Exercise 8.4-1

All Quick Questions to

8. Solar Cells

General Concerns

- Give some rough numbers (with some reasoning whereever applicable), always per $\mathbf{m^2}$, for
  - Maximum solar power.
  - Maximum and practical efficiency of "standard" **Si** solar cells.
  - Average power for "standard" **Si** solar cell.
  - Average energy harvest of "standard" **Si** solar cells per year.
- Compare indirect and direct semiconductors with respect to light absorption at the "band edge", i.e. for light energies around bandgap energy. What follows for solar cells?
- What is your first priority with respect to the coupling of light and semiconductor when you want to make a solar cell with a good efficiency?
- Draw the current density (***j***) - voltage (***U***) characteristics of a **pn**-junction in the dark and under illumination in the interesting part of the ***j-U*** plot. Point out the important points of the illuminated diagram and give some approximate numbers for typical intense sun light.
- The typical ***j-U*** equation for a **Si pn**-junction is

$$j = j_1 \cdot \left(\exp \frac{eU}{kT} - 1 \right) + j_2 \left(\exp \frac{eU}{2kT} - 1 \right) - j_{Ph}$$

  Discuss the origin of the ***j*** terms. Compare (qualitatively) the magnitude of j_1 and j_2. What kind of properties of **Si** influence the value of j_{Ph}?
- Why is "dirty" **Si** not good for solar cells? *Hint*: Follow the fate of a photon-generated carrier.
- Draw the ***j-U*** curve of an illuminated decent solar cell. Draw (qualitatively) the power curve into this diagram. Discuss the curve shortly with respect to real power applications
- Your electrical energy bill shows that you, personally, consumed **2 000 kWh** electrical energy per year in your home. How man square meters of solar cells (roughly) would you need on your roof to supply this much energy?
- Give the eqivalent circuit diagram of a realistic **Si** solar cell. Discuss the components with the aid of schematic **IV**-characteristics.
- Define the fill factor of a solar cell and discuss its dependence on solar cell parameters.

Making Bulk Si Solar Cells

- Discuss the basic requirements for mass production of solar cells including technical constraints resulting from economical boundary conditions
- Describe the essential production steps of a **mc-Si** solar cell. Start with suitable poly-**Si** and discuss essential problems encountered with the solutions. Use schematic drawings.
- Describe "anti reflection" technologies.
- Compare screen-printing for the deposition of the metallic grid on a **Si** solar cell to other layer deposition methods. *Hint:* Consider that a good solar cell may deliver **5 A** at **0.5 V** and consider how that converts into thickness requirements of the metal grid layer. The *specific* resistivity ρof a decent metal is about **2 μΩcm**, the resistance ***R*** for a cross sectional area of ***A*** $\mathbf{cm^2}$ and a length ***l*** is $R = \rho \cdot l / A$.

Making Thin Film Solar Cells

- List basic requirements that semiconductors must meet if they are to be used for *thin film* solar cells.
- Give some examples of existing thin film solar cell technologies and list their strengths and weaknesses.
- What is the logic behind "concentrator cells"? Discuss the basic principle and necessities concerning application.
- Give a schematic cross section through a **CIGS** solar cell, indicating the major layers and the in-situ series connection.