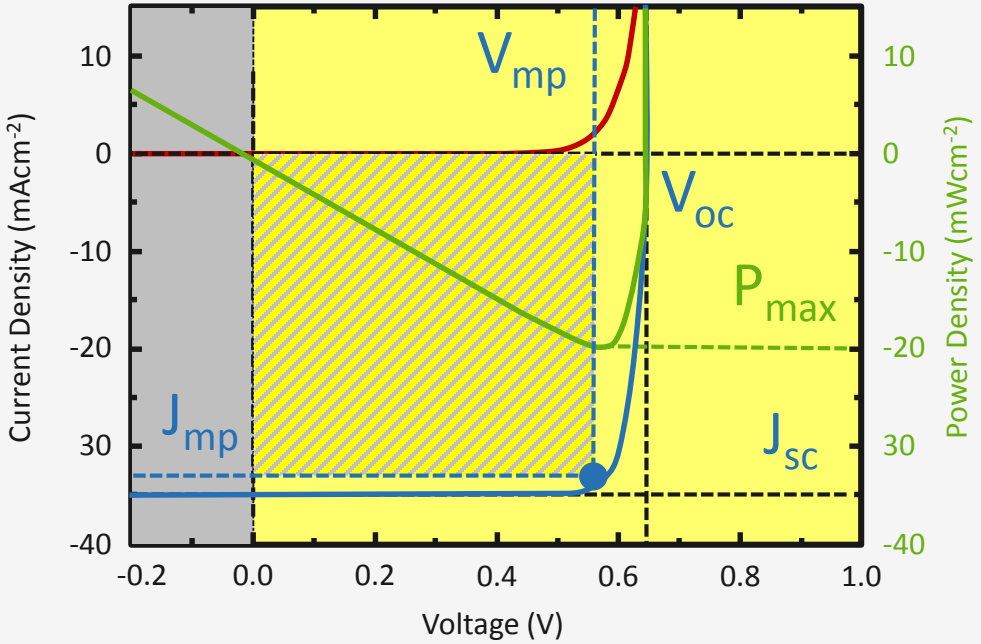
Week 3.1

Arno Smets

Equivalent Circuit



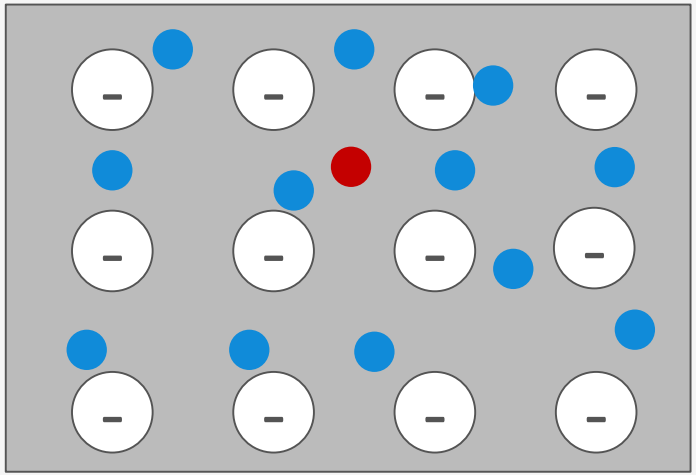
JV-Curve



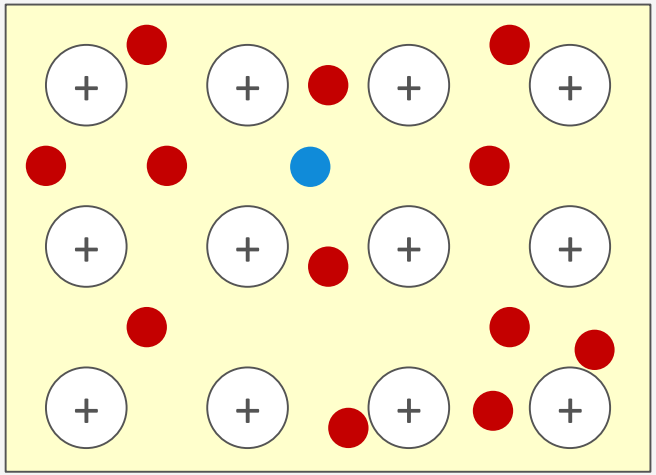
Maximum power point

pn Junction

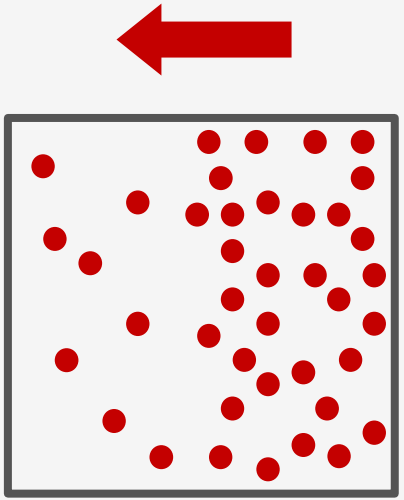
p-doped

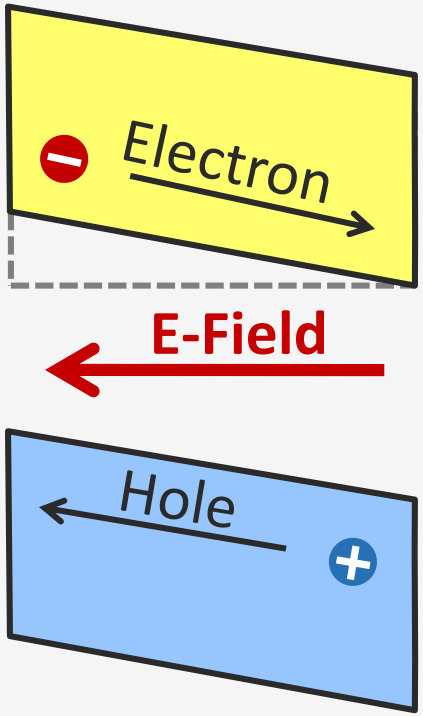


