Solar cells

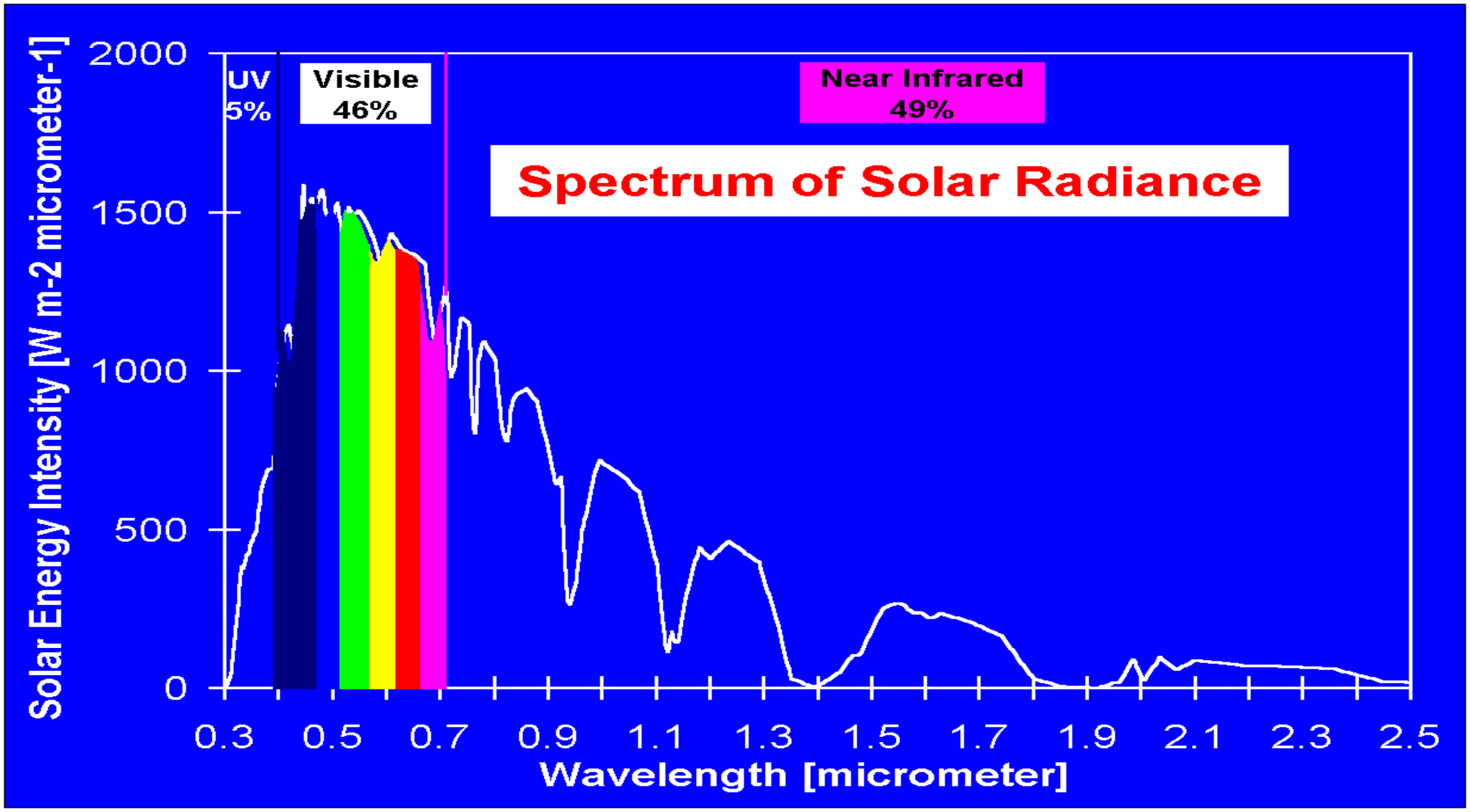
Overview

- Solar cell fundamentals
- Novel solar cell structures
- Thin film solar cells
- Next generation solar cell

Appealing Characteristics

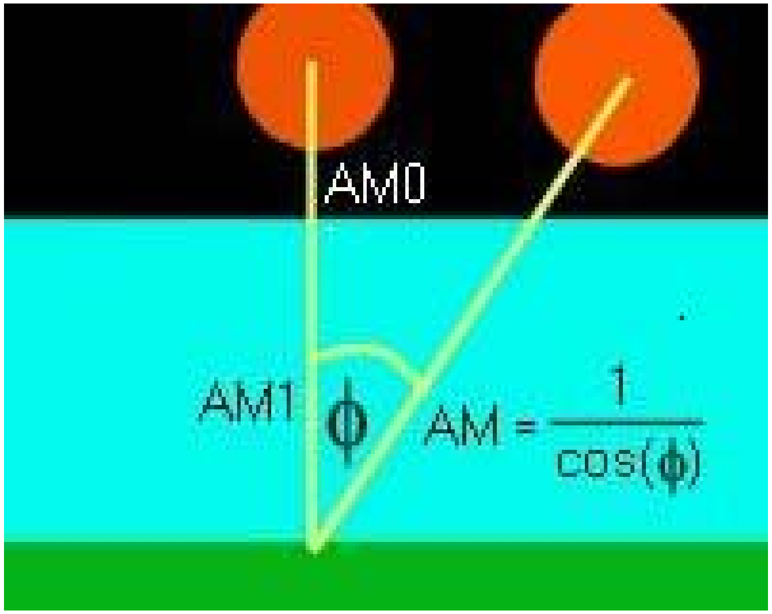
- Consumes no fuel
- No pollution
- Wide power-handling capabilities
- High power-to-weight ratio

