Silicon Solar Cells

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http://keetsa.com/blog/wp-content/uploads/2007/08/solar-panel-1.jpg

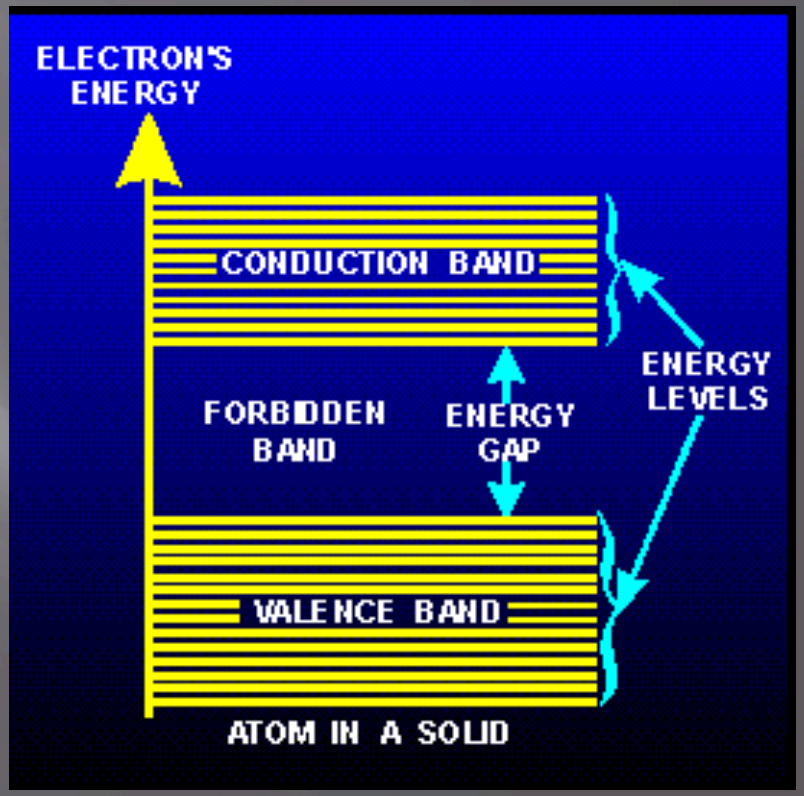
Brief History of Photovoltaics

- 1839 – Becquerel discovers he can generate an electric current with light
- 1905 – Einstein postulates $K_{max} = h\nu - W_0$
- 1954 – photovoltaic cell developed at Bell labs, 4% efficient
- 1964 – Satellite with photovoltaic array launched, space development major factor in growth of technology

