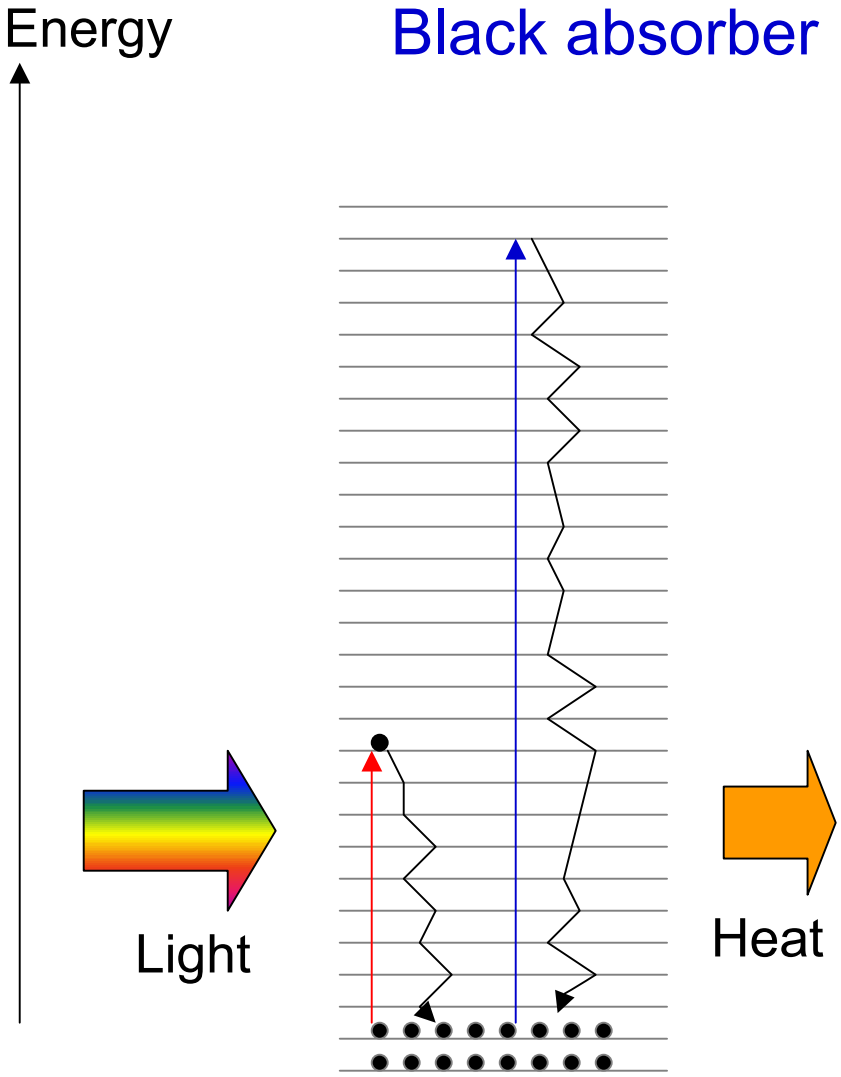
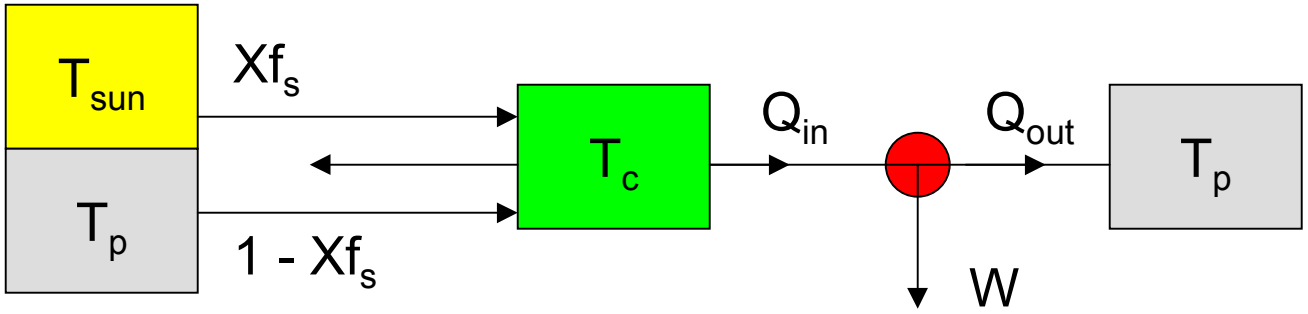
Lecture 17