Solar Energy Spectrum



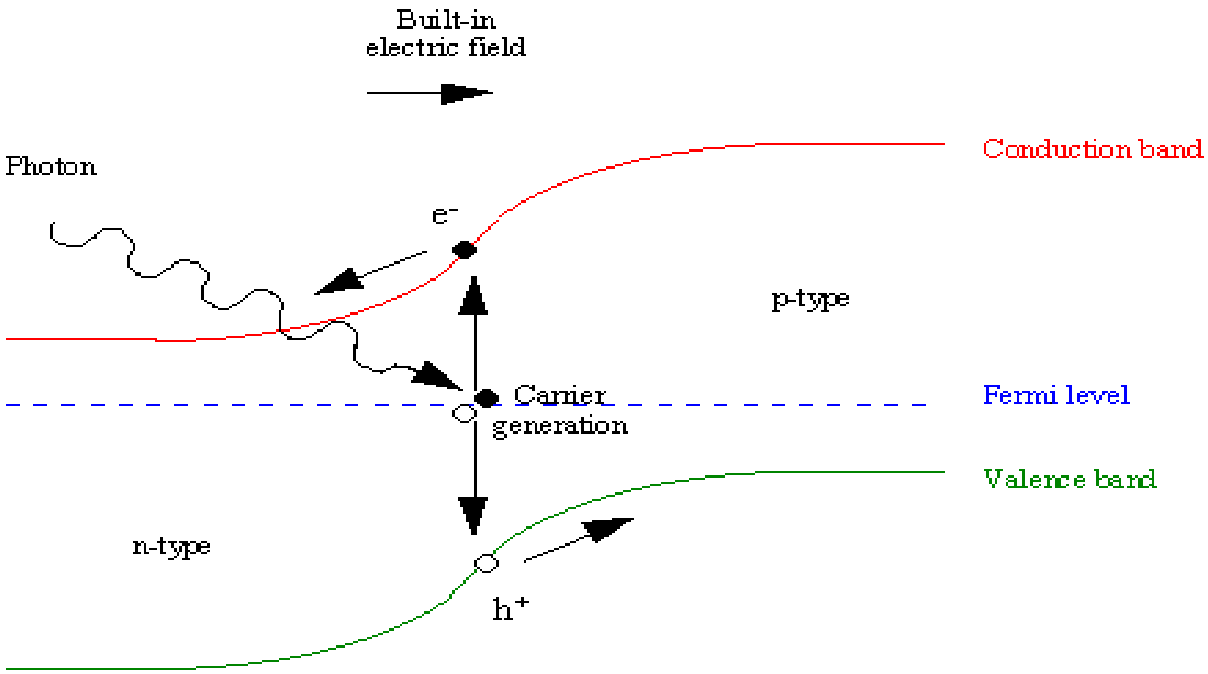
- Power reaching earth 1.37 KW/m^2

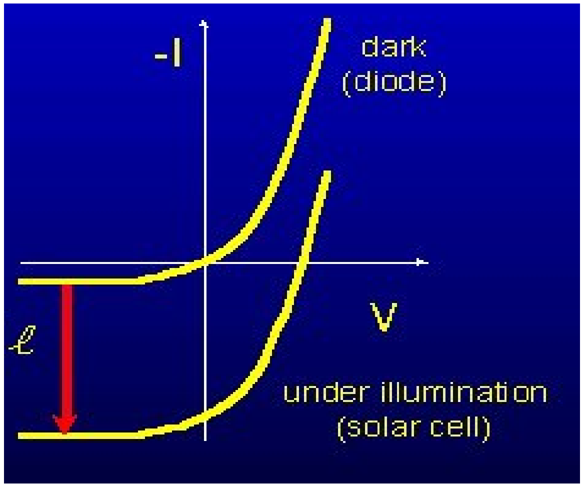
Air Mass



- Amount of air mass through which light pass
- Atmosphere can cut solar energy reaching earth by 50% and more