http://www1.eere.energy.gov/solar/pdfs/solar_timeline.pdf

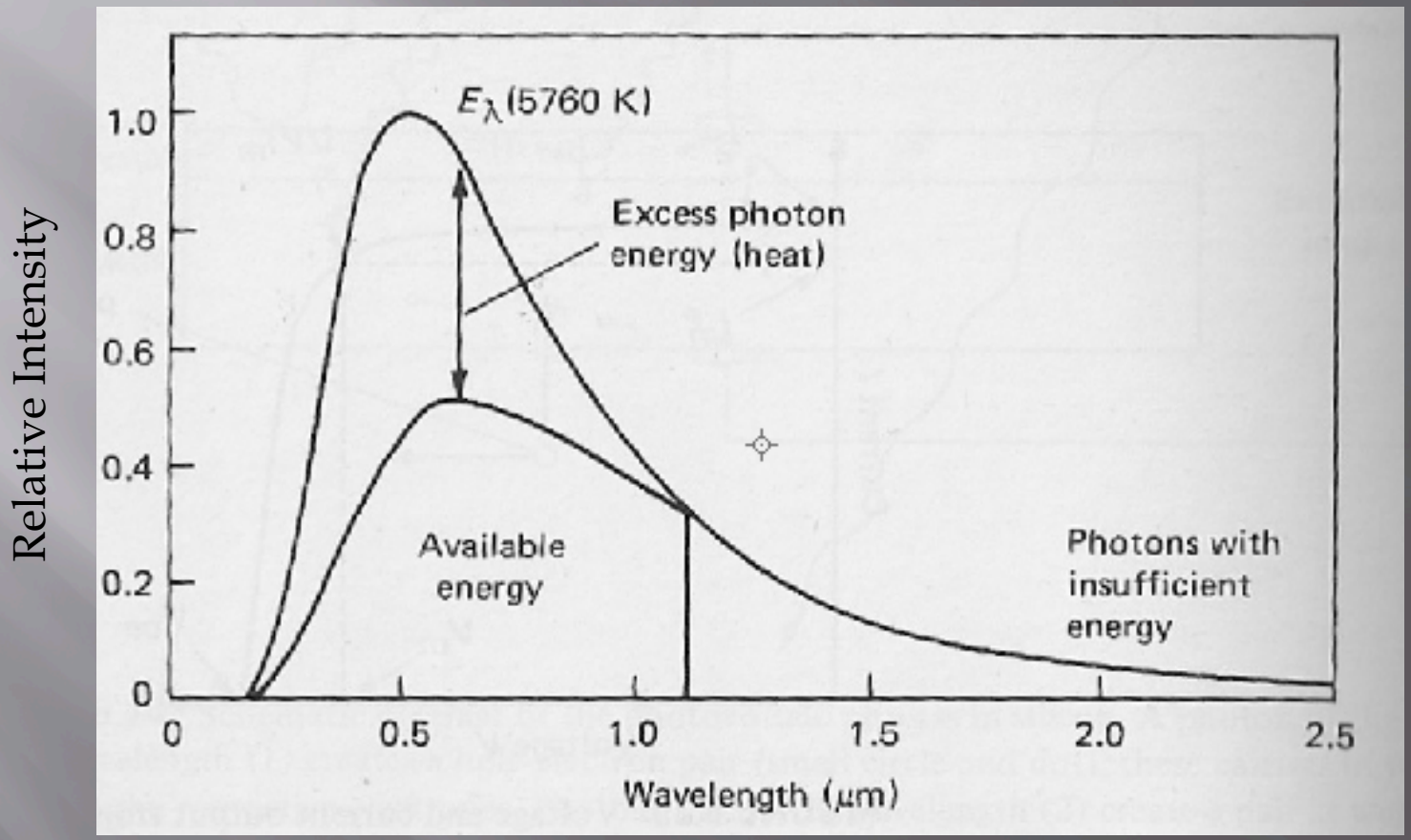
Light Incident on a Solar Cell

- Photons reflected
- If E ≥ energy gap, an electron-hole pair is formed in solar cell
  - Extra energy lost as heat
  - Energy gap is 1.1 eV for crystalline silicon
- If E < energy gap, the photons pass right through solar cell



http://www1.eere.energy.gov/solar/photoelectric_effect.html

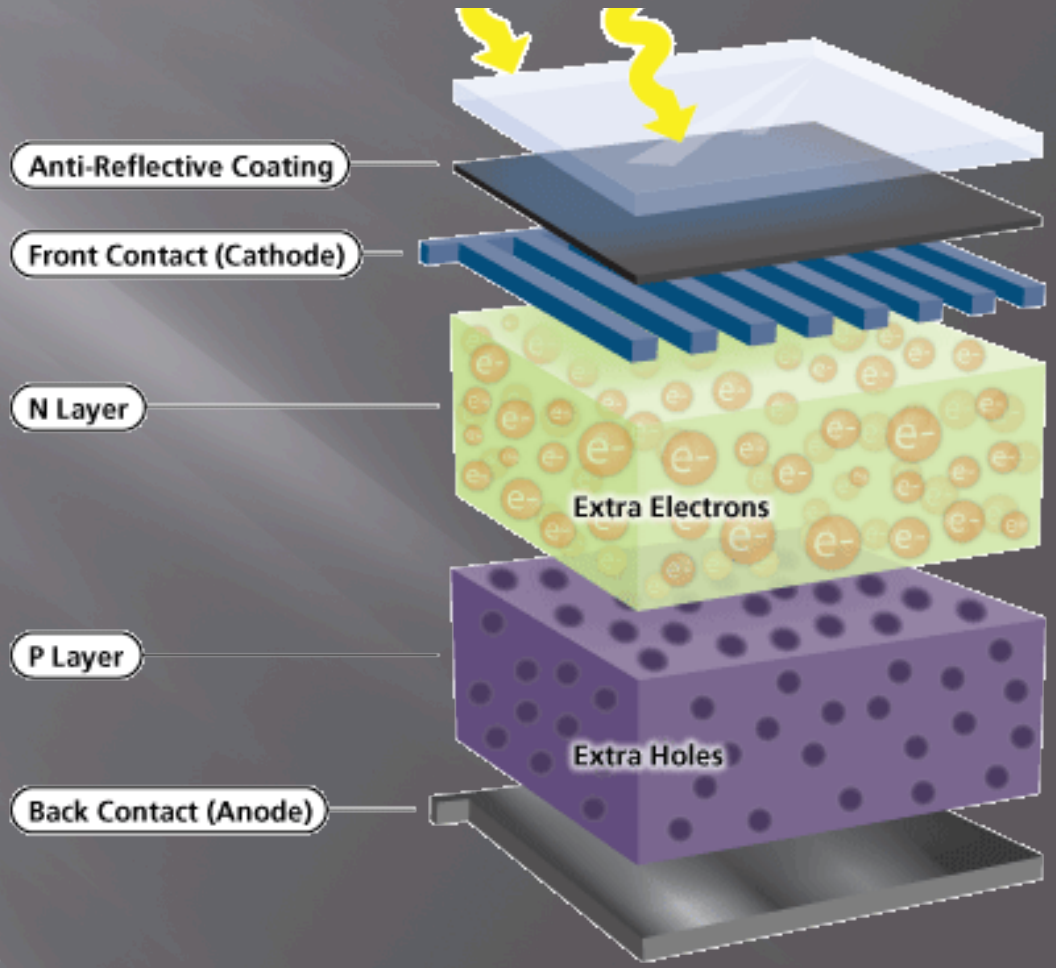
Energy utilization for silicon photocell