- Black solids: thermalisation and radiation $\Rightarrow$ HEAT

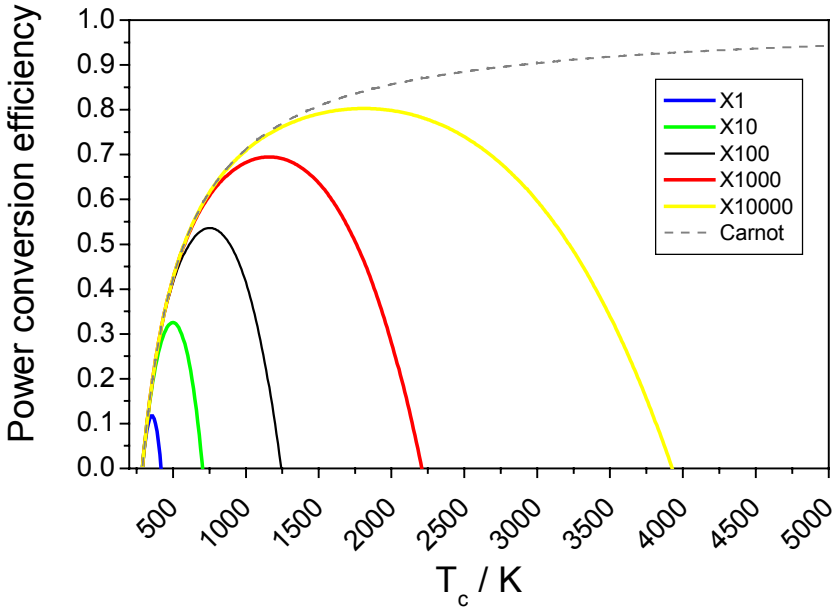
Black absorber



Lecture 18



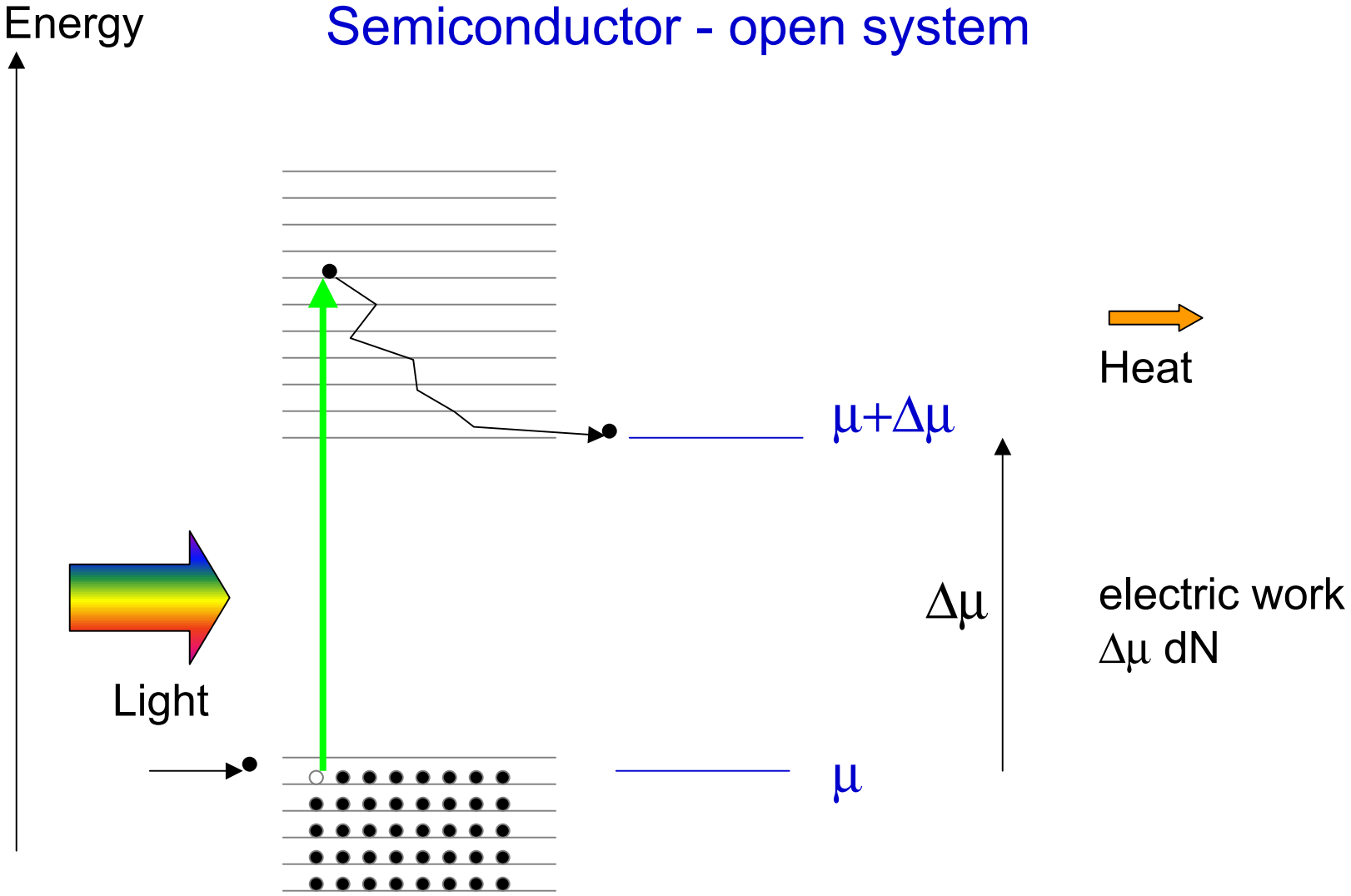
$$\eta = \left\{1 + \frac{1 - Xf_s}{Xf_s}\left(\frac{T_p}{T_{sun}}\right)^4 - \frac{1}{Xf_s}\left(\frac{T_c}{T_{sun}}\right)^4\right\}\left(1 - \frac{T_p}{T_c}\right)$$