Solar cell – Working Principle





- Operating diode in fourth quadrant generates power

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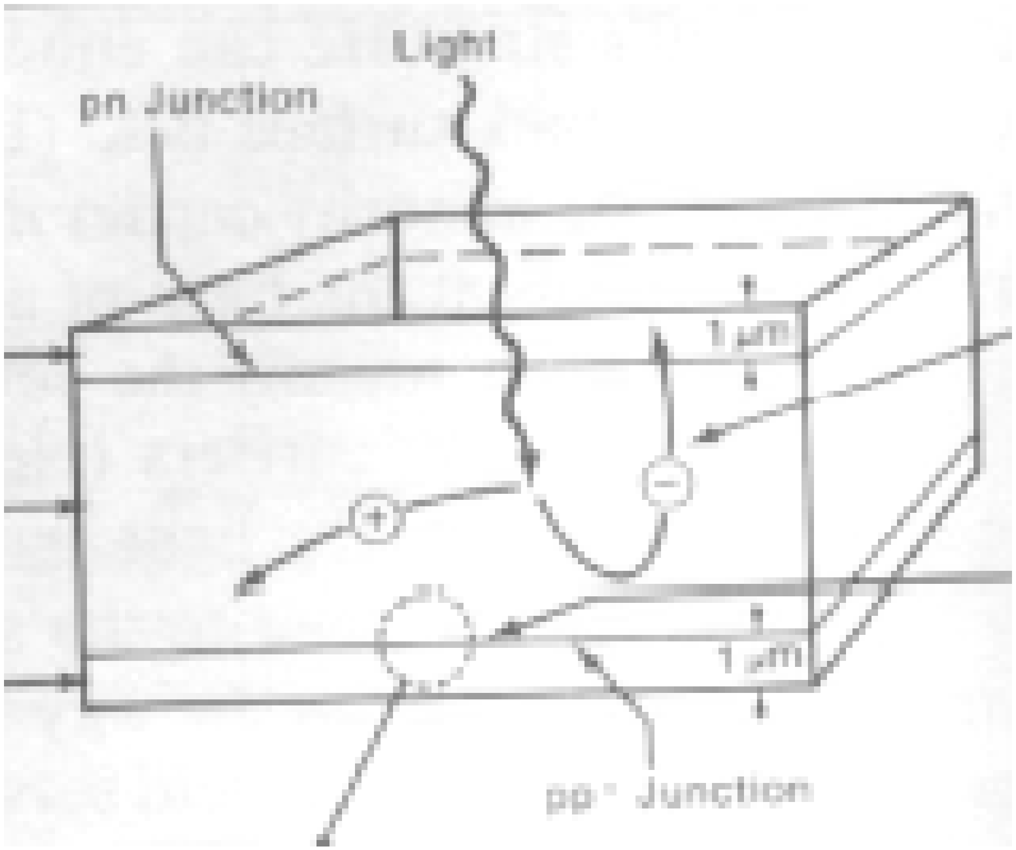
Back Surface Fields



- Most carriers are generated in thicker p region
- Electrons are repelled by p-p$^+$ junction field

