ANALYSIS OF COMPOSITE POLYMER SOLAR CELL FUNCTION

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In last decade, plastic solar cells (SCs) on the base of conjugated polymers were prepared and investigated. Today many publications appeared are claiming the realization of the efficiency of conversion of solar energy to electricity more than 1 % . Even 3.5 % efficiency was reported. Unfortunately, different definitions of the efficiency (solar, monochromatic power, and incident photon to current efficiency) have been applied. Of course, results obtained under monochromatic illumination of very low intensity in the comparison with the Sun radiation, are very useful and interesting from scientific point of view, but they are not so much useful for estimations of the possibility of the use of such cells under the solar illumination. Only in Ref. [1] concerning organic SC made of polymer and fullerene layers, power conversion efficiency under Sun is in the range of 1%. In Ref. [2], authors reported about the efficiency 2.6% in AM1.5 conditions. Such a cell is realized on the conjugated polymer/fullerene blend.

Experimental data on composite polymer fullerene plastic solar cells have been analyzed in detail in order to arrive at a working model for analysis of its performance and prospects for improvements.

Among the most characteristic properties identified were the following:

- a photo voltage of U_{ph}=0,7 V, which is significantly higher than expected from the difference of the work function of the contact materials aluminum and ITO (0.4 V)
- photoinduced electron transfer reactions which involve electronic states at electrochemical potentials between -1 and -2 V against NHE, making this system

photochemically very reactive (hydrogen can easily be evolved from traces of water).

We were focused on solar cells, where a thin layer of p-type conjusting polymer with fullerene C_{60} or its derivative (below fullerene) sandwiched between two thin electrodes, one of which (the ITO electrode) is semitransparent one. The polymer layer is not so thin in order the tunneling of charge carriers will be dominant. We took into account the curvature of permitted bands near the ITO and Al electrodes.

We think that a carrier mobility which is determined by an imprinted electrical field and percolation mechanisms to be expressed by the formula [3] $\mu = \mu_o \exp\left[A + BE^{p/1+p}\right]$, where A, B are constants depend on temperature and energy state density distributions; E is electrical field; p is parameter determined by percolation theory.

The ITO contact with fullerene molecules gives rise to an electronic charge separation, which causes an interfacial potential drop and a significant increase of the ITO work function. XPS data from a variety of sources are found to be consistent with this interpretation of ITO interfaces. This phenomenon explains the surplus photovoltage observed beyond the nominal work function difference between contacts. The involvement of the second (higher) unoccupied molecular orbital of the fullerene in electron transfer is evidenced.

An analytical description of the cell function presented. Various aspects of plastic composite solar cells are discussed ranging from the potential for improvement of efficiency, the replacement of components, taking into account series and parallel resistances in equivalent circuit of solar cell, evaluation of minimal losses, the optimization of the fill factor to questions of long-term stability.

References

1. 1. J. Rostalski, D. Meissner Solar Energy Materials and Solar Cells 61 pp. 87-95 (2000).
2. C. J. Brabec et al. Quantsol 2000, Abstracts, Italy.
3. P. E. Parris et al. Phys. Stat. Sol. (b) 218 pp. 47-53 (2000).