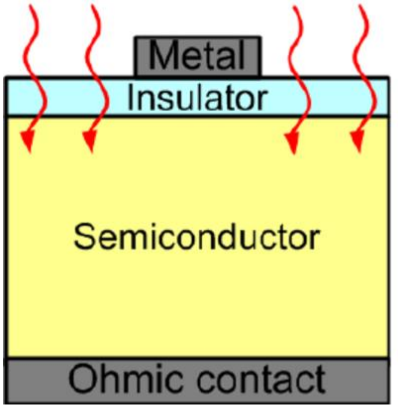
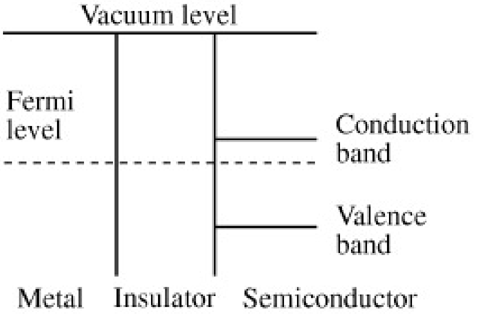
Chapter 5 Other Cells and Materials

MIS solar cells

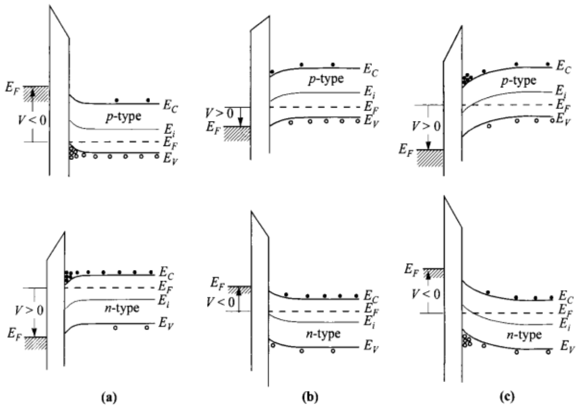




- Metal-Insulator-Semiconductor (MIS)

Dr. A.T.M. Saiful Islam
Assistant Professor
BSMRSTU

MIS solar cells



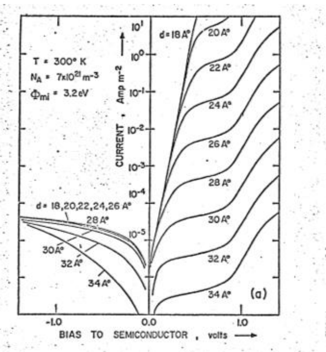


Fig. 2.4: Computed I-V characteristics of the MIS tunnel diodes when non-equilibrium effects in the semiconductor is included. The substrate is 2 Ωcm p-type silicon of <100> orientation. The variable parameter is d, the thickness of the insulating layer (surface states assumed negligible). Shown is the case where ϕ_{mi} = 3.2 eV demonstrating minority carrier MIS diode behaviour.

❖ Metal-Insulator-Semiconductor (MIS)

MIS solar cells

❑ Metal-Insulator-Semiconductor (MIS)

✓ The MIS diode is much simpler to fabricate as no diffusion process is required.

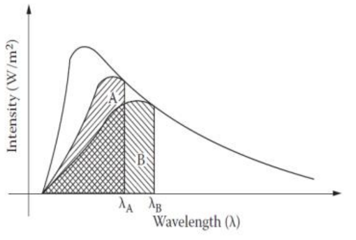
✓ Since high temperature steps can be avoided, the carrier lifetimes are not significantly degraded during fabrication.

✓ The collecting junction is located nearer the surface of the semiconductor for the MIS diode which results in improved collection of electron-hole pairs generated in the surface region. This is especially important for radiation such as short wavelength light which does not penetrate deeply into the semiconductor.

✓ Shallow diffused p-n junction diodes commonly have an excess component of current at small forward bias which degrades the diode performance at low power level.

Multijunction Solar Cells

- The limits imposed on solar cells owing to band gap can be partially overcome by using multiple layers of solar cells stacked on top of each other
- Each layer with a band gap higher than the layer below it.
- The total output and therefore the efficiency of this tandem cell would be higher than the output and the efficiency of each single cell individually.
- The efficiency would increase with the number of layers.