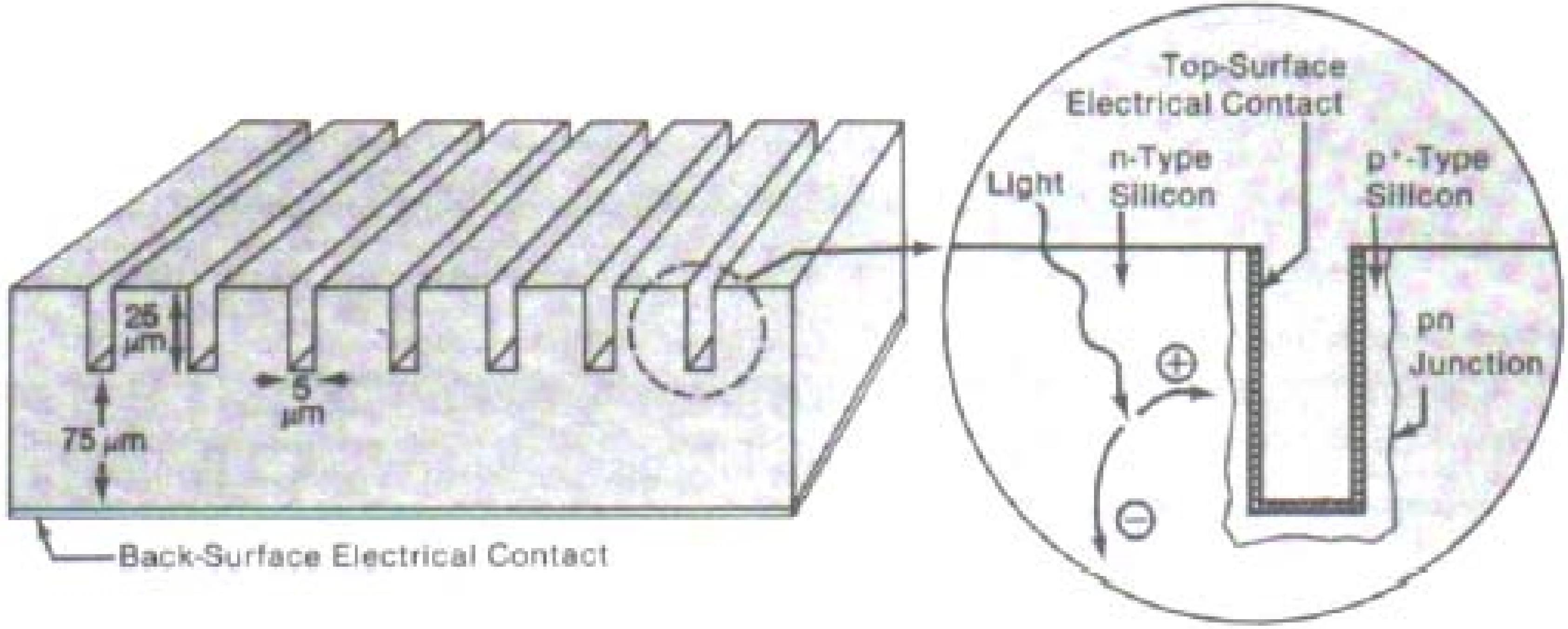
Schottky Barrier Cell

- Principle similar to p-n junction cell
- Cheap and easy alternative to traditional cell

<u>Limitations:</u>

- Conducting grid on top of metal layer
- Surface damage due to high temperature in grid-attachment technique

Grooved Junction Cell



- Higher p-n junction area
- High efficiency (> 20%)

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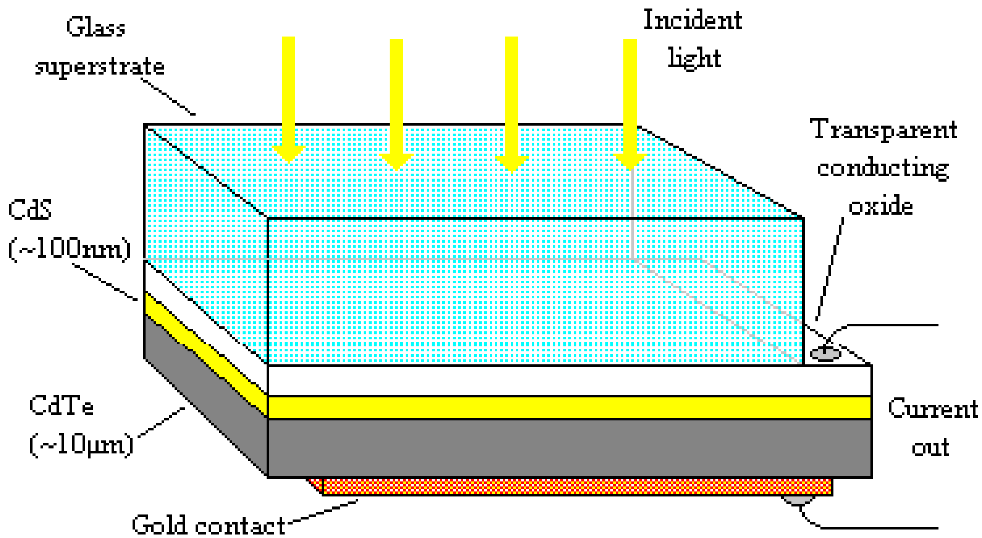
Thin Film Solar Cells

- Produced from cheaper polycrystalline materials and glass
- High optical absorption coefficients
- Bandgap suited to solar spectrum