n-doped

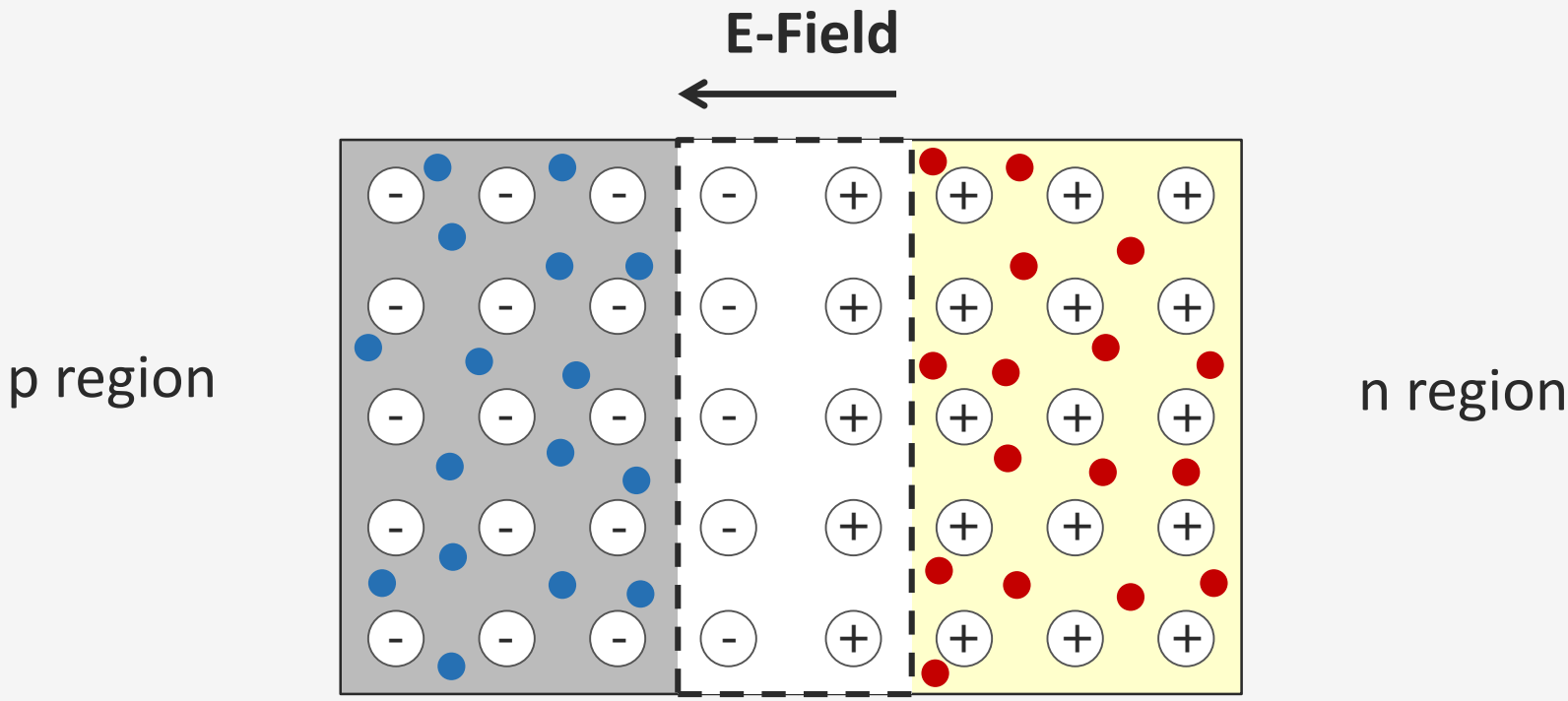


Transport of Charge Carriers

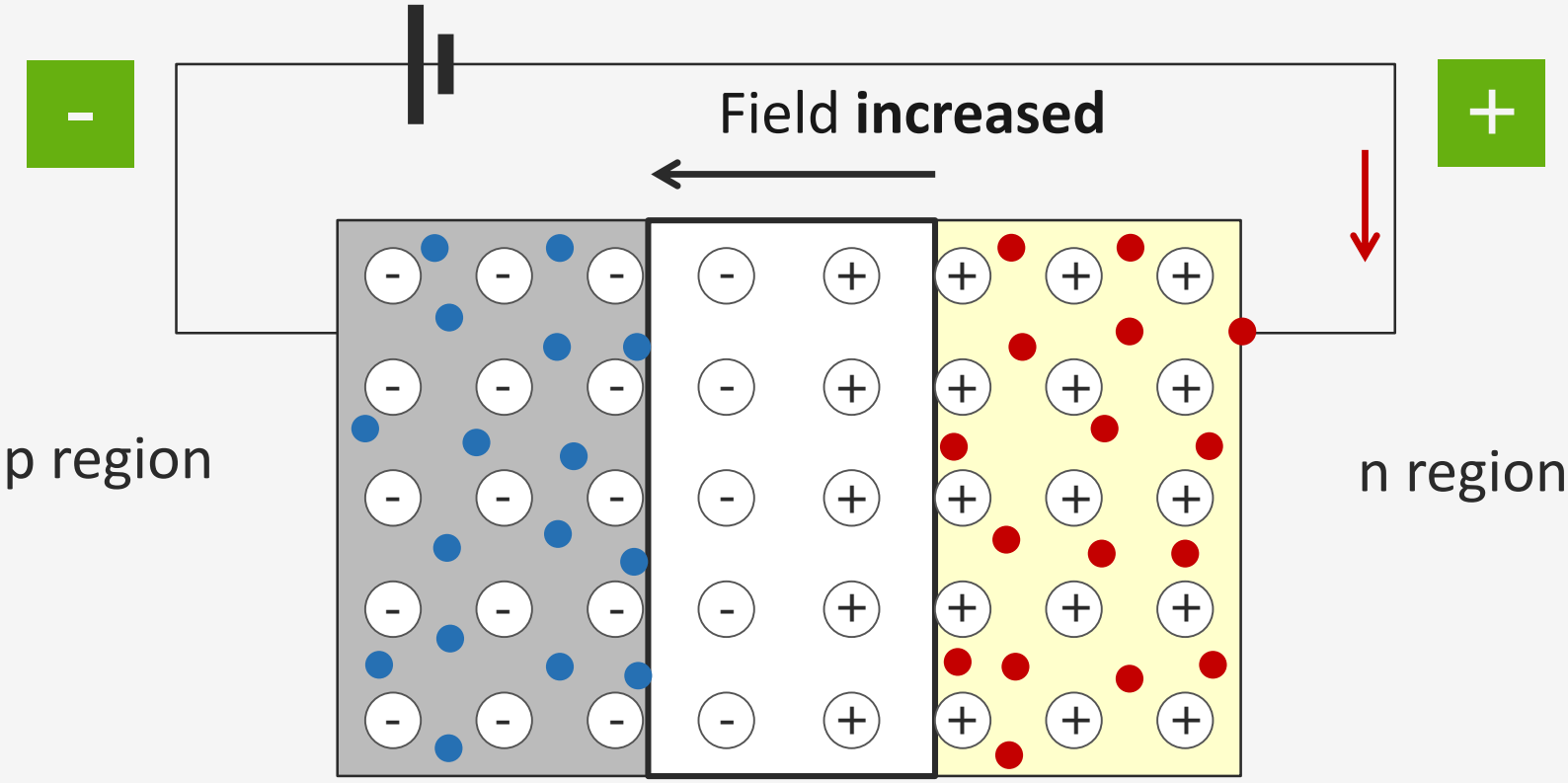




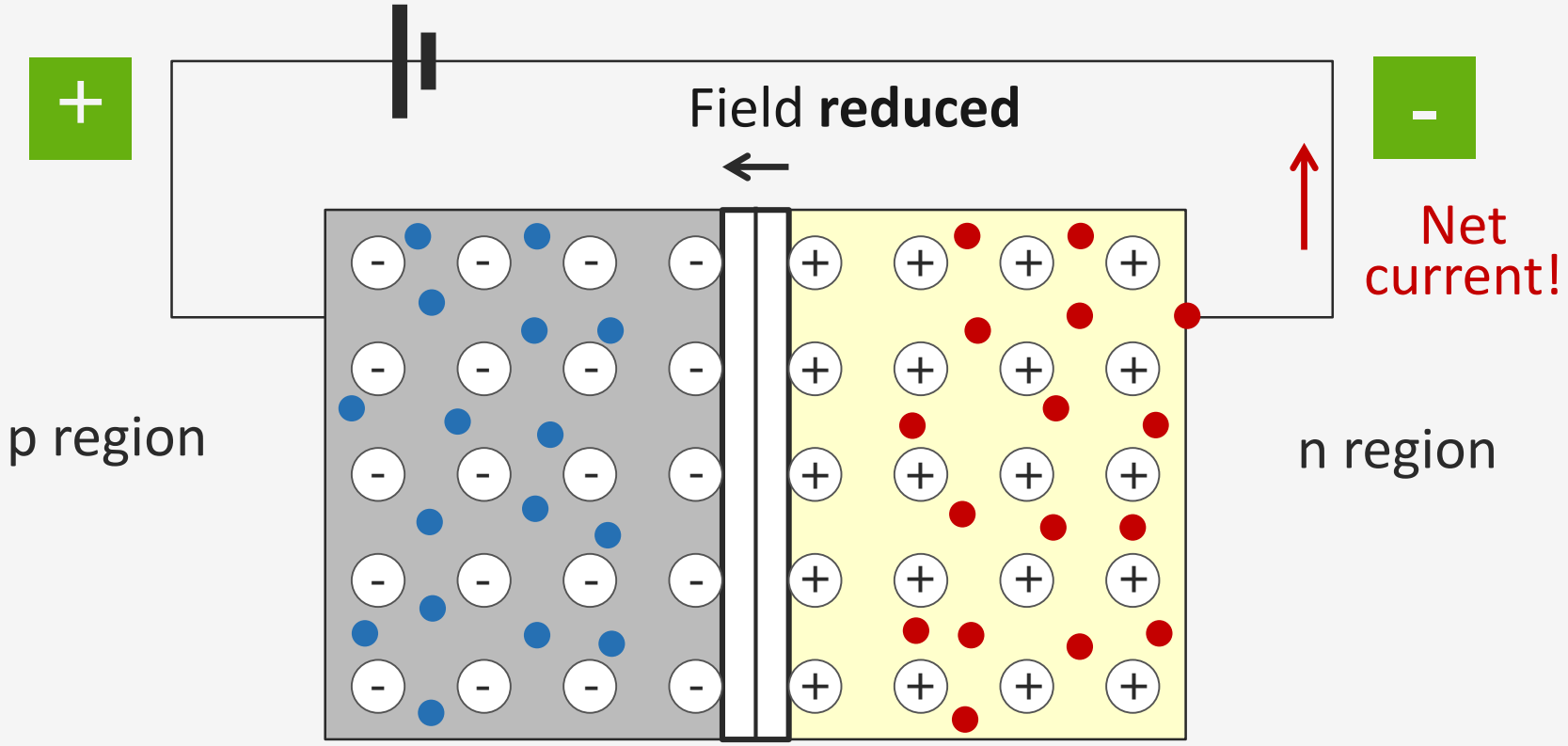
pn Junction



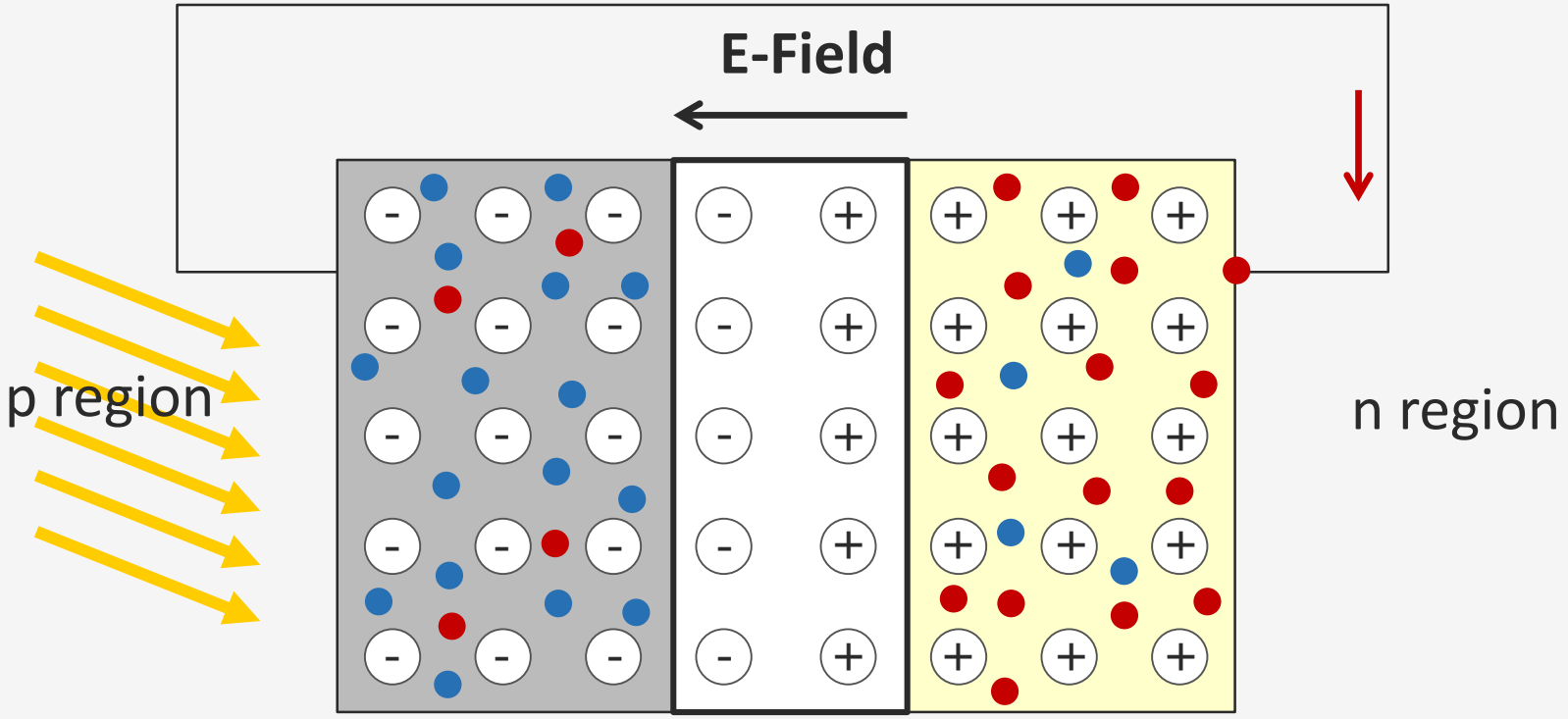
pn Junction - *Reverse bias in the dark*