Kreith, Frank, and Jan F. Kreider. *Principles of Solar Engineering. Washington: Hemisphere Publishing Corp, 1978.*

Components of Solar Cell

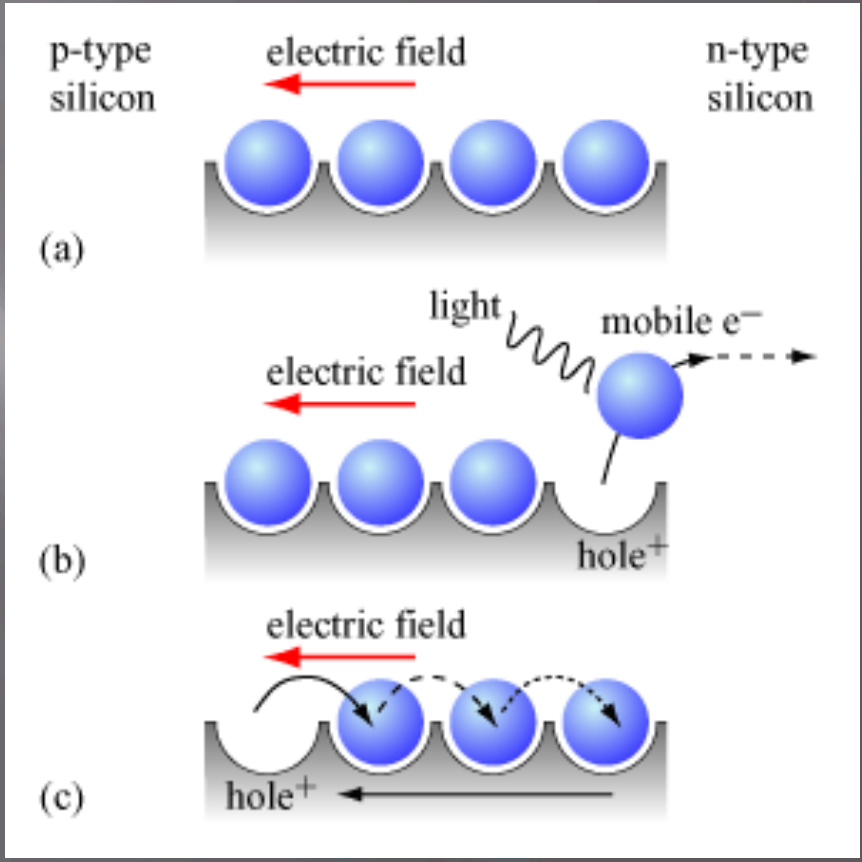
- Short wavelengths absorbed in N layer
- Long wavelengths absorbed in P layer