CdTe/CdS Solar Cell

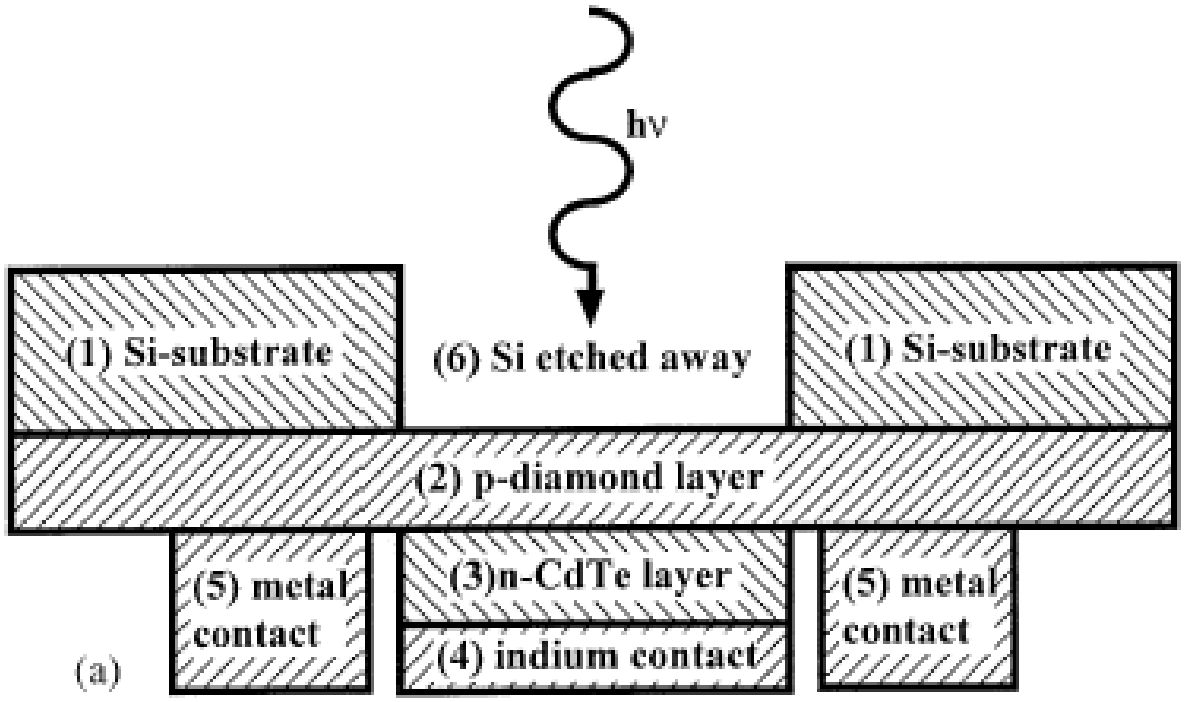


- **<u>CdTe</u>** : Bandgap 1.5 eV; Absorption coefficient 10 times that of Si
- **<u>CdS</u>** : Bandgap 2.5 eV; Acts as window layer

Limitation :

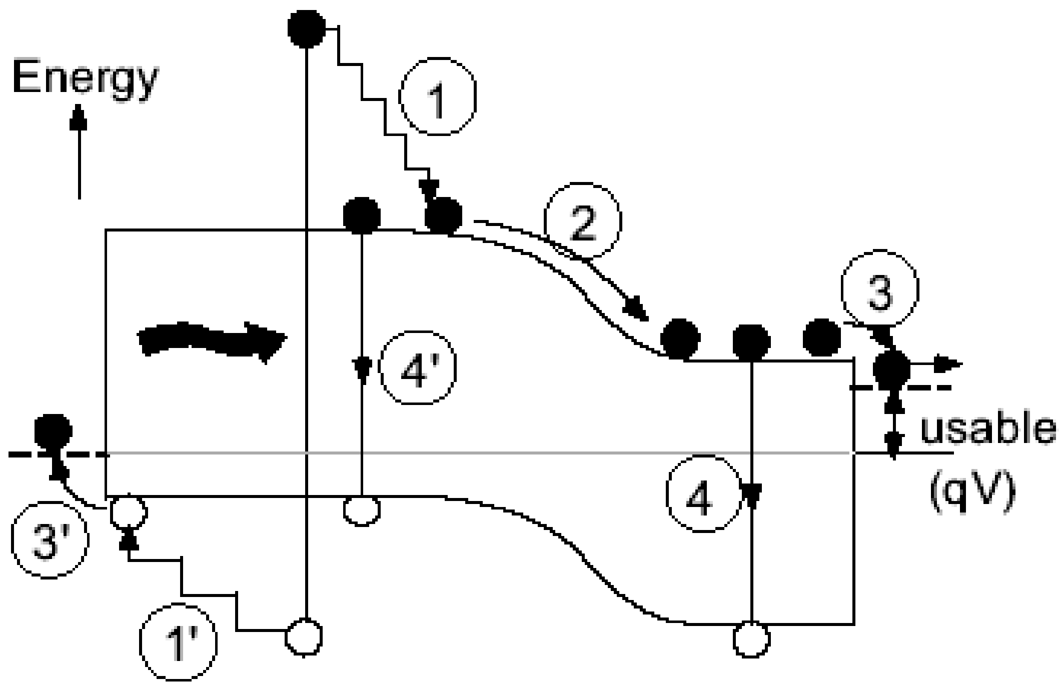
Poor contact quality with p-CdTe (~ 0.1 Ωcm^2)

Inverted Thin Film Cell



- p-diamond (Bandgap 5.5 eV) as a window layer
- n-CdTe layer as an absorption layer

