# EFFECT OF HTL/CONTACT DEPOSITION TECHNIQUE ON ELECTRICAL CHARACTERISTICS OF BULK-HETEROJUNCTION ORGANIC SOLAR CELLS

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Solar cells based on solution-processed organic thin films semiconductors represent an attractive alternative to inorganic technologies. This attractiveness is due to the numerous advantages offered by the organic technology such as low cost production, availability of flexible and low weight substrates, semitransparency and thin film manufacturing by continuous roll-to-roll process using printing tools. The highest photovoltaic conversion efficiency of an organic solar cell (OSC) is 12% [1] using a bulk heterojunction (BHJ) structure. This structure consist on a structure Substrate/ITO/Electron transport layer (ETL)/Active layer/Hole transport layer (HTL)/Metallic contact. In France, these aspects have convinced the company ARMOR to fabricate flexible organic solar cells for commercial applications, taking advantage of all the accumulated years of experience in printing technics and developing tools. For this reason, the Institut des Matériaux Jean Rouxel (Université de Nantes) and the ARMOR Corporate started a mutual R&D project focused on the understanding of the organic solar cell physics and the achievement of improved conversion performances. The presented work focuses on the study of the degradation of solar cells caused by the growth of the HTL layer ($WO_3$) and metallic contact (Ag) using two different deposition techniques, namely, Joule effect evaporation and RF sputtering. The degradation is mainly observed through the current-voltage (I-V) measurements of organic solar cells. The I-V curves shows a degradation of the OSC's electrical parameters in the case of RF sputtering deposition, meanwhile the cells submitted to a Joule effect evaporation deposition were not affected. The degradation of sputtered cells is observed as an "S-shaped" I-V curve which especially deteriorates the fill factor in comparison with thermal evaporation. To confirm the effect of RF sputtering deposition on the OSC's characteristics, the structure Substrate/ITO/ ETL/Active layer was exposed to a plasma treatment and then submitted for the deposition of the HTL and metallic contact by Joule effect thermal deposition. The I-V measurements shows an S-shaped curve, which indicate that active-plasma interaction could be one aspect responsible for this electrical behavior. For further explanations of the degraded OSC's, XPS studies were carried out in order to study the interface between the active layer and the HTL formed during the thermal evaporation and RF sputtering. The study was achieved by depositing 1nm thin layers of HTL on the active layer. For both deposition techniques, the XPS spectra of W4f core levels shows four spin-doublets with which correspond to a higher oxidation state $W^{6+}$ and a lower oxidation state $W^{5+}$, owed to a deficiency of oxygen. Nevertheless, a lower reduction of the $WO_3$ is observed in the case of RF sputtering compared to thermal evaporation. Furthermore, the valence spectra of the interfaces confirms the oxygen deficiency as a density of occupied defects states close to the Fermi level, being the RF sputtered sample the one with the lowest density. The last points out that the level of oxygen deficiency in the oxide could have a role in the electrical characteristics of the solar cell. Considering all the aforementioned, the OSC's electrical characteristics could be strongly affected by the deposition technique used for the deposition of HTL/Metallic contact. More experiments are needed in order to study further discriminate the effect of plasma on the active layer and the HTL material formation using different deposition techniques.

[1] H. Gmbh, T. U. Dresden and V. Whereas, Heliatek press release, 2013, 1–3.

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