ICAM2009
11th International Conference on Advanced Materials
Rio de Janeiro Brazil
September 20 - 25

FONDAZIONE BRUNO KESSLER

Degradation studies of rigid and flexible rr-P3HT:PCBM bulk heterojunction solar cells encapsulated with a parylene polymeric coating

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Abstract – In order to increase lifetime of flexible organic solar cells for future commercialization, either new materials with high stability against degradation by water vapor and oxygen are required or a high-barrier plastic encapsulant. In this work, we studied the validity of parylene (i.e., poly(p-xylylene) derivatives) deposited by vapor deposition polymerization as an encapsulant for flexible photovoltaics on poly(ethylene terephthalate) (PET) made of a semiconductor blend of regioregular poly(3-hexylthiophene): [6,6]-phenyl-C61 butyric acid methyl ester (P3HT:PCBM).

Photovoltaics made of organic semiconductor blends have become attractive for industry due to the high efficiency attained for P3HT:PCBM on glass substrates (~5%) [1]. On the way for making durable, flexible and transparent devices, a race was settled to replace glass with bendable materials. Parylene layers show excellent transparency in the visible with homogeneous and conformal coverage, i.e. without the formation of pinholes or micro-cracks that could cause a reduction in the barrier performance. Degradation processes by oxygen-assisted photochemical reactions, such as photobleaching and chain scission can be reduced by applying a multilayer barrier of parylene and aluminum oxide [2]. Kim et al. combined the deposition of layers of SiO_x or SiN_x (100 nm) by plasma enhanced chemical vapor deposition (PECVD) followed by Al_2O_3 (10–50 nm) by atomic layer deposition and 1-μm-thick parylene by CVD to attain water vapor transmission rates of $(2 \pm 1) \times 10^{-5}$ g/m^2 day at 20 °C and 50% relative humidity. In this context, we present the effectiveness of a parylene coating deposited in rigid glass and flexible PET substrates preventing device degradation. Solar cells are studied by the variation of its main parameters along time.

Samples are fabricated on a sandwiched vertical structure of material layers (Fig. 1). Device fabrication starts by ITO anode etching and cleaning under standard solvents such as acetone, water and isopropyl alcohol. Poly(3,4-ethylenedioxythiophene) poly(styrenesulfonate) (PEDOT:PSS) is spun on substrates at 5000 rpm and dried on a hot plate at 120ºC. After stirring the blend solution for hours prior to deposition, 5 wt % rr-P3HT:PCBM in dichlorobenzene is spun at 2000 rpm. Samples are then loaded into a thermal evaporator for depositing lithium fluoride (LiF) and aluminum (Al). Half of the fabricated devices are encapsulated with parylene. Organic solar cells are characterized using a solar simulator Abet Sun 2000 under AM1.5 for 100, 50 and 10% of $1000 W/m^2$ at room temperature. Devices electrical parameters are the open circuit voltage (V_{oc}), short circuit current (I_{sc}), fill factor (FF) and power conversion efficiency (PCE). The quantum external efficiency is monitored in time at the maximum of absorbance of the blend (500-550 nm).

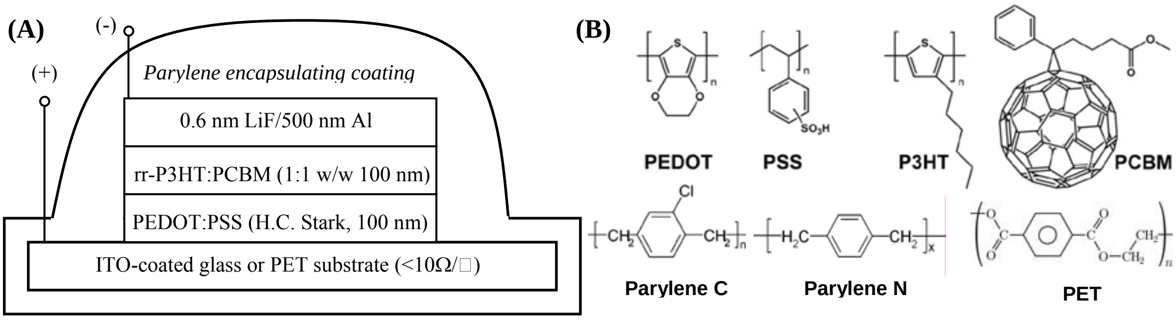

Figure 1: (A) Organic bulk heterojunction solar cell structure. **(B)** Organic materials employed in our devices.

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