Solar Cell Fundamentals

Topics

- History
- Solar Cell Basics
  - Diode
  - Major parts of a Si Solar Cell
  - How does it work
    - Absorption
    - Losses
  - Electrical Characteristics
    - VOC, ISC, RS, RSH, Max Power Point
  - Advantages/Disadvantages

History

- 1839 Becquerel
  - Observed that there was a light dependant voltage between two electrode immersed in an electrolyte.
- 1876 The same effect was demonstrated in selenium
- 1941 First silicon based solar cell demonstrated
- 1954 Beginning of modern solar cell research.

History of Cell Efficiencv

- M.A. Green, “Very High Efficiency Solar Cells-Science and Technology”, *IEEE Transactions on Electron Devices*, Vol. 46, No. 10, pp. 1940-1947, (1999).

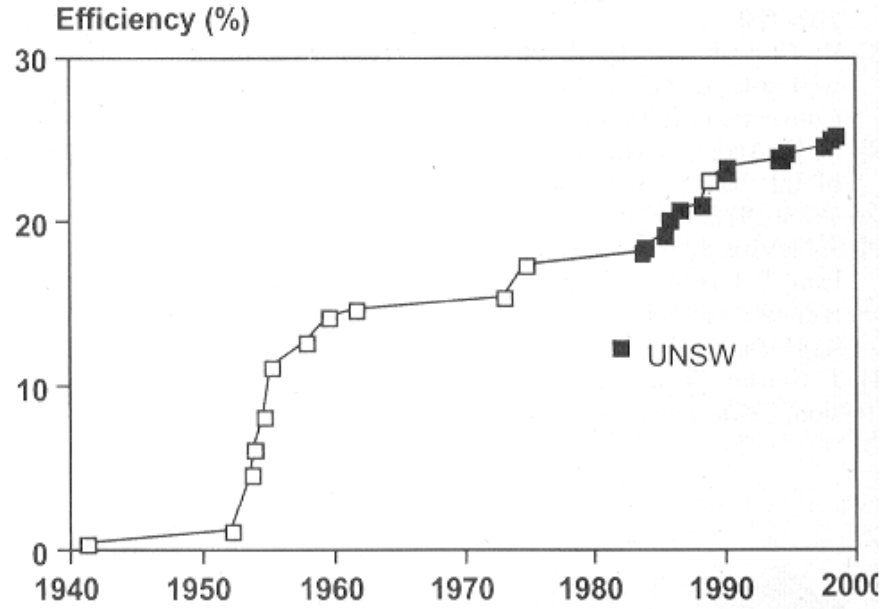
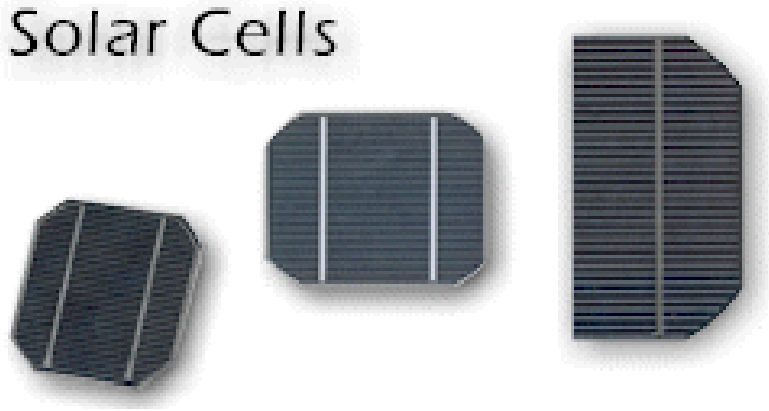


Fig. 1. Evolution of laboratory silicon solar cell efficiency.

- Notice: This trend is not like “Moore’s Law”.
- Price per installed Watt is probably a better figure of merit to track.
- Deregulation (Blame anyone you like.) made power generated by solar or wind economically viable!

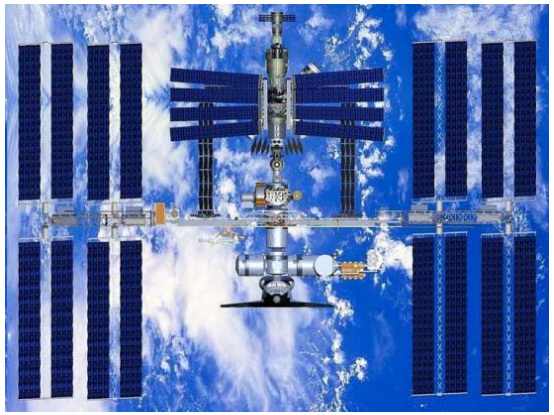
What is a Solar Cell?



- A structure that converts solar energy directly to DC electric energy.
  - It supplies a voltage and a current to a resistive load (light, battery, motor).
  - Power = Current x Voltage=Current^2 x R= Voltage^2/R
- It is like a battery because it supplies DC power.
- It is not like a battery because the voltage supplied by the cell changes with changes in the resistance of the load.

Uses for Solar Energy

- It is fun to watch PG&E's meter run backward.
- Renewable power
- Power for remote locations



Basic Physics of Solar Cells

- Silicon (Si) is from group 4 of the period table. When many Si atoms are in close proximity, the energy states form bands of forbidden energy states.
- One of these bands is called the band gap(Eg) and the absorption of light in Si is a strong function of Eg.

Basic Physics of Solar Cells

- Si is covalently bonded: It shares electrons.
  - When a Si atom is replaced with a group 3 (Al, B) it forms a positive particle called a hole that can move around the crystal through diffusion or drift (electric field).
  - When a Si atom is replaced with a group 5 (As, P) it forms an electron that can move around the crystal.
  - By selectively doping the Si Crystal when can change the resistivity and which type of carrier transfers charge (carries current). Because we can selectively dope a Si crystal it is called a semiconductor.

Basic Physics of Solar Cells

- A solar cell is a very large diode.
  - When Si that is doped p-type is next to a region of Si doped n-type, the holes from the p-type side diffuse to the n-type side. The electrons diffuse to the p-type side.
  - This creates an electric field.
  - This electric field makes it easy for current to flow in one direction, but hard to flow in the other.
  - This electric field also separates electrons and holes that have been created by the absorption of sun light. When the electrons and holes are separated electric power can be extracted from the circuit.