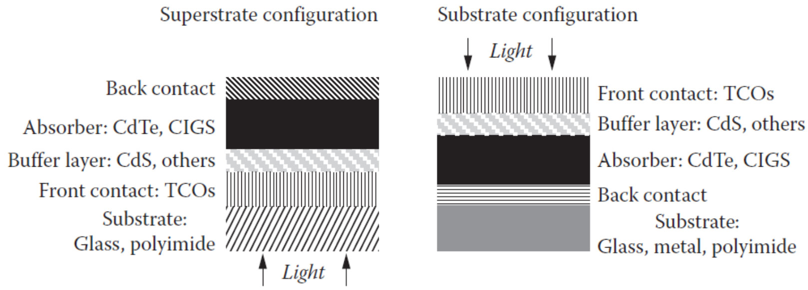


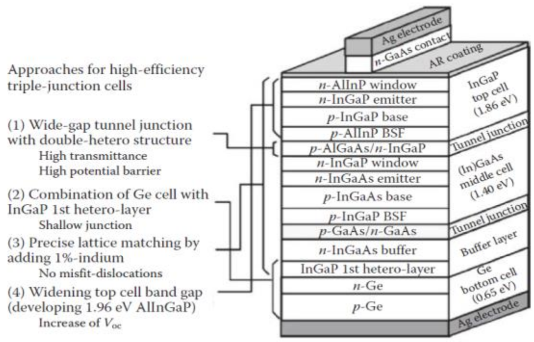
- Each layer must be as thin as possible.
- At present, a triple-junction a-Si solar cell is under development.
- This cell consists of layers of cells made from a-Si,C:H (an amorphous silicon, carbon, and hydrogen alloy) with a band gap of 2.0 eV, a-Si:H (an amorphous silicon and hydrogen alloy) with a band gap of 1.75 eV, and a-Si,Ge:H (an amorphous silicon, germanium, and hydrogen alloy) with a band gap of 2.3 eV.

Thin-Film Solar Cells

- Thin-film solar cells based on cadmium telluride (CdTe), copper indium gallium diselenide (CIGS), and gallium arsenide (GaAs) have been the most developed and have become commercially available in the last 10–15 years.
- Mainly because of their potential highest efficiencies on the basis of their band gaps.
- Among these, CdTe panels achieved the most commercial success because of their low cost of production.
- However, since 2010, silicon cells achieved the same cost reductions because of improved manufacturing technologies and high efficiencies.
- Multijunction GaAs cells have achieved efficiencies of 44% under concentrated sunlight.

Thin-Film Solar Cells

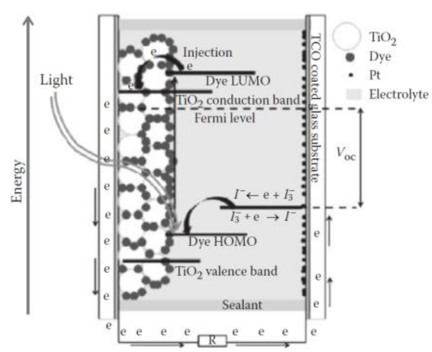




Dye-Sensitized Solar Cells

- ❑ A dye-sensitized solar cell (DSSC, DSC, DYSC) is a low-cost solar cell belonging to the group of thin film solar cells.
- ❑ It is based on a semiconductor formed between a photo-sensitized anode and an electrolyte, a photoelectrochemical system.

- ➢ A photoanode consisting of a porous thick film (~10 μm) of a wideband semiconductor, such as TiO2 (10–30 nm diameter) coated with a dye, which absorbs in the visible wavelength range.
- ➢ The film is deposited on a transparent conducting oxide (TCO) coated on a transparent glass substrate.
- ➢ The porosity of the TiO2 film is around 50%.
- ➢ An electrolyte, usually an organic solvent containing iodide/triodide
- ➢ redox system.
- ➢ A cathode consisting of a TCO coated on a glass substrate and containing a catalyst, such as platinum.
- ➢ A sealant to seal the cell assembly.



Dr. A.T.M. Saiful Islam
Assistant Professor
BSMRSTU

Dye-Sensitized Solar Cells

- The dye absorbs the visible light photons, with energy equal to or greater than the difference between its highest occupied molecular orbital (HOMO) and the lowest unoccupied molecular orbital (LUMO),
- The electrons from the ground state of the dye (S) get energized to an excited state (S*), which is known as the photoexcitation of the dye.
- The energized electrons from the photoexcited dye are injected into the conduction band of TiO2.
- The dye in turn gets electrons from the electrolyte, thereby becoming electrically neutral.
- The excess electrons in the TiO2 conduction band pass through the TCO to the external circuit returning through the cathode to the electrolyte.
- In the electrolyte, the I− ions close to the dye transfer electrons to the dye, bringing it to the ground state and themselves being oxidized to I_3^-.

