ANFORDERUNGSPROFIL UND REALISIERUNGSKONZEPTE DER ORGANISCHEN PHOTOVOLTAIK

REQUIREMENTS AND REALISATIONCONCEPTS FOR ORGANIC PHOTOVOLTAICS

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PART 1: Economical Aspects

The flexible photovoltaic (PV), based on thin plastic films, would open up a wealth of uses. From the self-powered electronic newspaper to buildings that would be energy self sufficient, the medium would find many applications as yet out of bounds. One obstacle hindering this to date has been the poor efficiencies of plastic thin film PVs. Recently however, efficiencies have been improved by mixing electron-donor-type polymers with suitable electron acceptors. This has led to prototype plastic PV devices with solar power conversion efficiencies of around 4%, which in turn has triggered renewed interest from several groups around the world.

The PV has a semi-conducting material between two electrodes. When excited by light the anions and cations move in opposite directions, ending up in the metal electrodes, so producing a charge. Crystalline silicon (c-Si) is the leading commercial material for photovoltaic cells, and is used in several forms – single-crystalline or monocrystalline silicon, multicrystalline or polycrystalline silicon, ribbon and sheet silicon and thin-layer silicon.

Ways to reduce costs yet further has seen the development of a variety of advanced approaches. Dye-sensitised solar cells use a dye-impregnated layer of titanium dioxide to generate a voltage, and because titanium dioxide is relatively inexpensive, they offer the potential to significantly cut costs. Another approach is to use polymer (or plastic) as the semiconductor, which when coupled with thin film technology would give a truly flexible solar cell that could be manufactured relatively cheaply.

The presentation addresses in the first part all details with respect to the cost assessment for organic solar cells and deduces the requirements for realization of OPV concepts, evaluating material costs, substrate costs, packaging and production costs. The following key question will be addressed: "What is the price limit (€/W_p) OPV can reach in which time"?

PART 2: Scientific Aspects

Polymer PV initially came about when the first polymer light-emitting diode (PLED) were reported in 1990. Immediately uses in lighting, displays and lasers were mooted and very soon after, solar cells. Unfortunately the capability of polymers to generate charge from light is poor, so a dual molecule approach was suggested. Here, photocarrier generation is enhanced by using a second, charge sensitising component – for example, for a device consisting of a composite thin film with a conjugated polymer/fullerene mixture, the efficiency of photogeneration of charges is near 100%, although much of the sun light is not absorbed by the rather wide bandgap polymers (Eg ~ 2eV), giving at best an overall AM1.5 efficiency of about 5 %. These single composite photoactive films comprise a 'bulk heterojunction' formed between the electron donors and acceptors.

Bulk heterojunction overcome the limitation of charge generation at a two-dimensional interface by distributing the acceptor more or less homogeneously into the donor matrix so generating a three-dimensional network of light-induced charge generating interfaces. This is done by using highly soluble fullerenes such as PCBM. Recently, two different approaches have been identified to further improve the performance of organic solar cells: (a) a top down and (b) a bottom up approach.

The bottom up approach focuses on the investigation of the nano.morphology between the single phases in the blend. Their assumption is, that once the morphology is understood and can be controlled, proper materials can be synthesized for improved performance. This approach is closer to the chemical community.

The top down approach describes and handles organic solar cells like classical inorganic solar cells. Simulation models based on experimental data from devices are developed. Thereof, requirements on the single materials as well as on the material blends are deduced as if they would be classical unipolar or ambipolar semiconductors, i. e., using classical semiconductor definitions like impurity density, quasi Fermi levels, charge carrier mobility and lifetime.

The second part of the presentation discusses a simulation concept for organic solar cells. Based on this concept, a simulation model is suggested and it is shown that organic bulk heterojunction devices can be reduced to single layer p-i-n type solar cells.

PART 3: Outlook and Future

At the moment, polymer PVs are still in the laboratory stage, and as such are built on a one-off basis by spin casting from solution, yielding a typical film thickness around 100 - 200 nm. In order to guarantee a very low cost level for these type of solar cells, the corporate technology of Siemens is developing production techniques allowing to completely print this type of solar cells from solution onto flexible substrates like transparencies. For commercial applications such an efficient method of production is essential to enable reel-to-reel manufacturing. Finally, the other major problem facing plastic thin film PVs, like all conjugated polymers, is stability. Encapsulation to protect against air, oxygen and humidity increases the lifetime considerably and recent work on LEDs suggests the stability problem has been overcome, which in turn bodes well for plastic solar cells.

So what does the future hold? In organic PV elements generally two different tasks are to be clearly distinguished: The photo-induced charge generation and the transport of created charges to the electrodes. These two different tasks are expected to be fulfilled by the same material simultaneously, so a possible strategy is to separate the two tasks by using separate components in one device for the charge transport and the charge generation. One thing is certain. Work on plastic solar panels has entered an exciting phase as many different groups around the world are working towards improved efficiencies. There is also an increasing need for clean, regenerative energy sources. The solar cell is about to come of age.

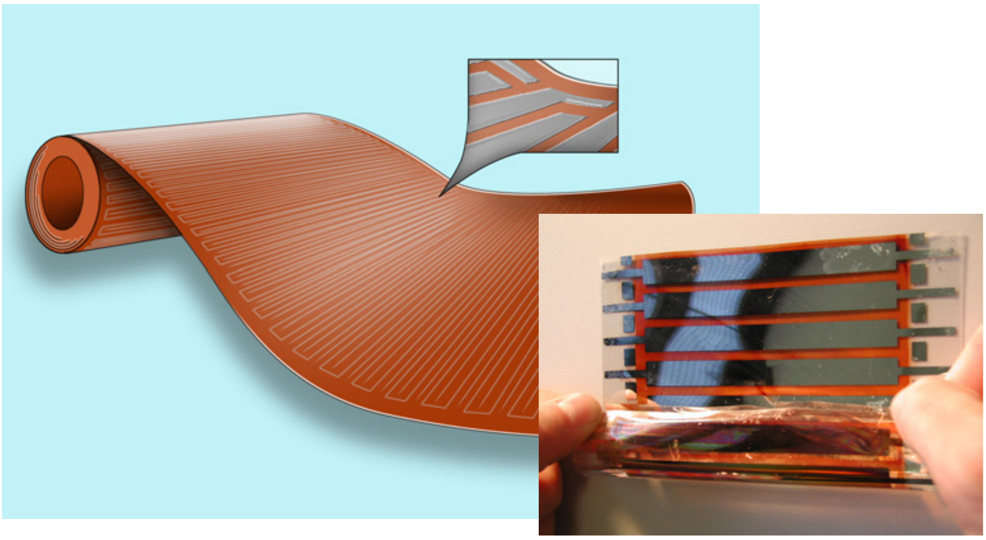

Figure 1: Schematic drawing how a polymer solar cell product might look like, in comparison to current prototypes.