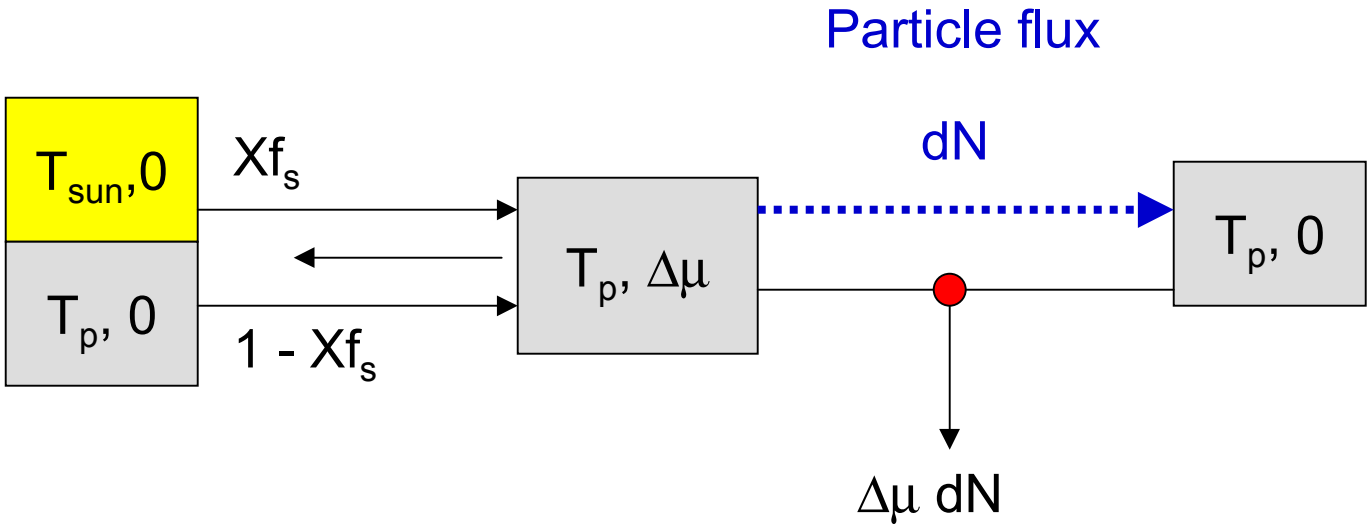


Lecture 17

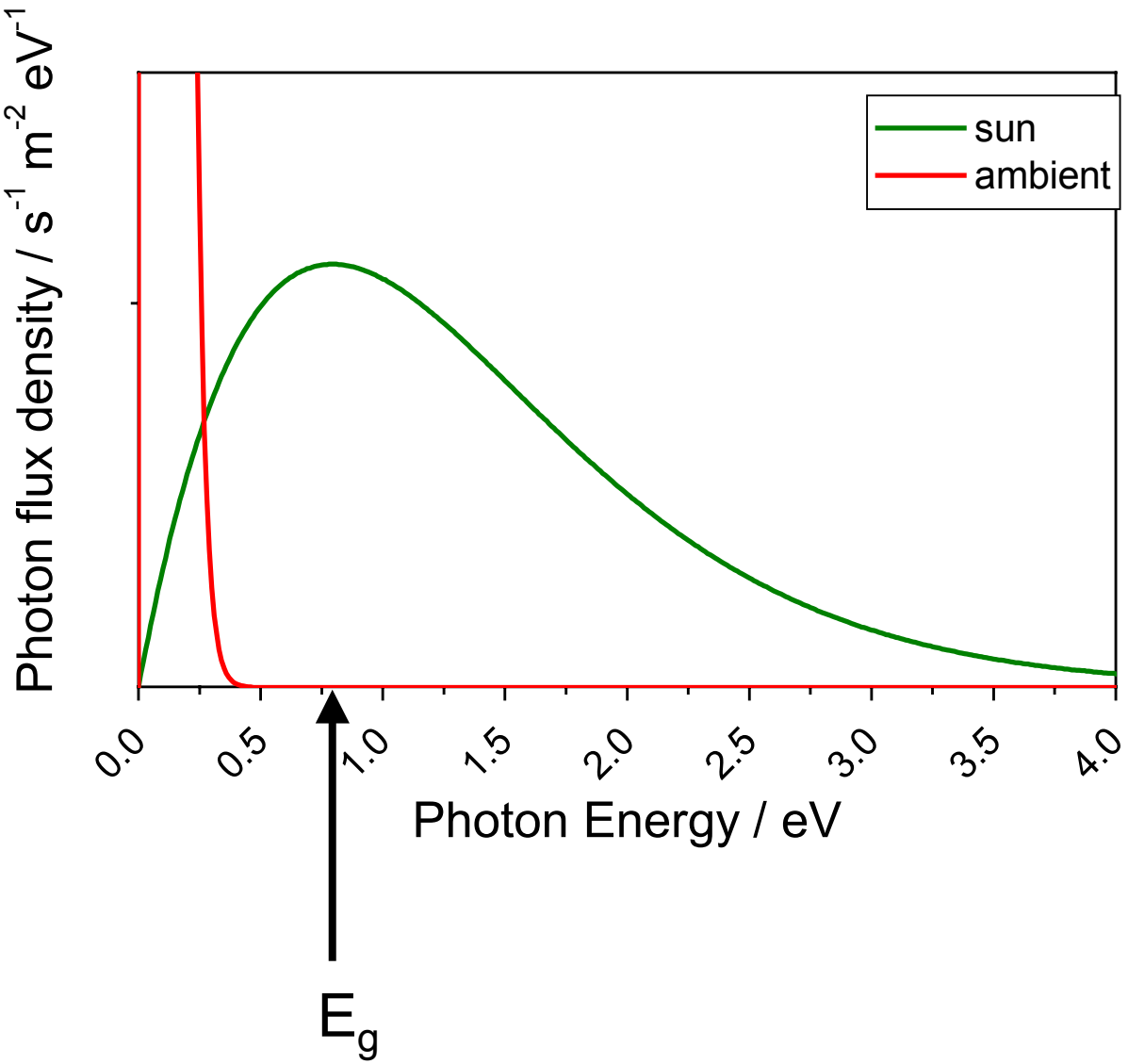
- Black solids: thermalisation and radiation $\Rightarrow$ HEAT
- Semiconductor, open system: electron motion with excess chemical potential energy $\Delta\mu \Rightarrow$ ELECTRIC WORK