pn Junction - *Forward bias in the dark*

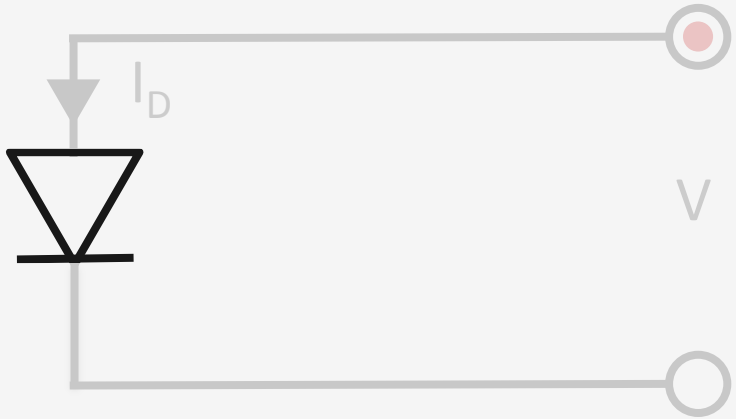


pn Junction – *Under illumination*



Equivalent circuit of solar cell

The dark current of the p-n junction



Equivalent circuit of solar cell - *Reverse bias*

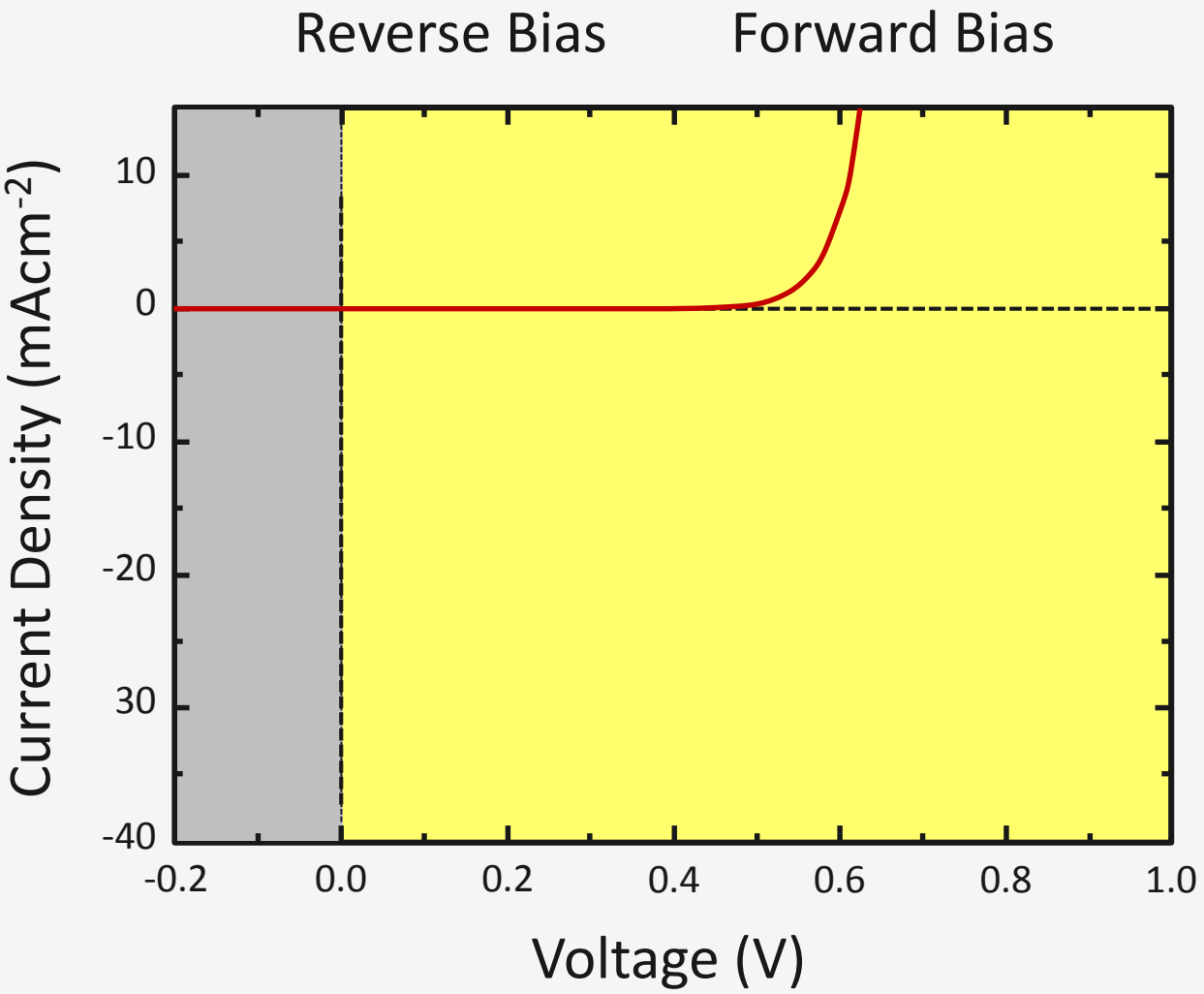
The dark current of the p-n junction

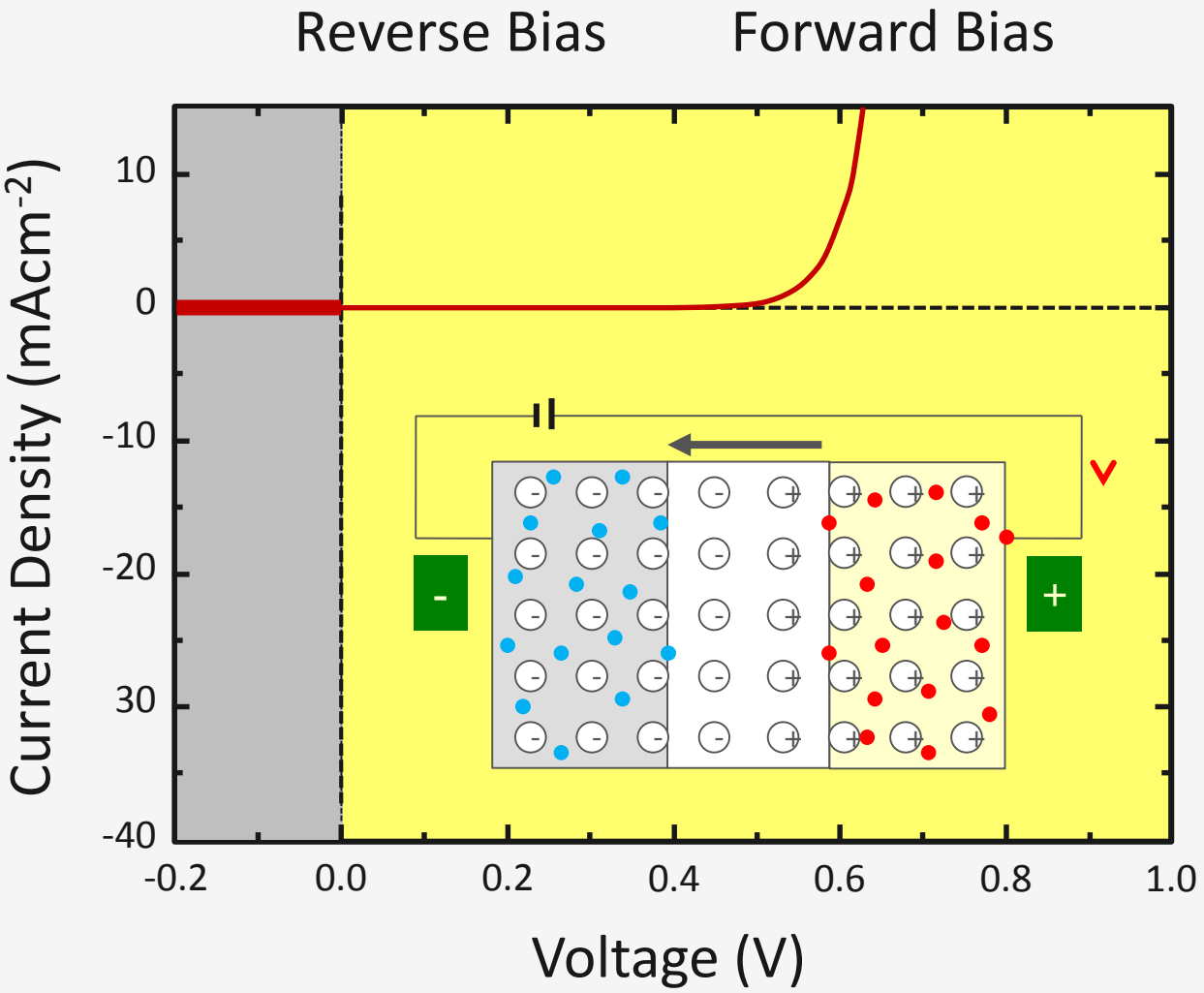
Extemely small net current!

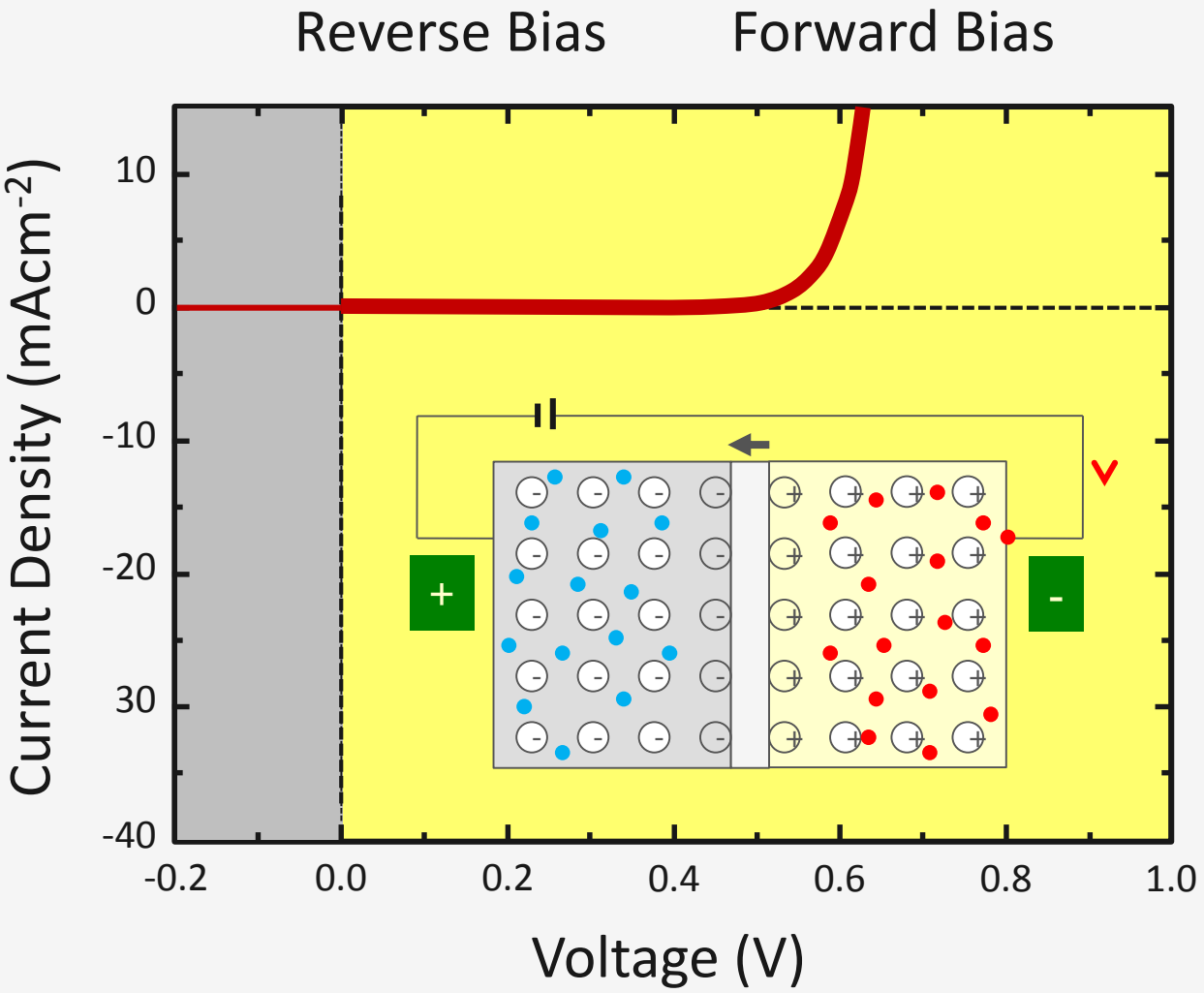
Equivalent circuit of solar cell - *Forward bias*