Efficiency Losses in Solar Cell



1 = Thermalization loss

2 and 3 = Junction and contact voltage loss

4 = Recombination loss

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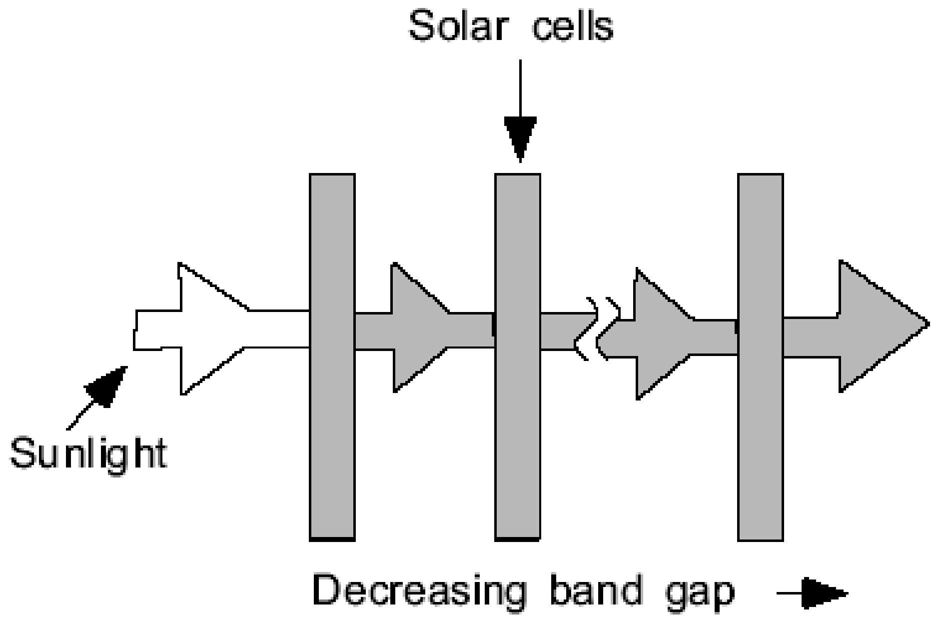
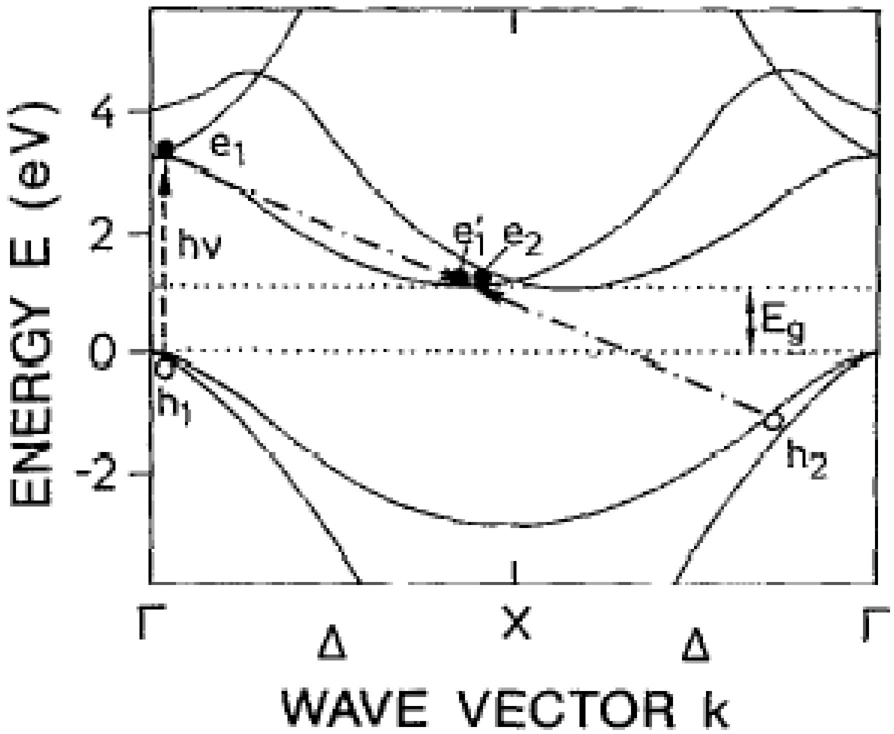
Tandem Cells



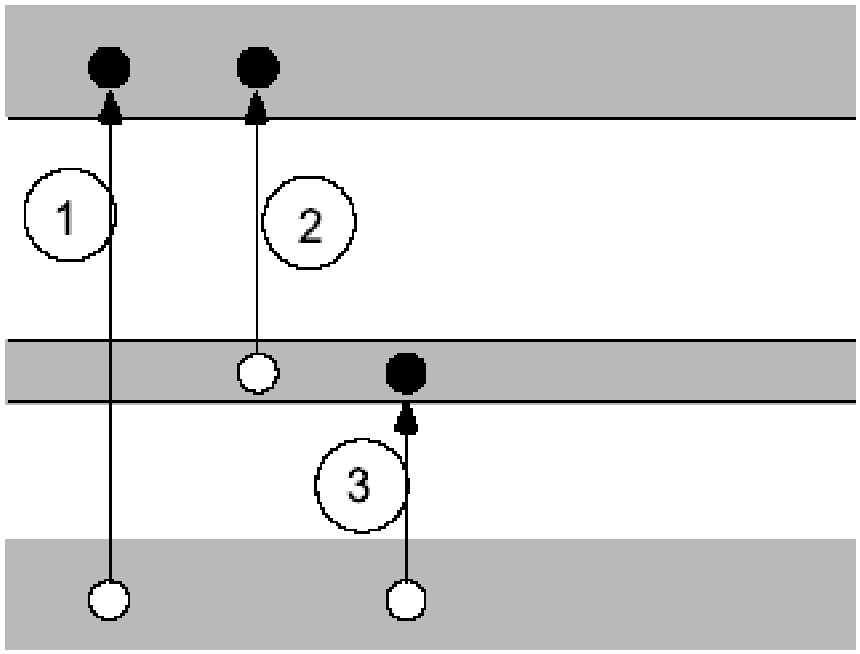
- Current output matched for individual cells
- Ideal efficiency for infinite stack is 86.8%
- GaInP/GaAs/Ge tandem cells (efficiency 40%)