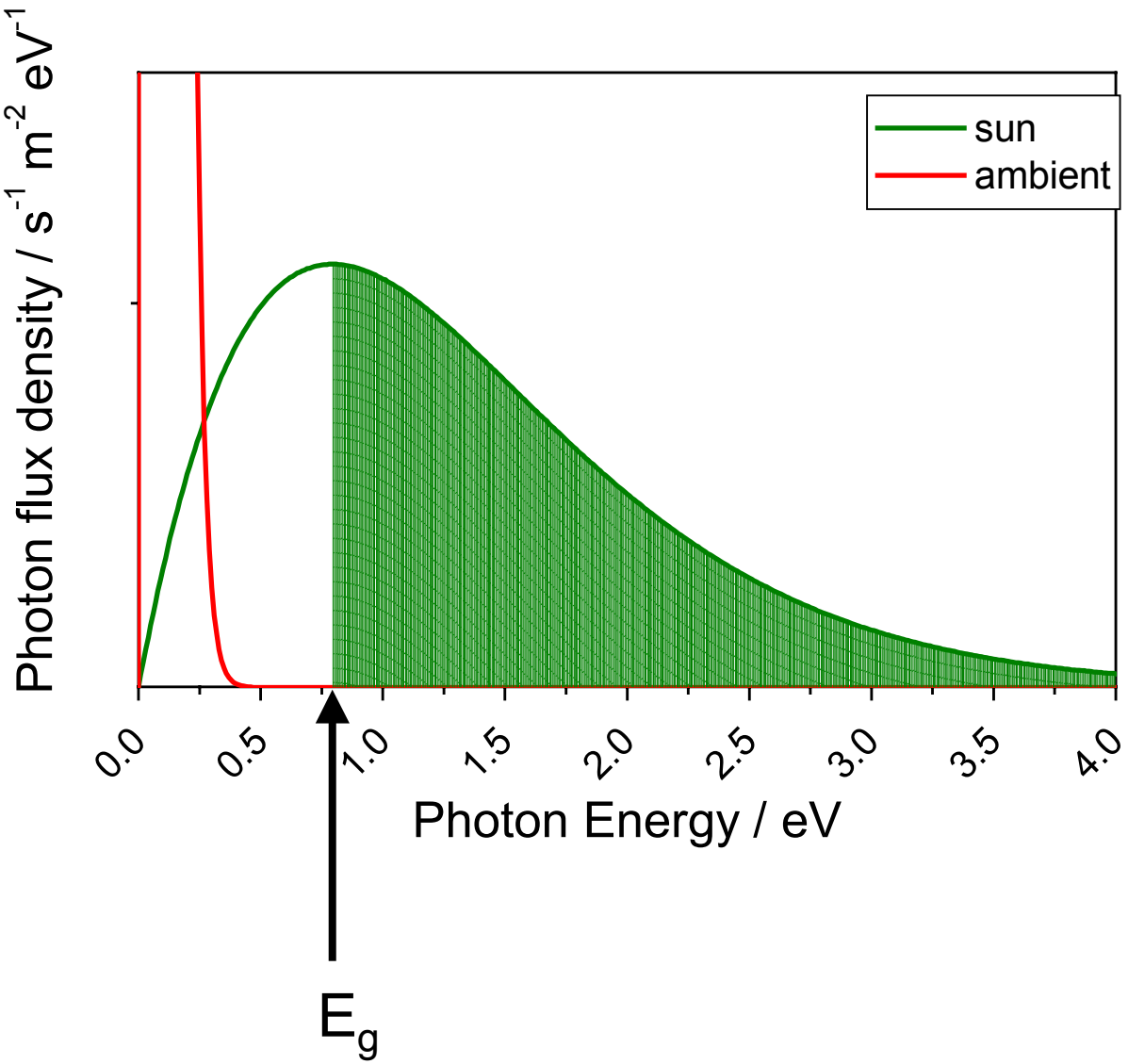
Semiconductor - open system

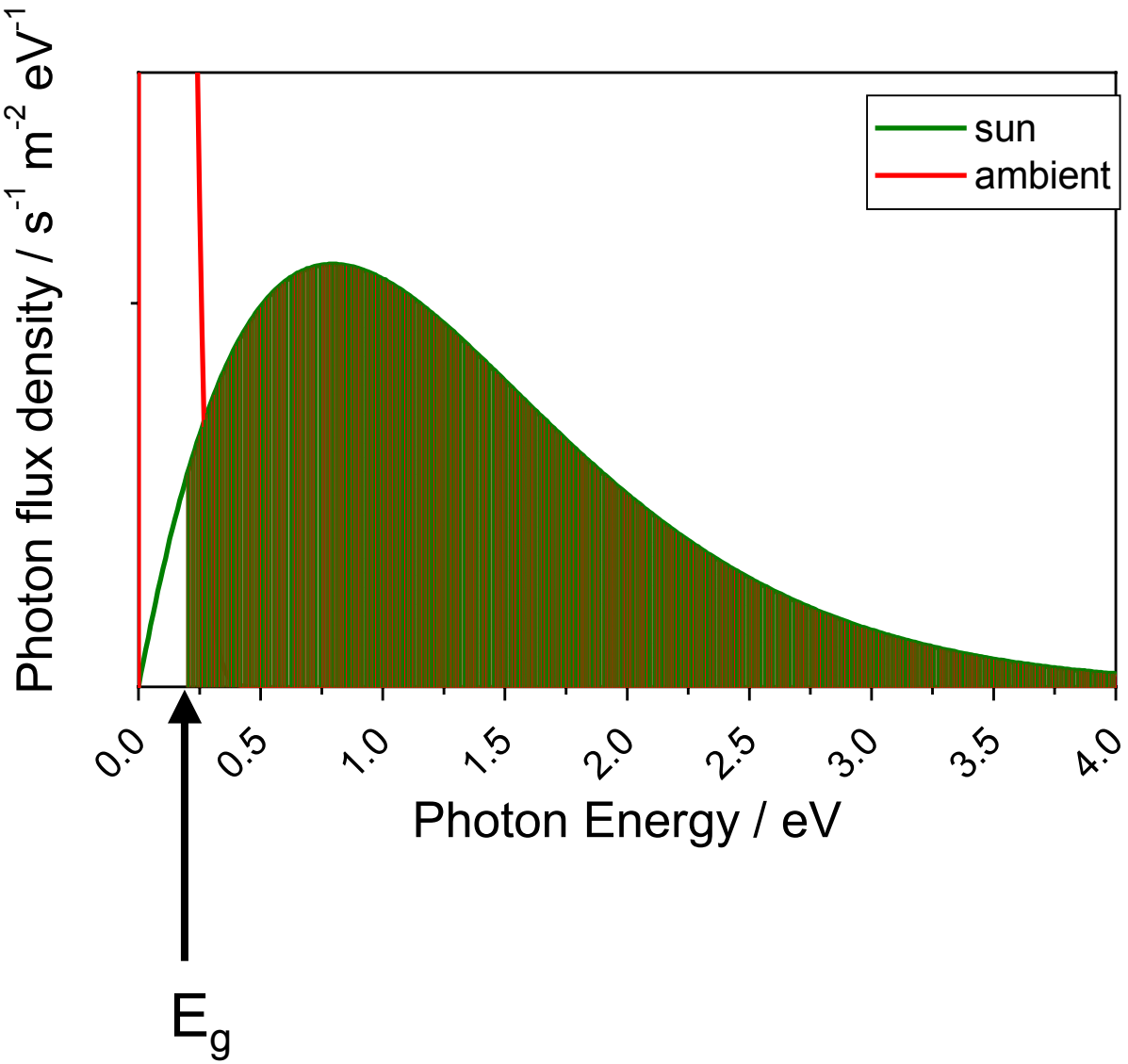


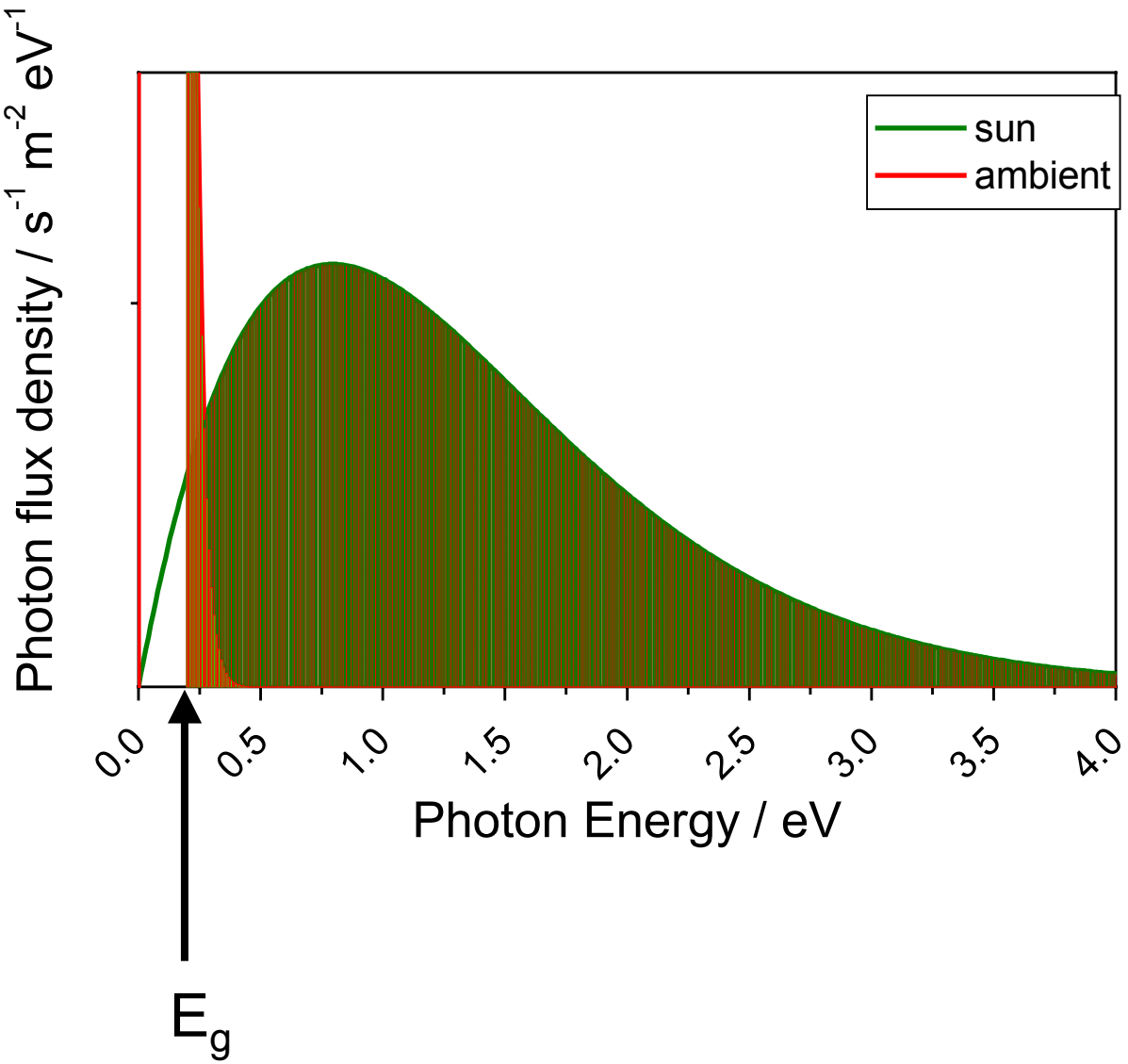