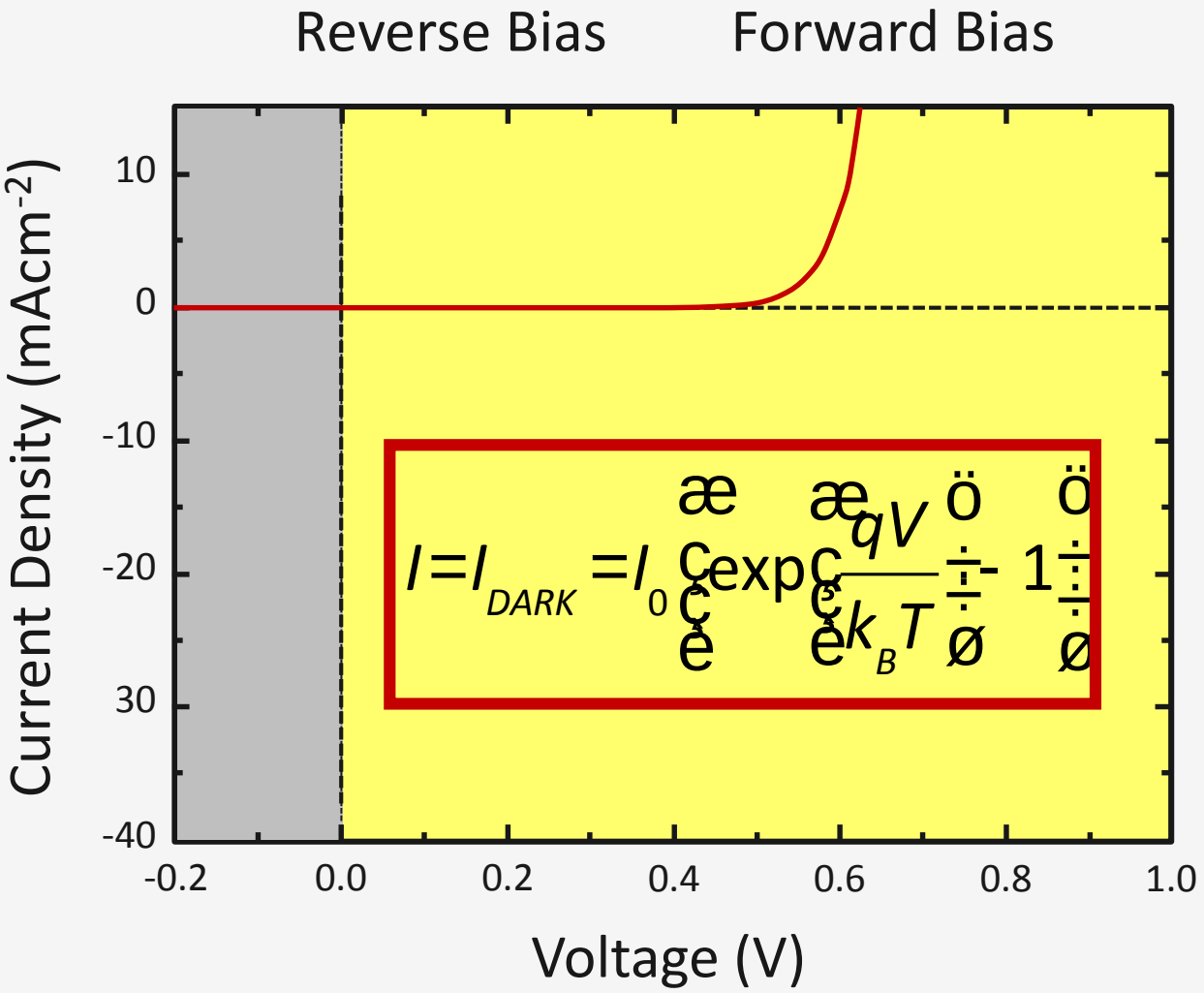
The dark current of the p-n junction

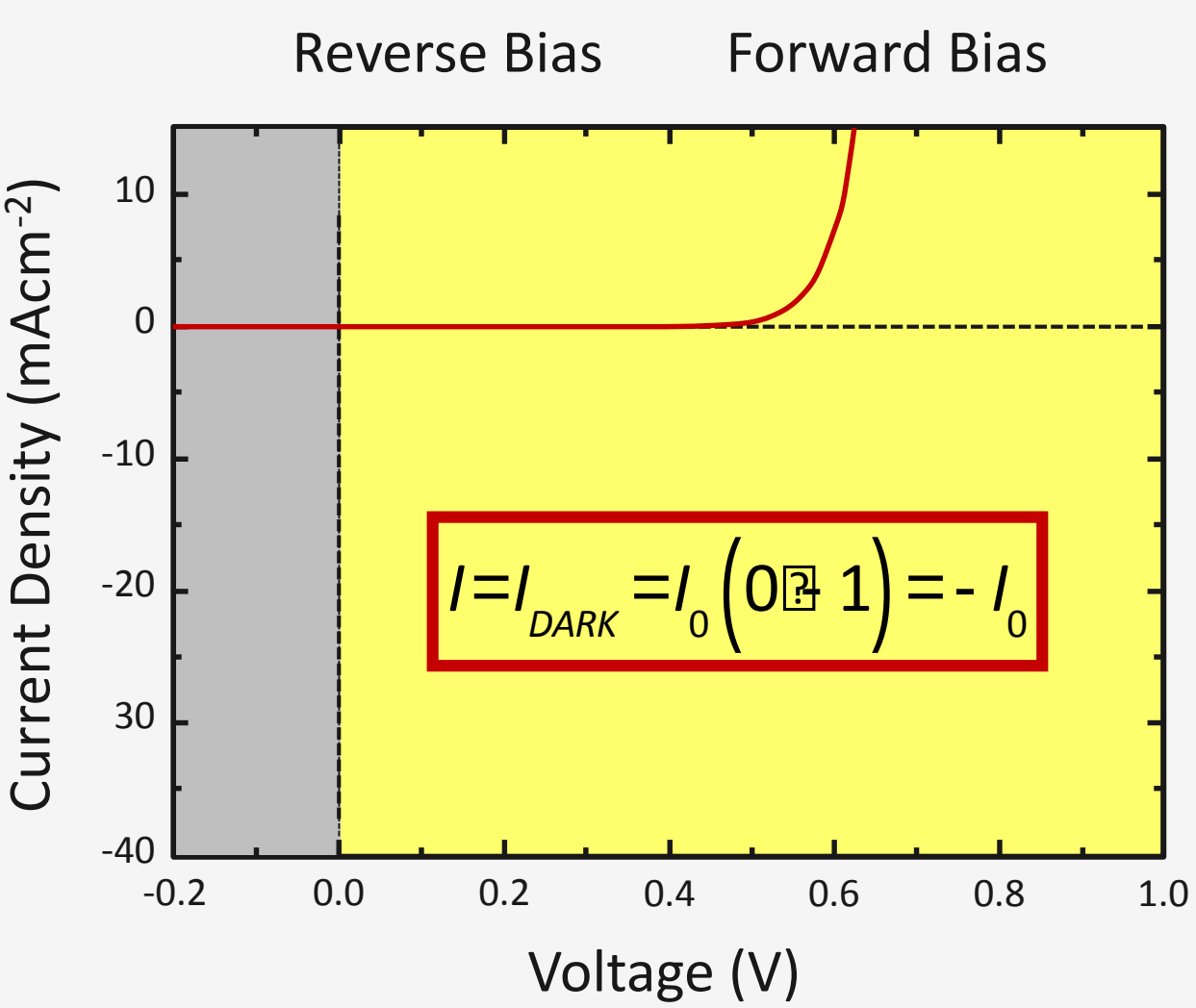
Extemely small net current!