Multiple E-H pairs



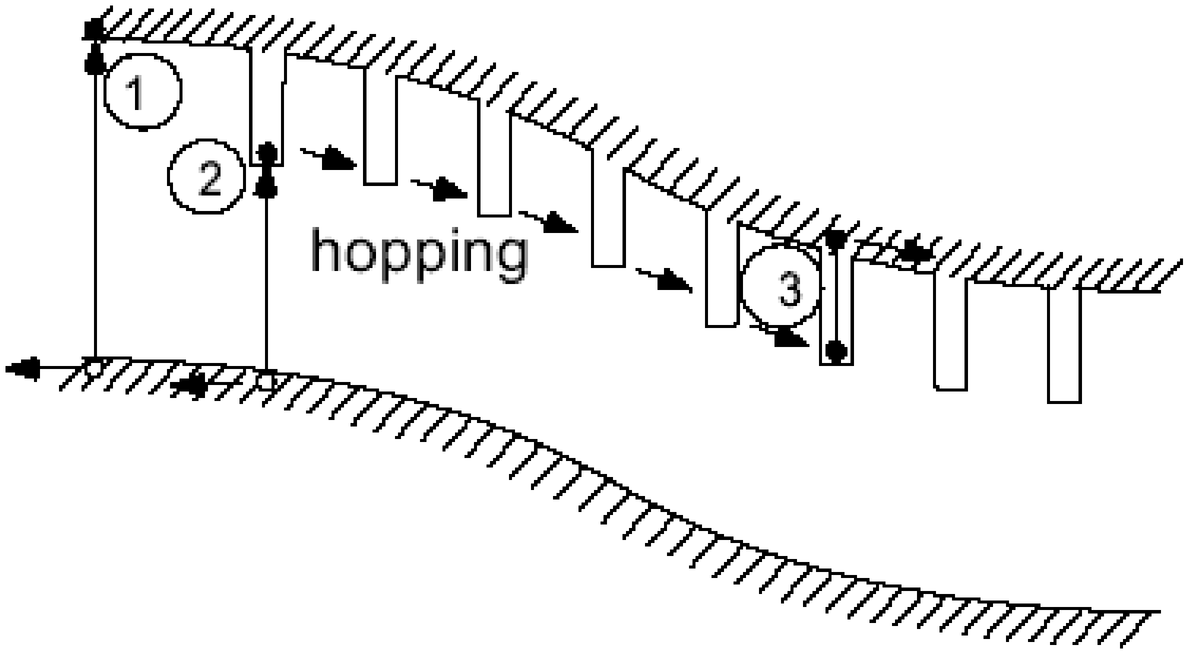
- Many E-H pairs created by incident photon through impact ionization of hot carriers
- Theoretical efficiency is 85.9%

Multiband Cells



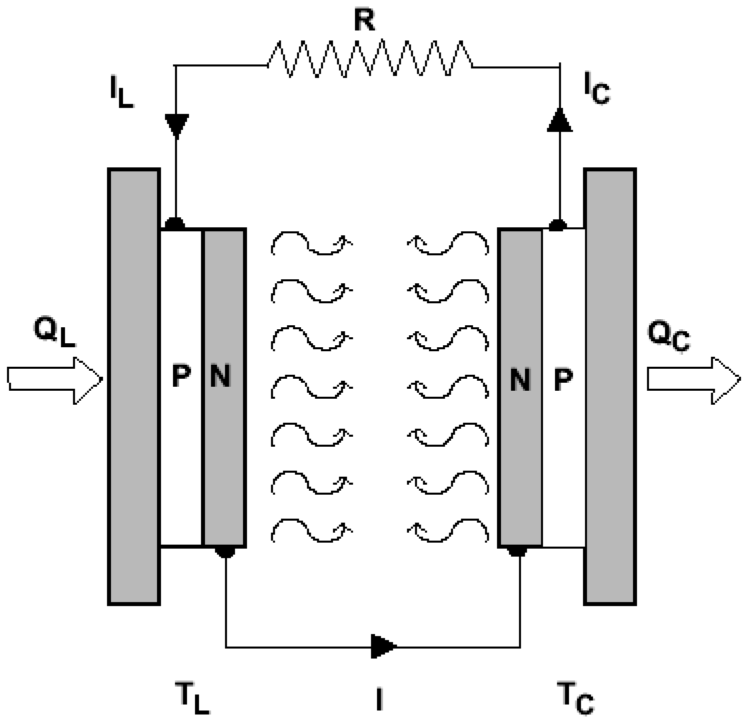
- Intermediate band formed by impurity levels.
- Process 3 also assisted by phonons
- Limiting efficiency is 86.8%