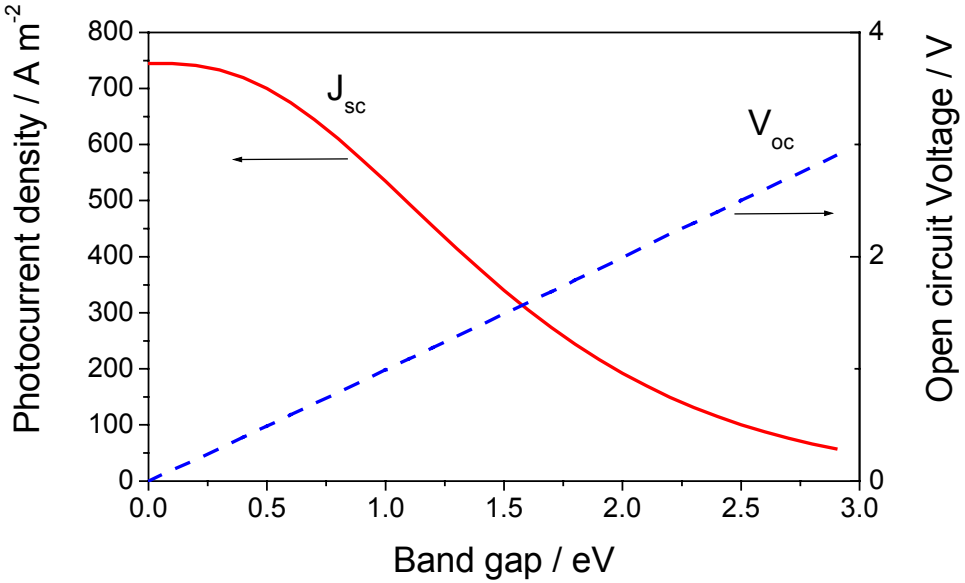
$$\frac{J}{e} = Xf_s \int_{E_g}^{\infty} b(E, T_{sun})dE + (1 - Xf_s) \int_{E_g}^{\infty} b(E, T_p)dE - e^{\Delta\mu / kT} \int_{E_g}^{\infty} b(E, T_p)dE$$