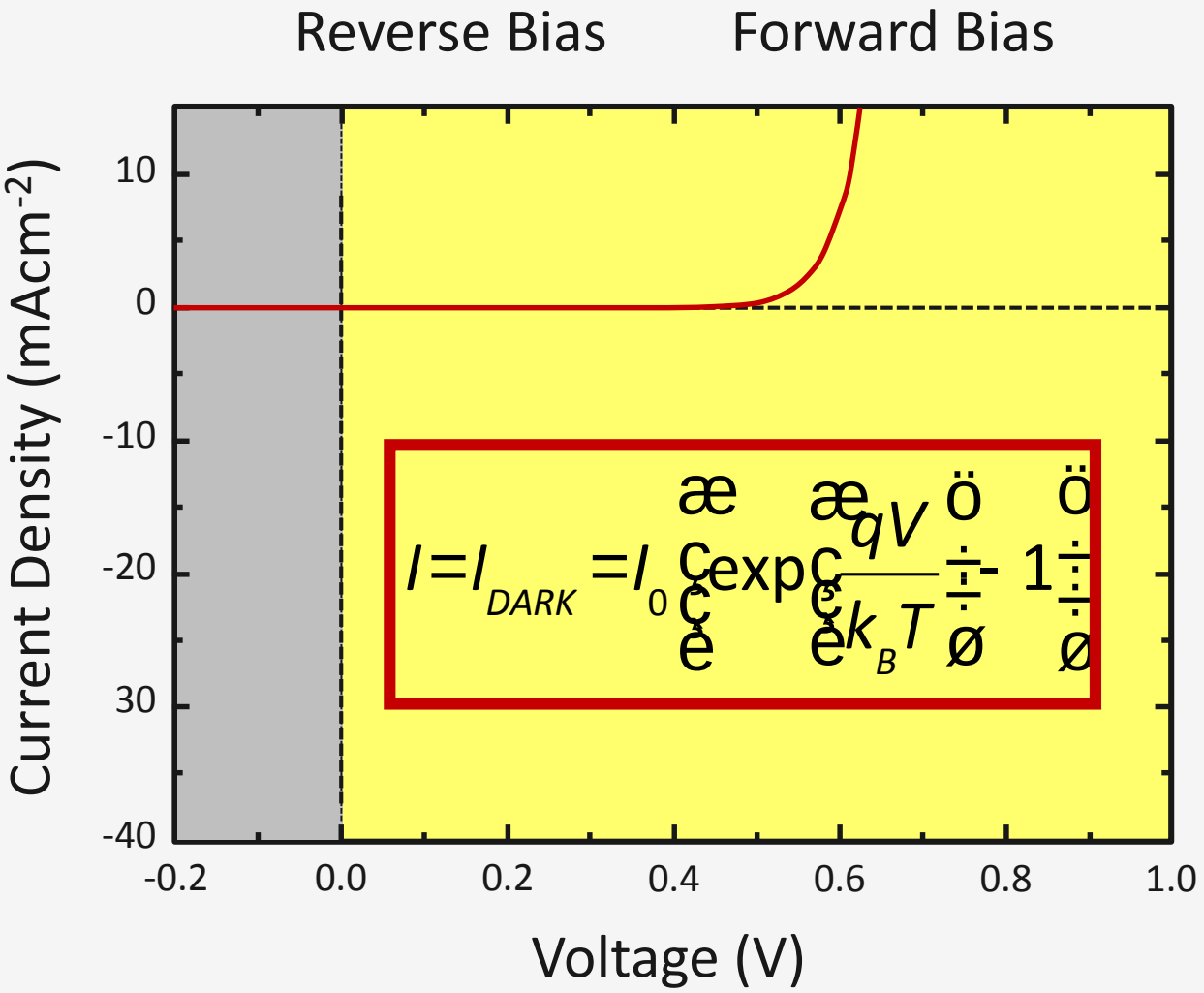

Reverse Bias
Forward Bias
Current Density (mAcm-2)
10
0
-10
-20
30
-40
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
Voltage (V)

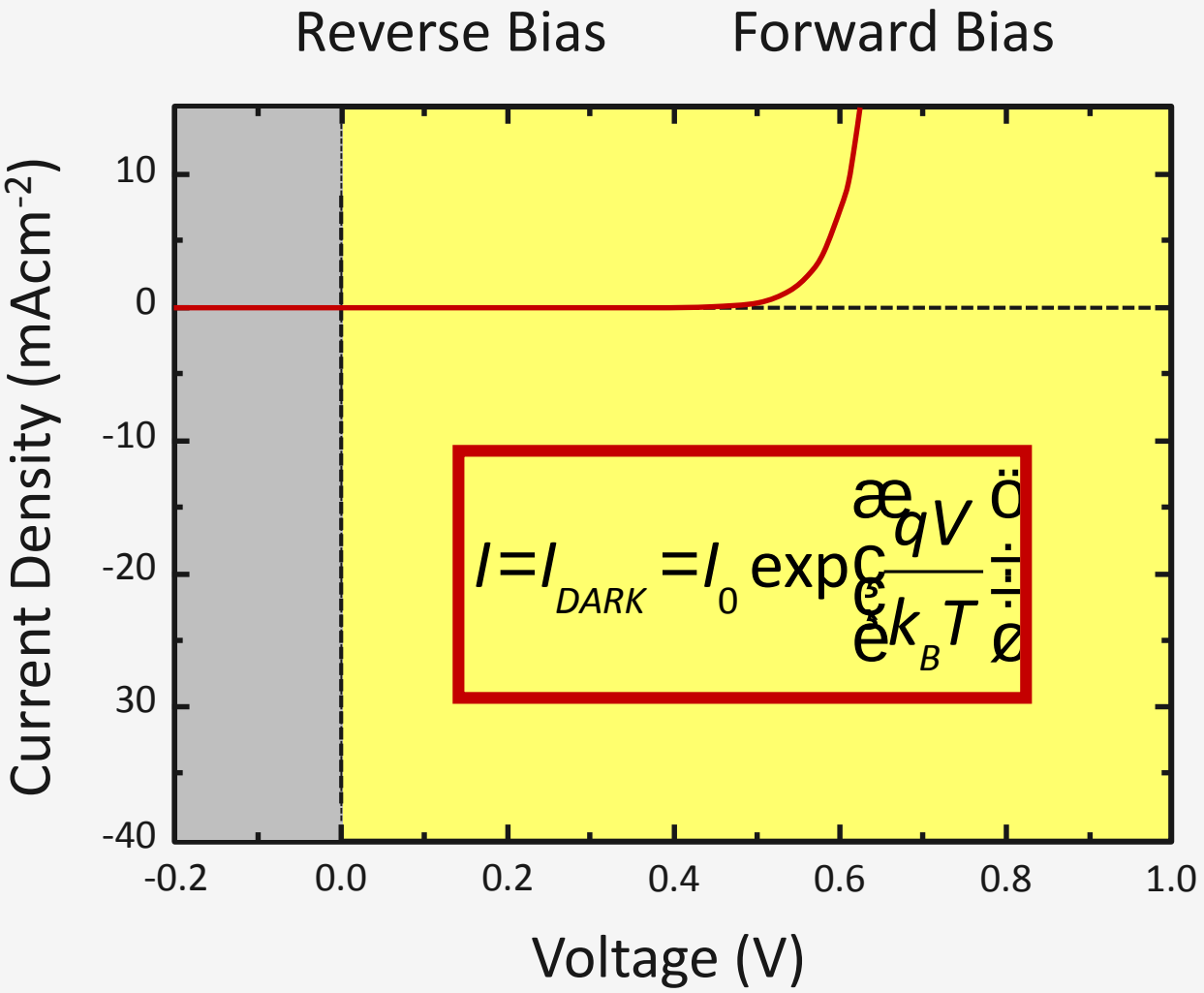

Reverse Bias
Forward Bias
Current Density (mAcm-2)
10
0
-10
-20
30
-40
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
Voltage (V)
V
-
+


Reverse Bias
Forward Bias
Current Density (mAcm-2)
10
0
-10
-20
30
-40
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
Voltage (V)
+
-
V


Reverse Bias
Forward Bias
Current Density (mAcm-2)
10
0
-10
-20
30
-40
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
Voltage (V)
$I = I_{DARK} = I_0 \left[\exp\left(\frac{qV}{k_B T} \right) - 1 \right]$

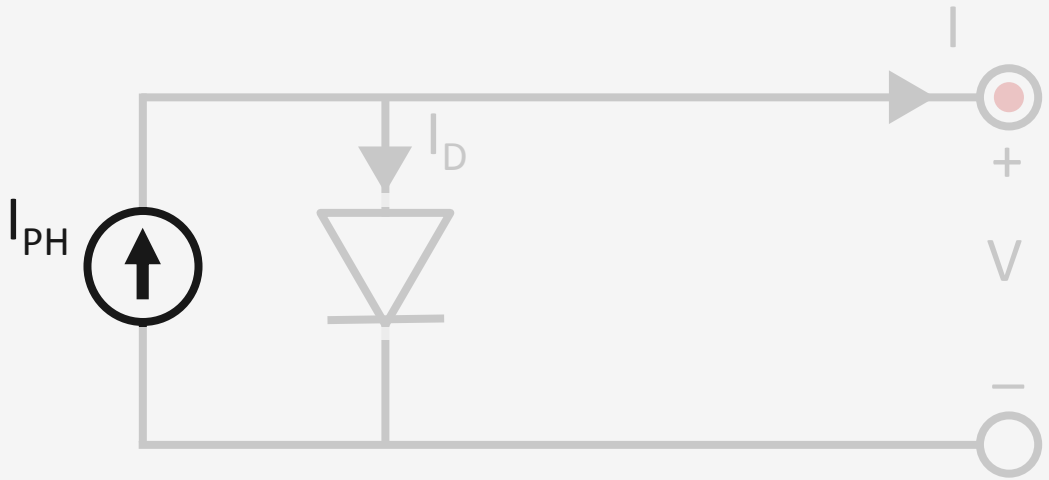

Reverse Bias
Forward Bias
Current Density (mAcm-2)
10
0
-10
-20
30
-40
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
Voltage (V)
I=IDARK=I0(0?1)=-I0

