Nanoparticle Solar Cells

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ECG 653 Term Presentation
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Outline

- Introduction
- Principle Behind
- Generations of solar cells
- Why Nanoparticles?
- How DSSC works
- Comparison between DSSC and Traditional silicon-based solar cell
- Comparison of Efficiencies
- Conclusion

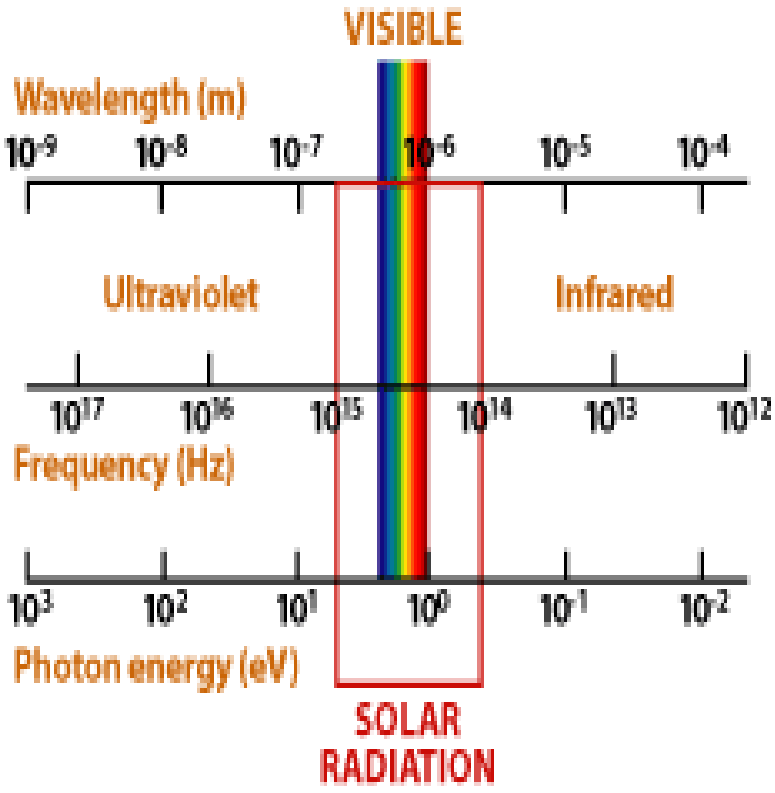
Introduction

- **Why Solar?**
  - More solar energy is absorbed by the earth every minute than is used in fossil fuels every year.
  - Pollution free and wastes/emissions are easily manageable.
  - Effective in providing electricity to remote locations where other forms of energy are difficult or expensive to get.

- **What is solar cell?**
  - Solar cells convert sunlight directly into electricity.
  - Made of semiconducting materials [usually silicon].
  - First used in spacecraft and satellites.
  - Traditional types are based on two types of silicon sandwiched together (n-type and p-type).
  - Based on using photons to separate charges: electron-hole pairs.
  - Many new types are in research/production stage.