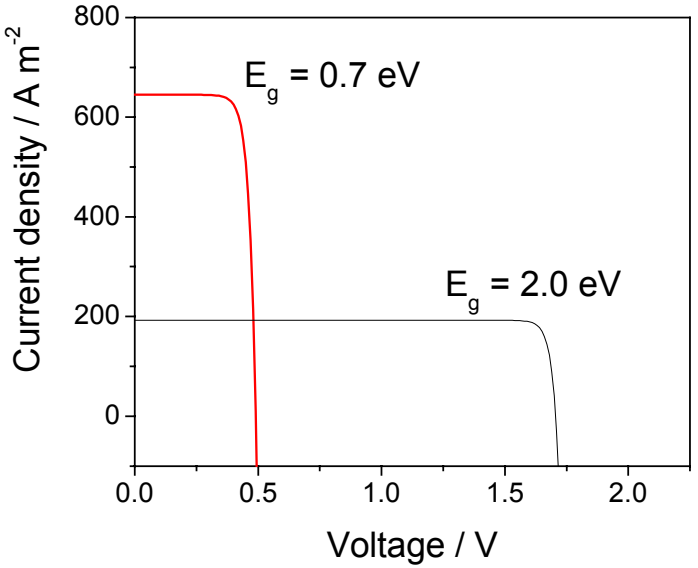

Photon flux density / s-1 m-2 eV-1
sun
ambient
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Photon Energy / eV
Eg