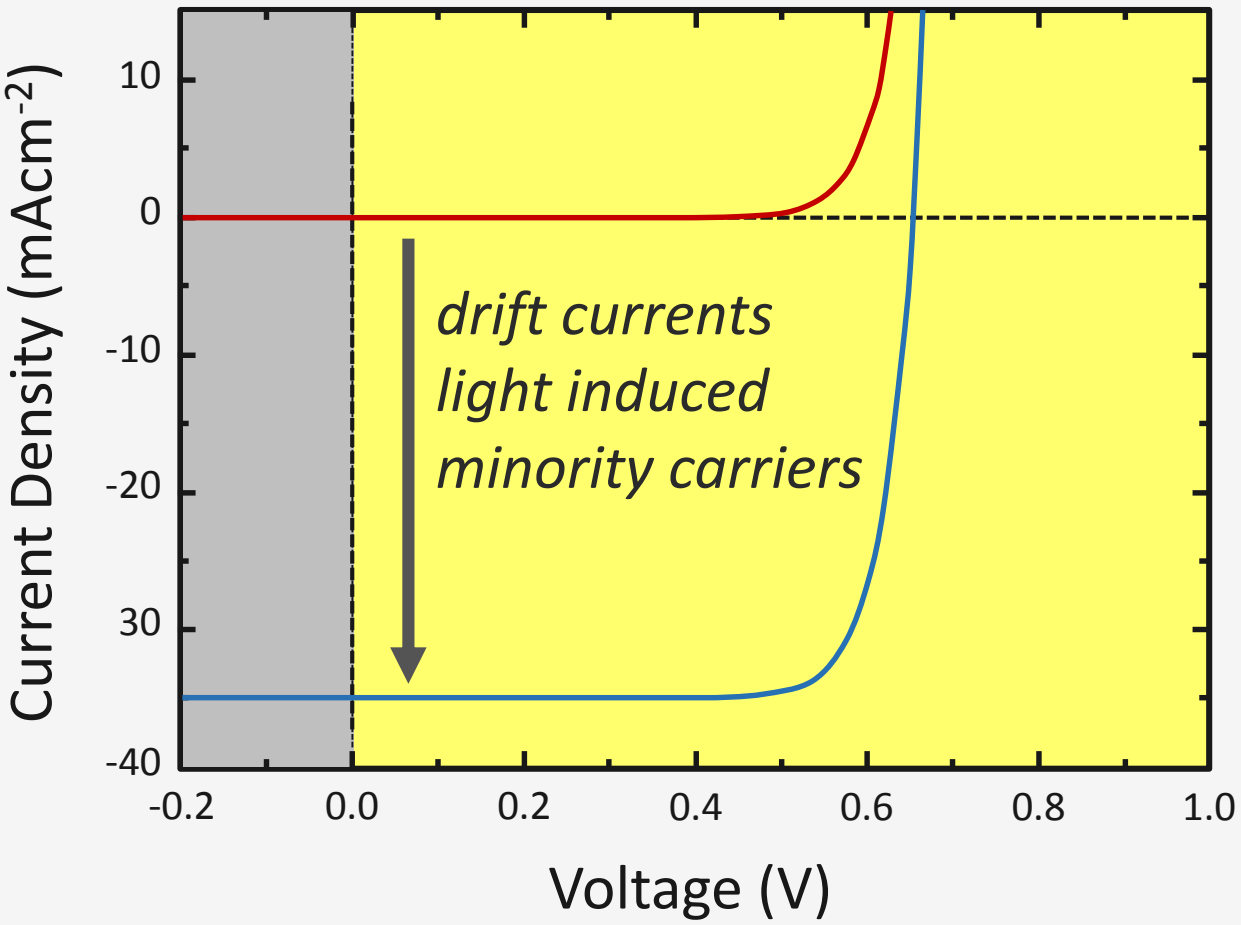

Reverse Bias
Forward Bias
Current Density (mAcm-2)
10
0
-10
-20
30
-40
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
Voltage (V)
$I = I_{DARK} = I_0 \left[\exp\left(\frac{qV}{k_B T} \right) - 1 \right]$

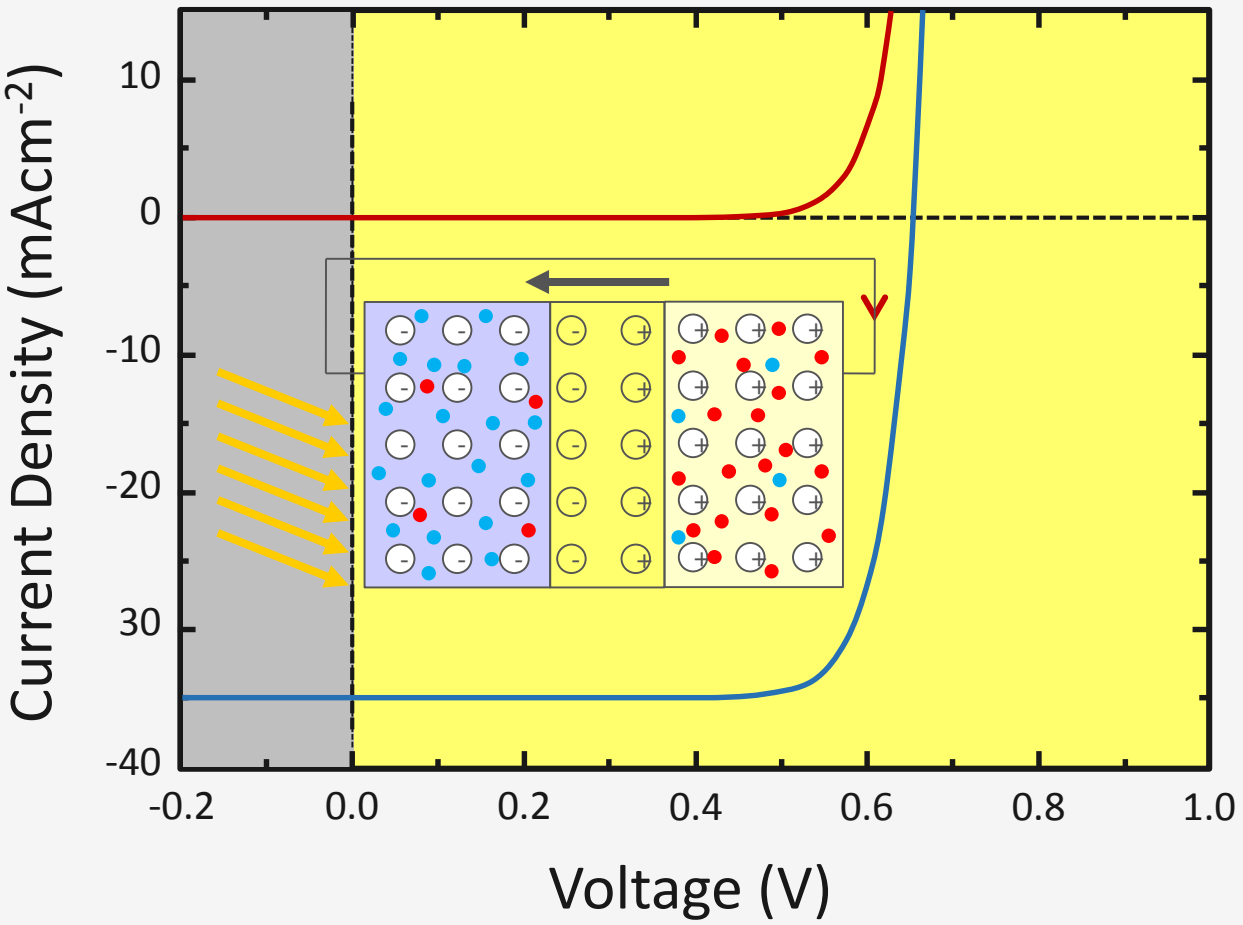

Reverse Bias
Forward Bias
Current Density (mAcm-2)
10
0
-10
-20
30
-40
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
Voltage (V)
I=I_DARK=I_0 exp(qV/k_BT)