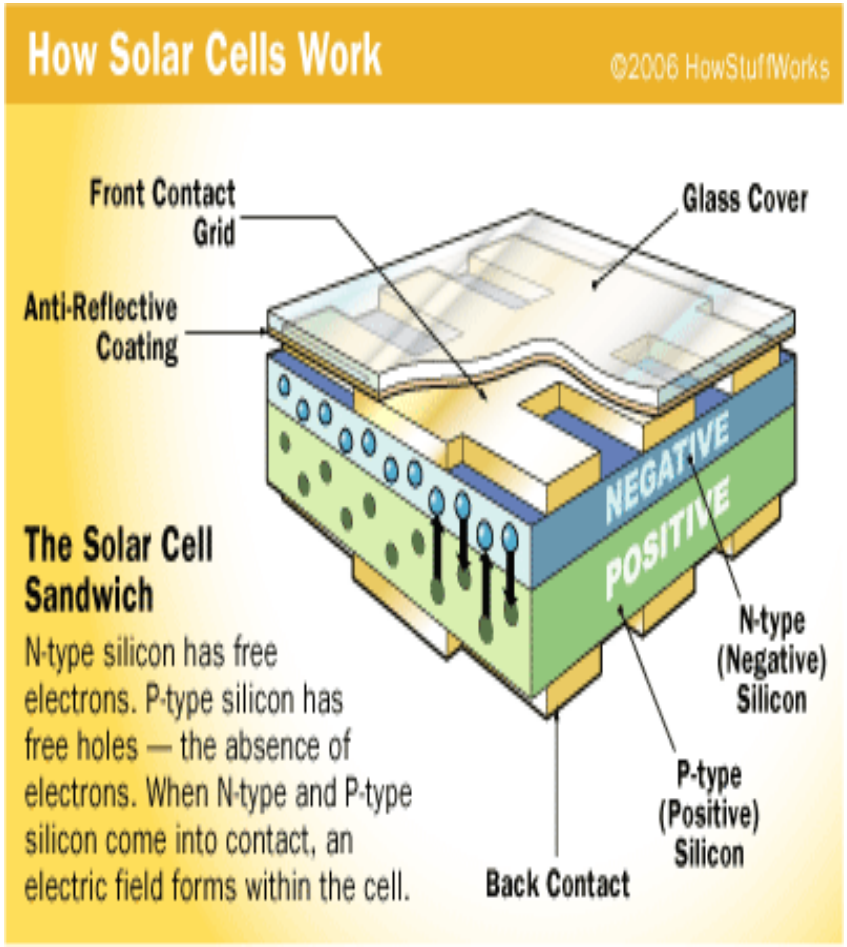
Introduction

- Solar cells respond differently to the different wavelengths, or colors of light.
- Each wavelength corresponds to a frequency and an energy: the shorter the wavelength, the higher the frequency and the greater the energy.
- Red light is at the low-energy end of the visible spectrum and violet light is at the high-energy end.
- Light that is too high or low in energy is not usable by a cell to produce electricity. Rather, it is transformed into heat.
- So solar cell mostly observe visible light to produce electricity.



Principle Behind

- When Photons with energy equivalent to band gap falls on semiconducting material, the electrons are released from their atoms, allowing the electrons to flow through the material to produce electricity.
- This process of converting light (photons) to electricity (voltage) is called the photovoltaic effect.



Generations of Solar Cells

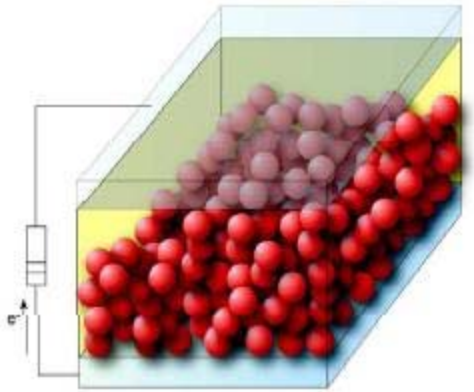
- First Generation
  - Consist of large-area, high quality and single junction devices.
  - Involve high energy and labour inputs making these very costly.
  - Example: Crystalline Silicon solar cells
  - Efficiency- 33%
- Second Generation
  - Consist of Thin film cells.
  - Techniques such as vapor deposition and electroplating are advantageous.
  - Developed to reduce production costs.
  - Examples: CdTe, Thin film silicon, CIGS
  - Efficiency reduces- 13%

Generations of Solar Cells

- Third Generation
  - Aim to enhance poor electrical performance of second generation while maintaining very low production costs.
  - Techniques involved are: *Dye-sensitized solar cells (DSSC).*
  - Efficiency- 40.8%

Why Nanoparticles?

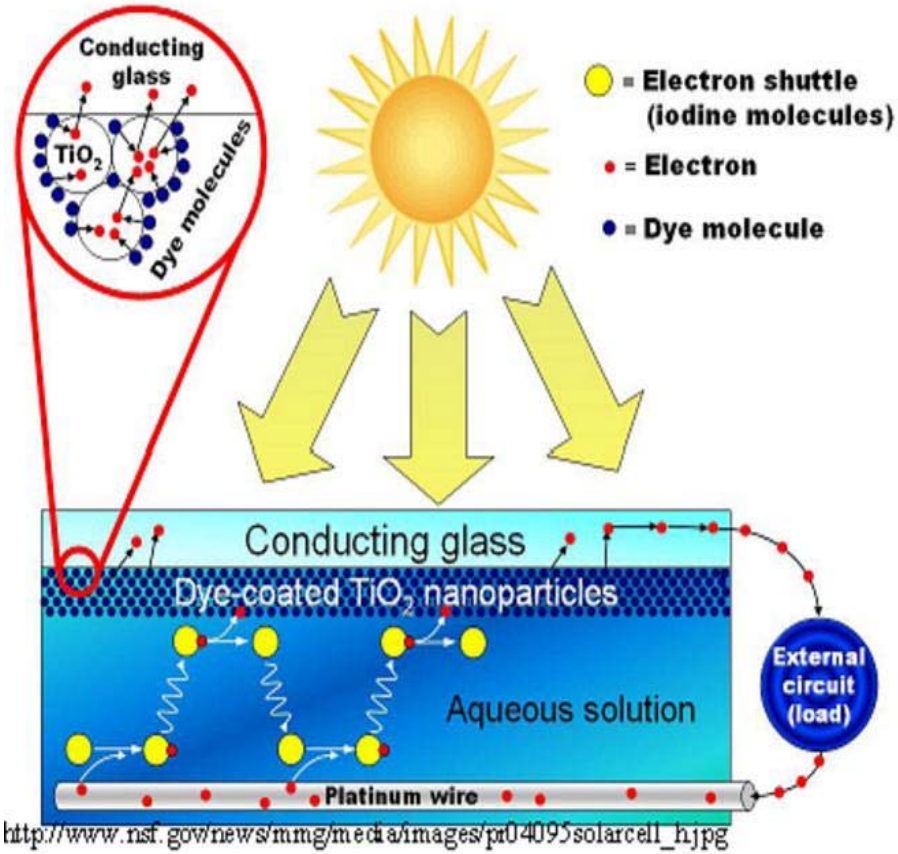
- High surface area
- Change in the size of nanoparticles makes solar cells to observe most of visible light, resulting high output voltage.
- For High Efficiency
- For smaller size and light weight solar cells.



