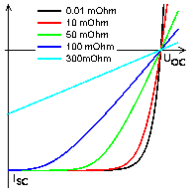
## 8.1.3 Summary to: 8.1 Solar Cells - General Concerns

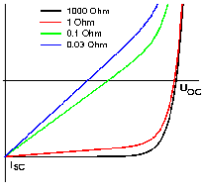
- A solar cell converts light power into electrical power. It's overriding parameter is the over-all conversion efficiency η
  - Any solar cell is essentially a large -area junction, usually of the **pn**-type.
  - It's essential parameter are the short-circuit current $I_{SC}$, the open-circuit voltage $U_{OC}$ and the fill factor **FF**
  - For optimal efficiency the bandgap $E_g$ should be matched to the solar spectrum; we need around **1.5 eV**.
  - Maximum efficiency from the *semiconductor physics* point of view is achieved if all light with energy **>=**$E_g$ produces minority carriers and all of these carrier are swept out as diode reverse current and
  - Maximum efficiency from the *module systems* point of view is achieved if the semiconductor part is **OK**, only very little light is reflected by the solar cell module, series resistances and shunt resistances can be neglected, and everything is uniform and homogeneous

The equivalent circuit diagram with the basic equation has is all!

- Series and shunt resistances, unavoidable for large areas, are of overwhelming importance for solar cells with η **<≈ 10 %**




**Effect of series resistance**

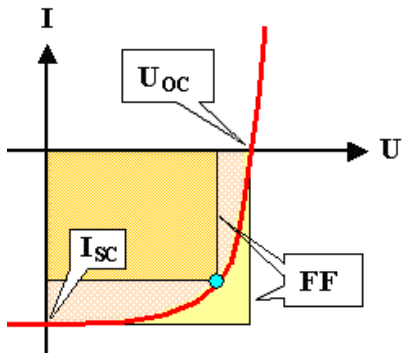


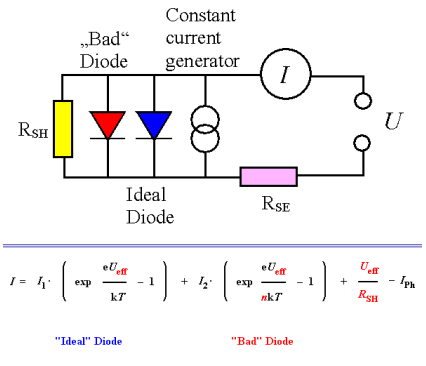

**Effect of shunt resistance**

**Important "raw" numbers.**

- **Maximum η Si solar cell ≈ 25 %**
- **Maximum sun power ≈ 1 kW / m².**
- **Maximum commercial solar cell power ≈ 200 W / m².**
- **Yearly average commercial solar cell power ≈25 W / m².**

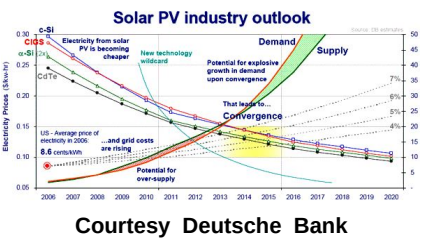
**Solar cell science and technology centers exclusively on *money*and *saving the earth*!**




$\eta = \text{const} \cdot U_{OC} \cdot I_{SC} \cdot FF$

- Switching solar cells with individual characteristics in series and / or in parallel causes all kinds of problems.
  - Worse: Any inhomogeneous solar cell (e.g. **mc-Si** solar cells) consists of *locally* different solar cells "somehow" connected internally
  - Optimizing solar cells with respect to "money" thus provides exciting science and engineering!




**Courtesy Deutsche Bank**

- There are many competing solar cell technologies and materials.
  - Bulk single-crystal and **mc Si** vs. thin film **Si (a-Si:H, µc-Si:H. ..**

- Other thin-film semiconductors:**CIGS, CdTe, ...**.
- Exotica: **$TiO_2$**- electrolyte ("Grätzel cell"), organic semiconductors, "Nano" materials, ...

Solar cells have a bright future!

| **Exercise 8.1-4** |
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| **All Quick Questions to 8.1** |