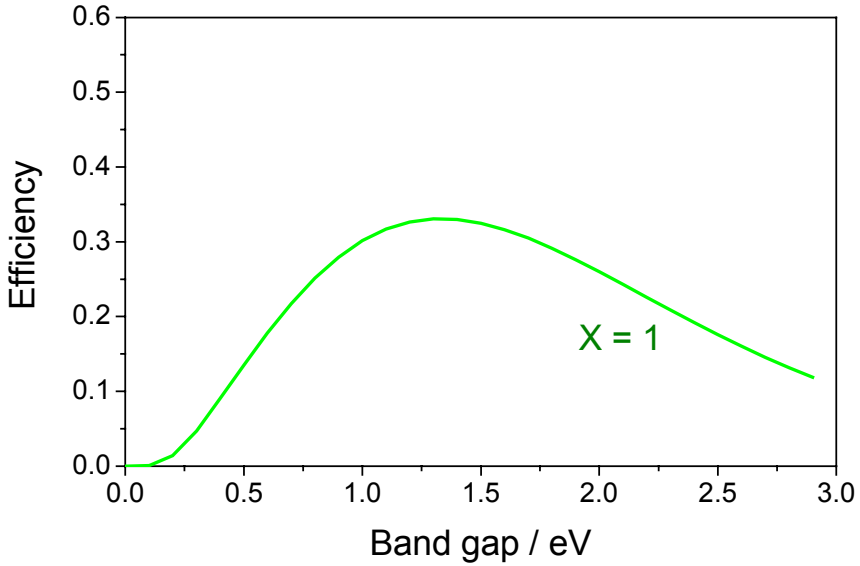

Photon flux density / s-1 m-2 eV-1
sun
ambient
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Photon Energy / eV
Eg

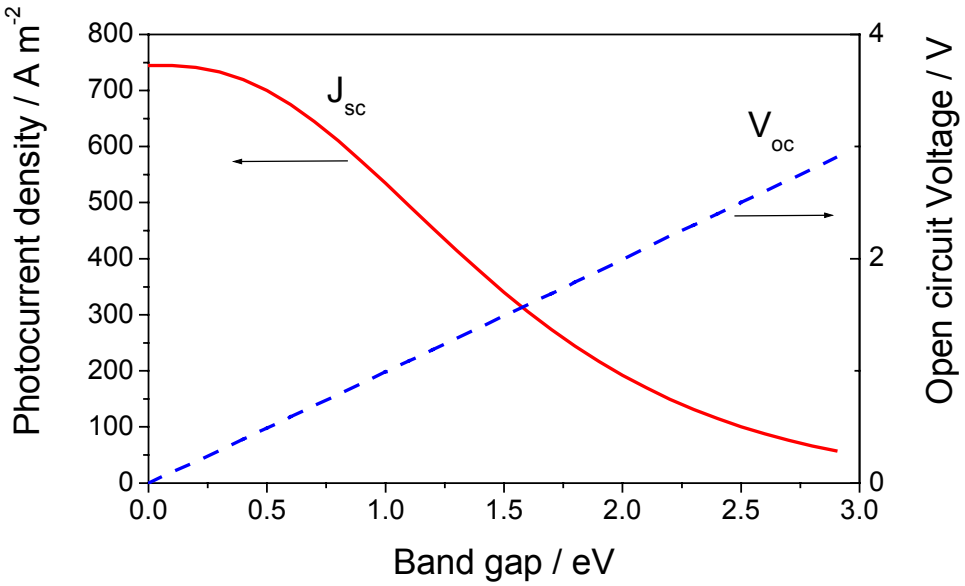

Photon flux density / s-1 m-2 eV-1
sun
ambient
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Photon Energy / eV
Eg

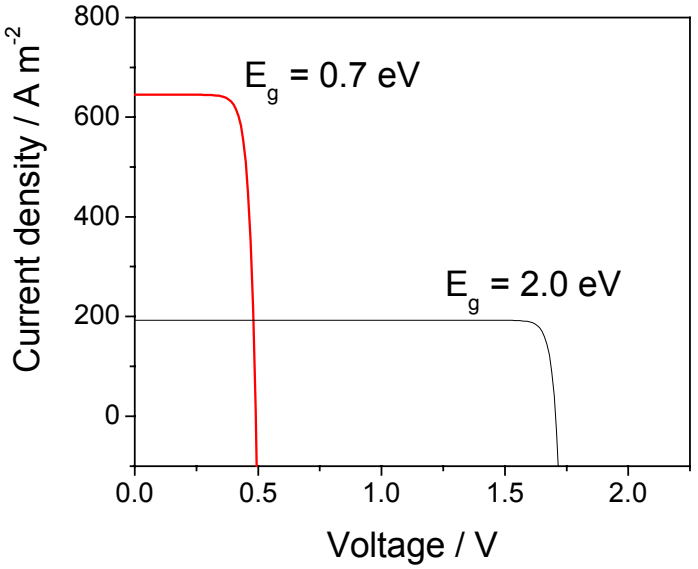

Photon flux density / s-1 m-2 eV-1
sun
ambient
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Photon Energy / eV
Eg

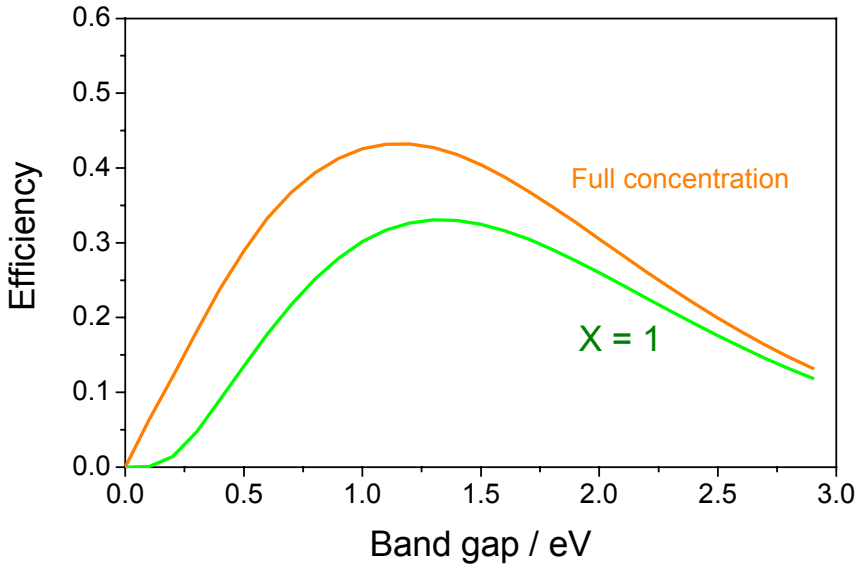

Photocurrent density / A m-2
Open circuit Voltage / V
Band gap / eV
Jsc
Voc
800
700
600
500
400
300
200
100
0
4
2
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0