Dye-Sensitized Solar Cells

- The oxidized I_3^- ions diffuse a short distance (>50 μm) to the cathode and get reduced to I− with the injection of the electrons.
- The concentration of iodine (I_2) in the electrolyte is typically less than 1 μM.
- The transfer of electrons from the dye to the conduction band of TiO_2 is an extremely fast process (picoseconds);
- However, the speed of diffusion of electrons from TiO2 to the anode depends on the crystallinity of TiO_2.
- Higher crystallinity results in faster diffusion and therefore higher current density.

❖ <u>Advantages</u>:

- ✓ It is simple to make using conventional roll-printing techniques
- ✓ It is semi-flexible and semi-transparent which offers a variety of uses

Dr. A.T.M. Saiful Islam
Assistant Professor
BSMRSTU

Dye-Sensitized Solar Cells

✓ Most of the materials used are low-cost
✓ Can work in low light condition

❖ **Disadvantages:**

✓ The major disadvantage to the DSSC design is the use of the liquid electrolyte, which has temperature stability problems.
✓ At low temperatures the electrolyte can freeze, halting power production and potentially leading to physical damage.
✓ Higher temperatures cause the liquid to expand, making sealing the panels a serious problem.
✓ Another disadvantage is that costly ruthenium (dye), platinum (catalyst).
✓ A third major drawback is that the electrolyte solution contains volatile organic compounds (or VOC's), solvents which must be carefully sealed as they are hazardous to human health and the environment.

Low boiling point, play an important role in communication between animals and plants

Organic Solar Cells

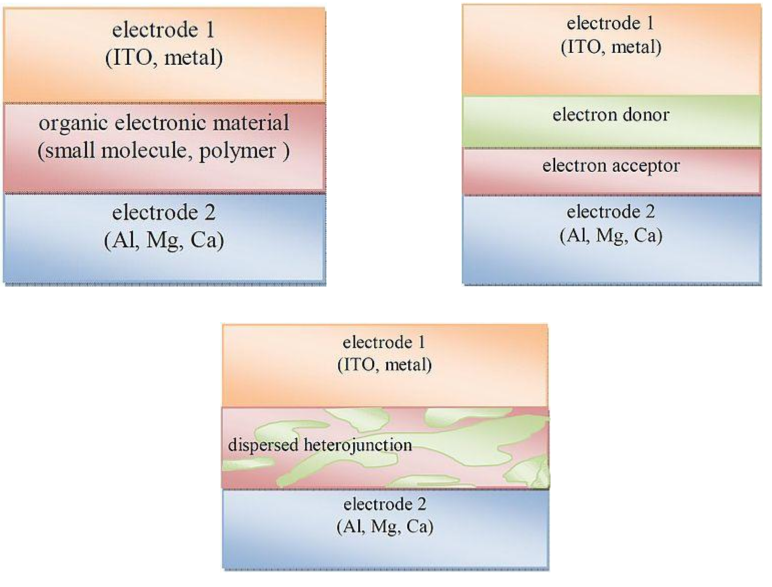
❑ An organic solar cell is a type of photovoltaic that uses organic electronics,
❑ Is a branch of electronics that deals with conductive organic polymers or small organic molecules
❑ The molecules used in organic solar cells are solution-processable at high throughput and are cheap, resulting in low production costs to fabricate a large volume.
❑ Combined with the flexibility of organic molecules, organic solar cells are potentially cost-effective for photovoltaic applications.
❑ The optical absorption coefficient of organic molecules is high, so a large amount of light can be absorbed with a small amount of materials
❑ The main disadvantages associated with organic photovoltaic cells are low efficiency, low stability and low strength compared to inorganic photovoltaic cells
❑ Are lightweight, potentially disposable and inexpensive to fabricate

Dr. A.T.M. Saiful Islam
Assistant Professor
BSMRSTU

Organic Solar Cells

- In organic semiconductor physics, the HOMO takes the role of the valence band while the LUMO serves as the conduction band.
- The energy separation between the HOMO and LUMO energy levels is considered the band gap of organic electronic materials
- When these materials absorb a photon, an excited state is created and confined to a molecule or a region of a polymer chain.
- The excited state can be regarded as an exciton, or an electron-hole pair bound together by electrostatic interactions.
- In photovoltaic cells, excitons are broken up into free electron-hole pairs by effective fields.
- The effective fields are set up by creating a heterojunction between two dissimilar materials.
- In organic photovoltaics, effective fields break up excitons by causing the electron to fall from the conduction band of the absorber to the conduction band of the acceptor molecule.

Organic Solar Cells



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