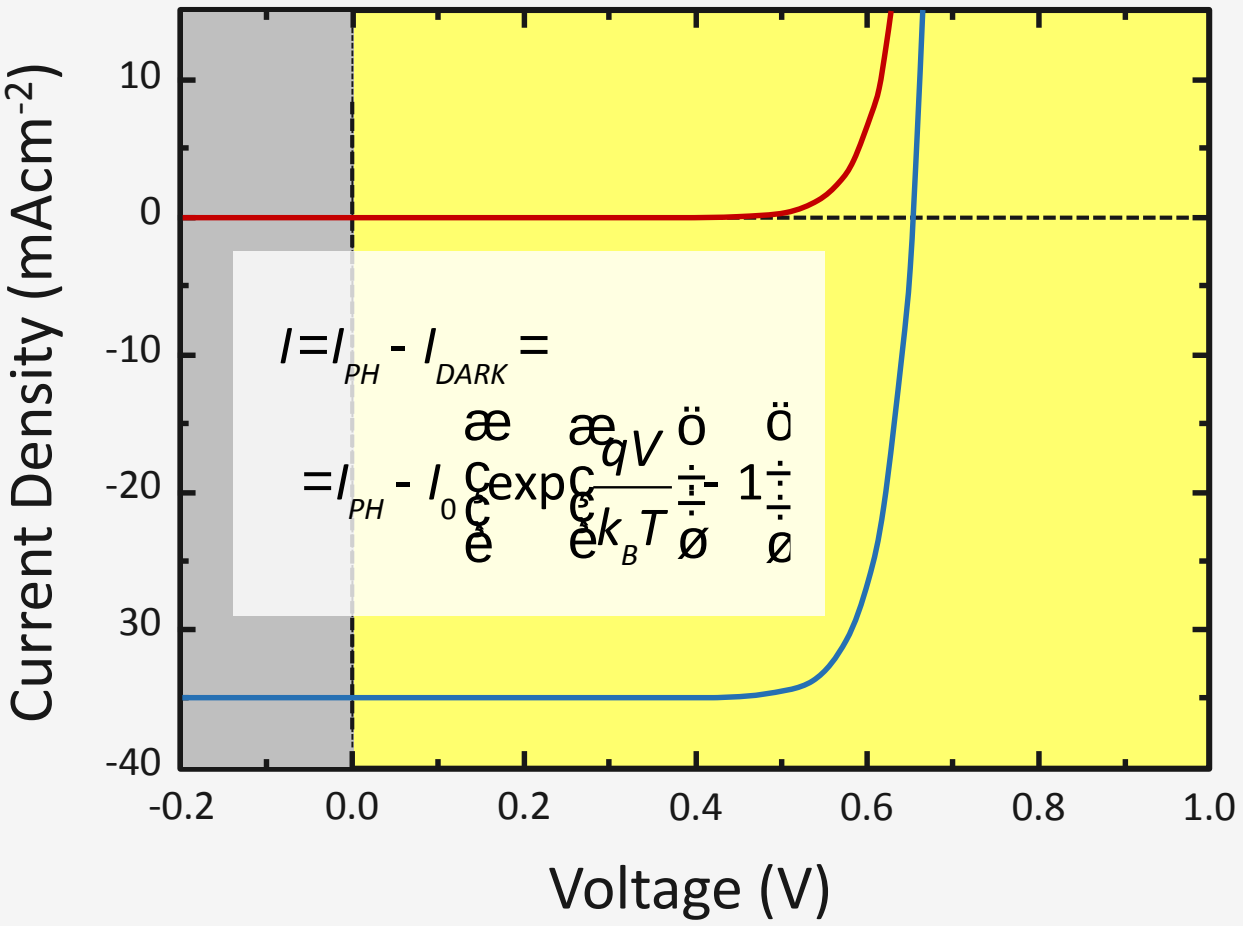
Equivalent circuit of solar cell

The illuminated ideal p-n junction

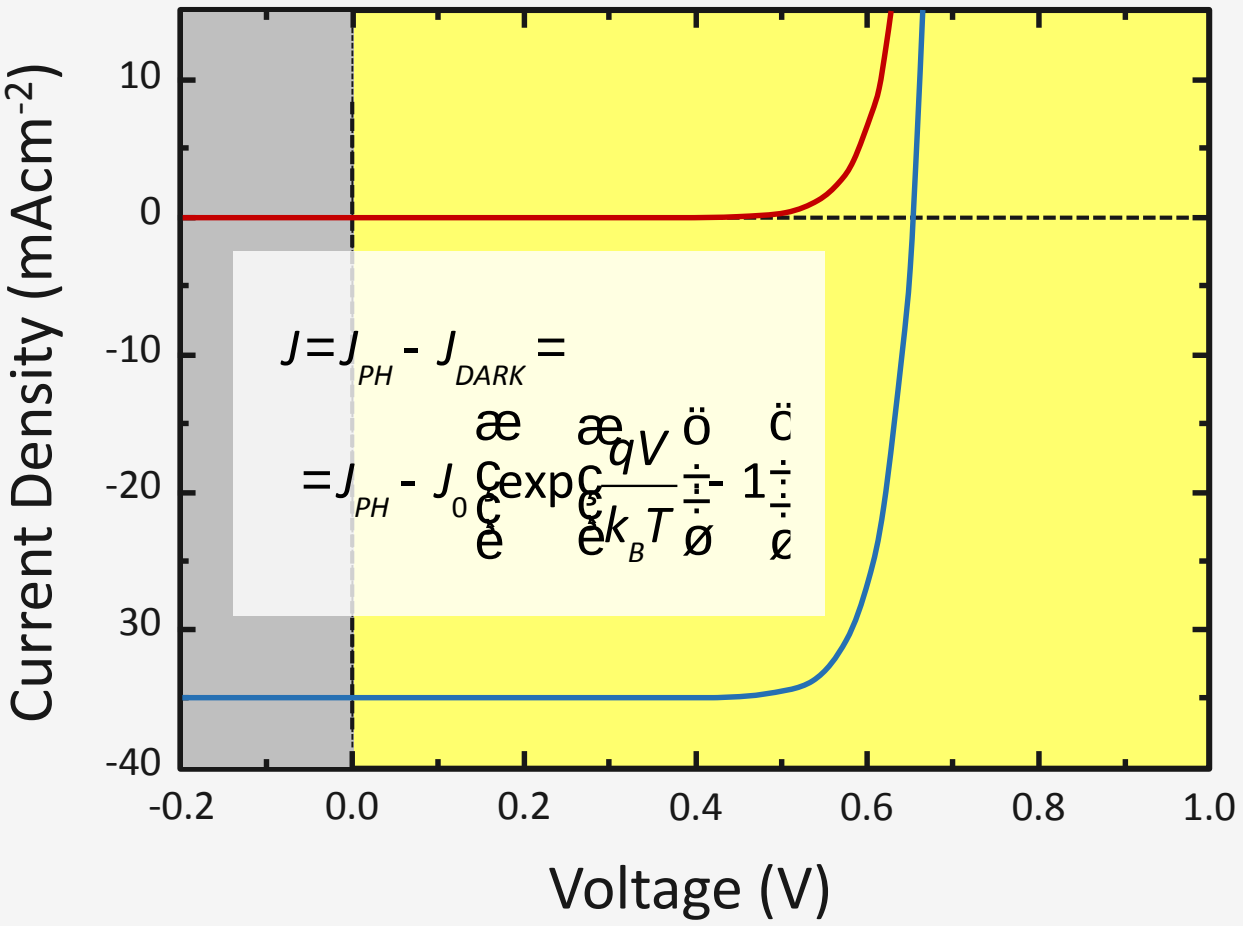



Current Density (mAcm-2)
10
0
-10
-20
30
-40
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
Voltage (V)
drift currents
light induced
minority carriers


Current Density (mAcm-2)
10
0
-10
-20
30
-40
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
Voltage (V)


Current Density (mAcm-2)
10
0
-10
-20
30
-40
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
Voltage (V)
I=IPH - IDARK =
=IPH - I0 (exp(qV/kBT) - 1)

$$J = \frac{I}{A}$$


Current Density (mAcm-2)
10
0
-10
-20
30
-40
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
Voltage (V)
J=JPH - JDARK =
=JPH - J0 exp(qV/kBT - 1)

$$J = \frac{I}{A}$$

Thank you for your attention!

Thank you for your attention!