Nanoparticle DSC

How DSSC works

- A photon is absorbed by the dye and excites an electron in the dye.
- The electron is then “injected” into the wires or particles.
- Travels to the electrode, which is connected to an external circuit.
- The dye is regenerated by the electrolyte



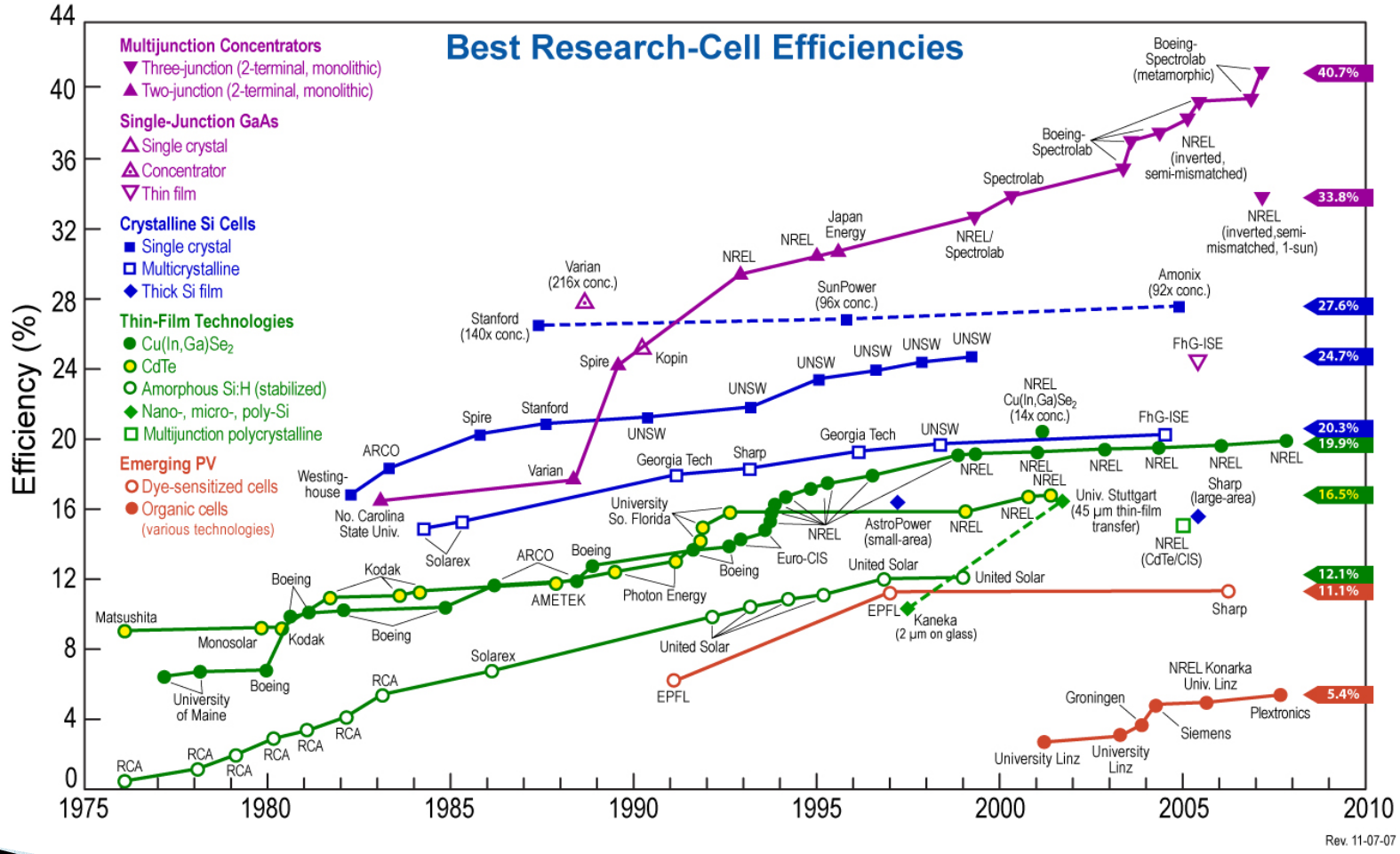
Comparison between DSSC and traditional silicon-based solar cell

- Advantages
  - Low cost materials
  - No elaborate apparatus
  - Works in low light conditions
  - High price/performance ratio
- Disadvantages
  - Slightly lower efficiencies
  - Breakdown of the dye
  - Bandgap slightly larger than silicon
  - Liquid electrolyte can leak

Silicon Nanoparticle SC

- Can be considered also as 3rd generation solar cell.
- Most efficient till date – 60%
- Developed using Thin film deposition of Silicon Nanoparticle on the polycrystalline silicon substrate of a photovoltaic (solar) cell.

Comparison of Efficiencies



Conclusion

- Nanoparticle solar cells are most promising material in future.
- Due to their low cost and high efficiency these can be used in applications varying from Satellites to Cell phones.