http://www.advanced-energy.com/en/PV_Sun_Times.html

Electron-hole Flow

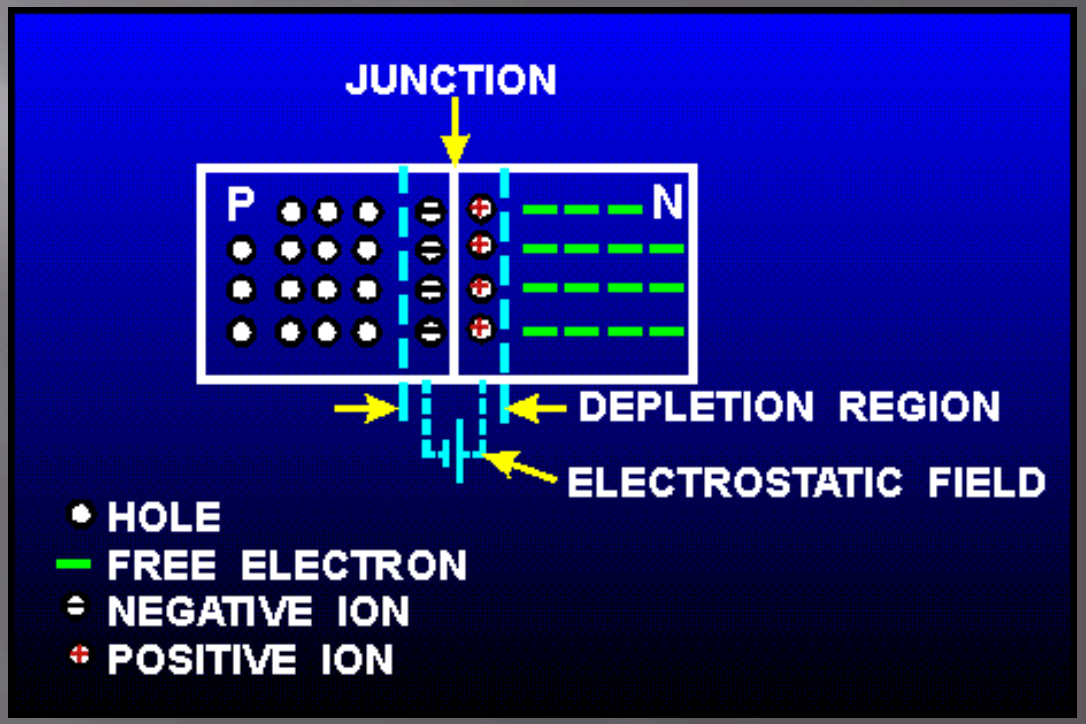
- PN junction creates a permanent electric field
- Electrons flow toward N layer
- Electron hole moves toward P layer



http://www.hk-phy.org/energy/alternate/solar_phy/images/hole_theory.gif

P-N Junction

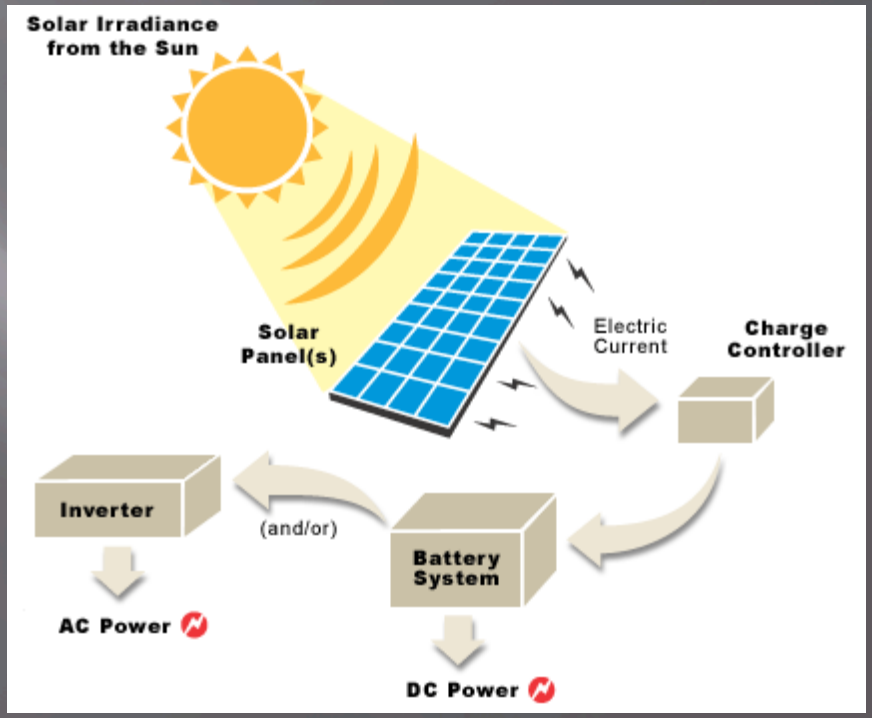
- P layer has an excess of electron holes by replacing silicon with boron
- N layer has an excess of free electrons by replacing silicon with phosphorus



http://www.tpub.com/neets/book7/24h.htm

Residential Solar Panel

- Output of solar panel is direct current
- Direct current can used directly, stored in a battery or converted to AC power through an inverter
- If connected to the grid, power can be bought by power company



http://www.carbethhuts.com/img/solar%20panel%20system%20diagram%201.gif

Limits to Silicon Cell Technology

- One photon yields one free electron
- Absorbed photon energy converted to heat
- Junction loss
- Long wavelengths not absorbed
- Max power
- Recombination
- Series resistance
- Reflection loss
- 15-20% of incident light usable power

Kreith, Frank, and Jan F. Kreider. *Principles of Solar Engineering. Washington: Hemisphere Publishing Corp, 1978.*

Multi-junction Cells

- Takes advantage different band gaps for different materials
  - Higher band gap material is on surface, absorbing high-energy photons, while allowing lower-energy photons to pass through
  - Lower band gap material is absorbed by material beneath

Sources

- Kreith, Frank, and Jan F. Kreider. *Principles of Solar Engineering. Washington: Hemisphere Publishing Corp, 1978.*
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