Multiple Quantum Well



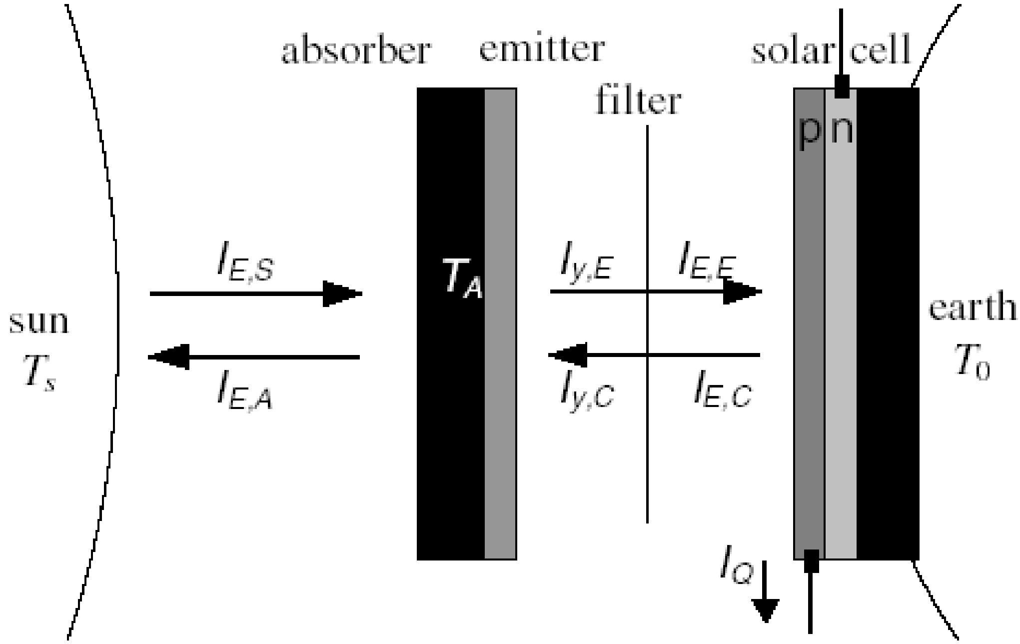
- Principle of operation similar to multiband cells

Thermophotonic Cells



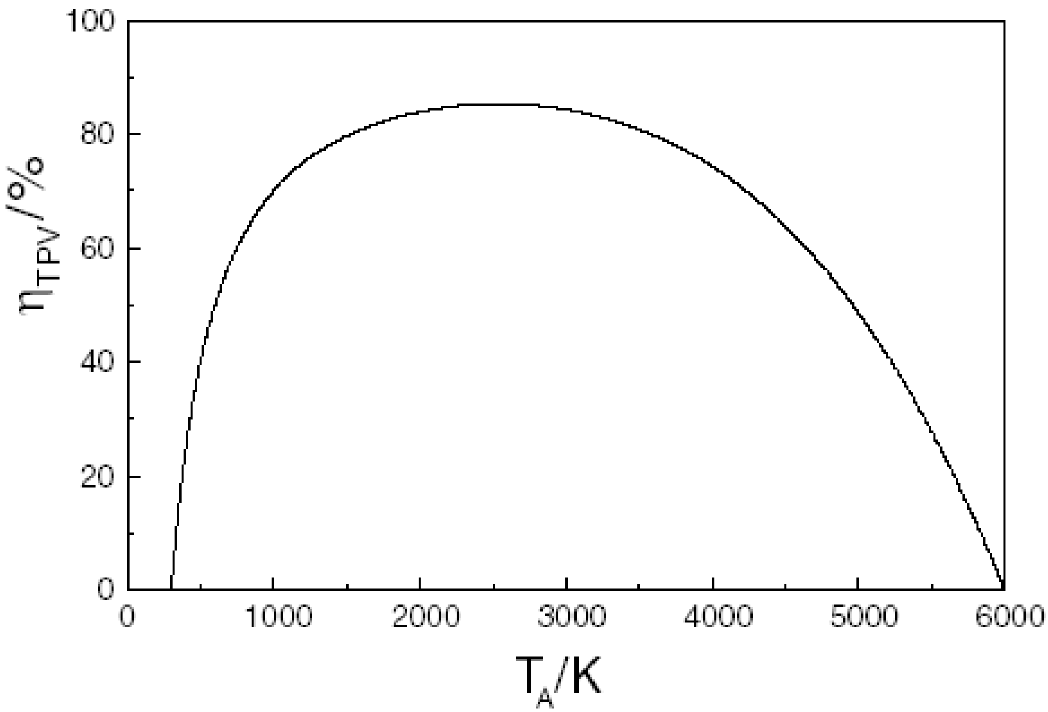
- Heated semiconductor emits narrow bandwidth radiations
- Diode with higher temperature has lower voltage

Thermophotovoltaic Cell



- Filter passes radiations of energy equal to bandgap of solar cell material
- Emitter radiation matched with spectral sensitivity of cell
- High Illumination Intensity (~ 10 kW/m^2)

Thermophotovoltaic Cells



$$\eta_{\mathrm{TPV}} = \left(1 - \frac{\pi}{\Omega_S}\frac{T_A^4}{T_S^4}\right)\left(1 - \frac{T_0}{T_A}\right)$$

- Efficiency almost twice of ordinary photocell