Influence of thickness of hole transport layer on performance of perovskite solar cells

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Perovskite solar cells (PVSC) have attracted significant interest over the past several years due to simplicity of their processing, low cost, high flexibility and the fastest growing performance among solar cell technologies. Currently, perovskite based solar cells has reached efficiency exceeding 20% [1] which is comparable to the inorganic photovoltaics developed for decades, such as multi-crystalline Si or thin film CdTe. Having said that, there are still several substantial issues to overcome. The most significant one is the stability. It has been observed that after a few days the efficiency of perovskite solar cells considerably deteriorated. The commonly used compositions, namely methylammonium lead halide $CH_3NH_3PbX_3$ ($MAPbX_3$, X = I, Br, and Cl), are both oxygen and moisture sensitive. Therefore it is necessary to encapsulate devices (for instance using epoxy) but still the problem is not totally solved.

We fabricated perovskite solar cells with **ITO/PEDOT:PSS/perovskite layer/ PC61BM/Al** architecture, using commercially available perovskite $CH_3NH_3PbI_{3-x}Cl_x$. Samples with different thicknesses of hole transport layer (HTL) (PEDOT:PSS) were simultaneously prepared. J-V characteristics of the cells were measured (see Fig. 1.) showing a build-up of photovoltage. The curves revealed some leakage current, most probably due to tunneling of electrons through the PEDOT layer. The series resistance, as determined from the J-V curve at forward bias, was relatively low. The prepared solar cells reached the open circuit voltage (Voc) equals 0.44 V and short circuit photocurrent density (Jsc) equals 13 mA/cm2. We found that cells with too thin HTL had very poor short circuit current density as well as open circuit voltage, in comparison to the sample with thicker HTL (Fig. 2.). Photocurrent spectroscopy measurements were performed in the range of 1 - 4 eV and the external quantum efficiency was determined. In Time Resolved Photoluminescence (TRPL) nanoseconds carriers lifetime was observed. Additionally, TRPL unveiled unusual blueshift of the bandgap with increasing temperature, which will be discussed.

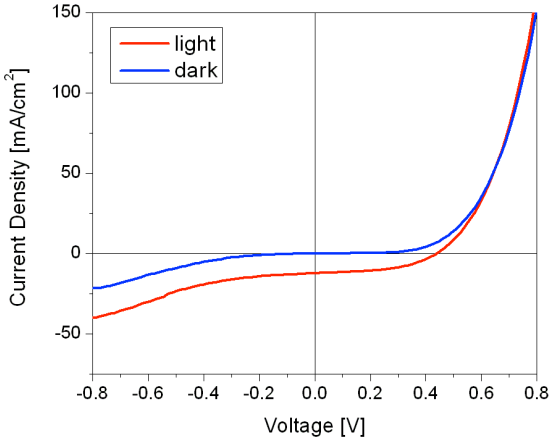

Figure 1. *J-V characteristic*

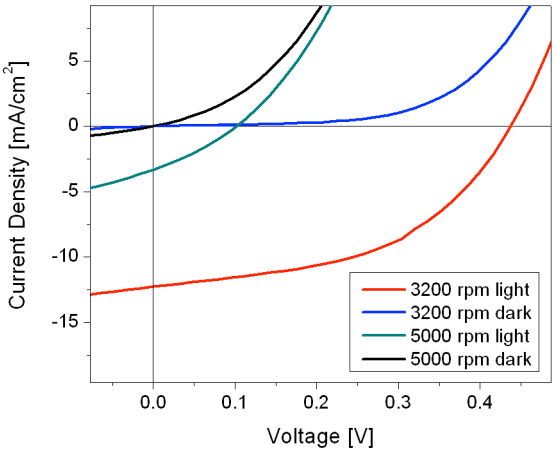

Figure 2. *Comparison of J-V characteristics. 3200 rpm corresponds to the thicker layer of HTL.*

[1] W.S. Yang, Science, Vol. 348, Issue 6240, pp 1234-1237