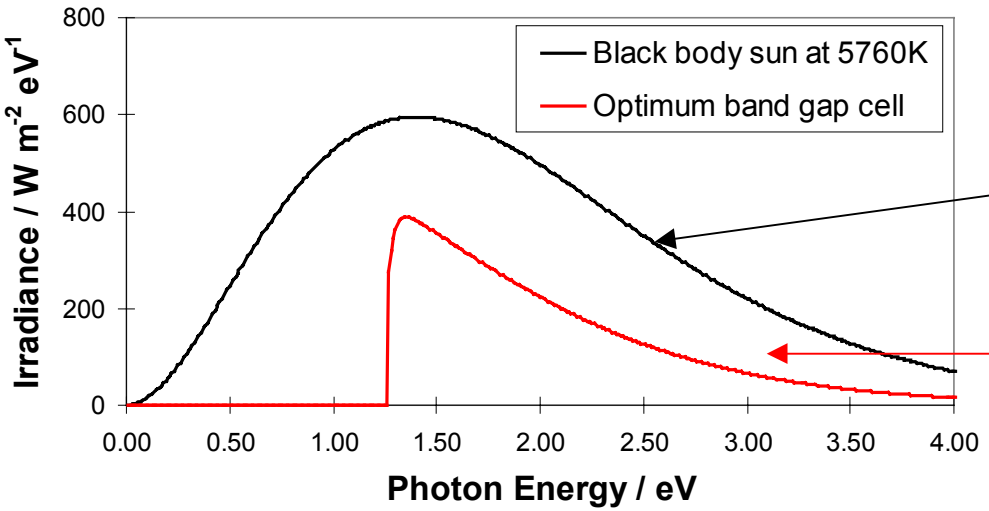

Current density / A m-2
Voltage / V
Eg = 0.7 eV
Eg = 2.0 eV
800
600
400
200
0
0.0
0.5
1.0
1.5
2.0


Efficiency
Band gap / eV
X = 1
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0


Photocurrent density / A m-2
Open circuit Voltage / V
Band gap / eV
Jsc
Voc
800
700
600
500
400
300
200
100
0
4
2
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0

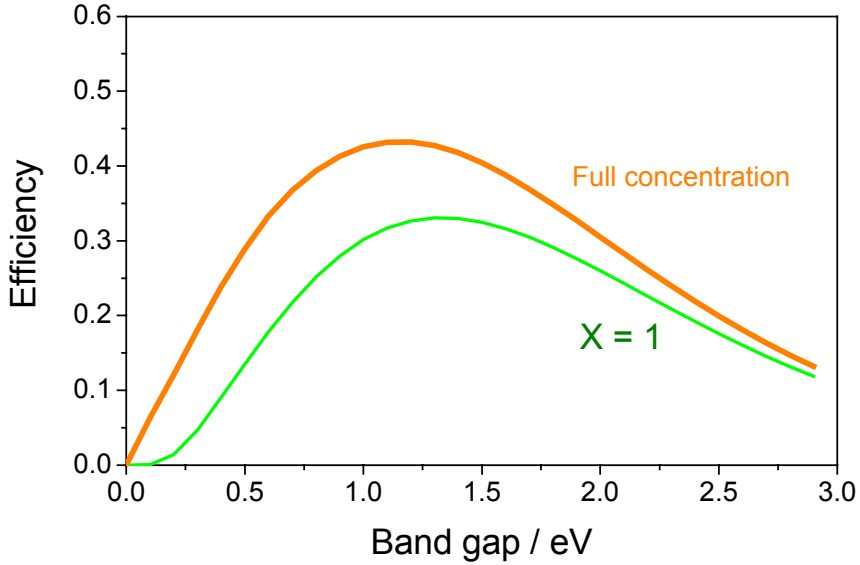

Current density / A m-2
Voltage / V
Eg = 0.7 eV
Eg = 2.0 eV
800
600
400
200
0
0.0
0.5
1.0
1.5
2.0


Efficiency
Band gap / eV
Full concentration
X = 1
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0



Radiant power from sun

Available power from PV device



Env Phys JN

Summary of Lecture 19

- Ideal solar photovoltaic converter at concentration X:
  - Absorbs all photons with E > Eg
  - Emits like black body with chemical potential $\Delta\mu > 0$
  - Every net absorbed photon $\rightarrow$ one electron in external circuit (QE = 1)
  - Delivers power density P = JV for $\Delta\mu = eV > 0$ (c.f. $dW/dt = \Delta\mu\, dN/dt$)

- J contains light dependent photocurrent and V dependent dark current

$$J = J_{sc} - J_o(\exp(eV/kT)-1)$$

- Efficiency depends on E_g.
  - Max 31% at Eg = 1.4 eV for BB sun at X = 1