Abstract

Organic photovoltaics technology has been established as a main field of applied research that is rapidly growing and evolving. Organic electronic device fabrication is pointing to the low production cost devices with optimized properties ensuring efficiency and lifetime. For this reason, numerous technologies were invented for the deposition of organic thin films that are used in OPVs. AIXTRON Company is a world-class provider of such technologies, producing machines from R&D lab-scale to factory large scale deposition systems. One of the emerging technologies provided by AIXTRON is the Organic Vapor Phase Deposition – OVPD. This technology utilizes inert gas transport of organic vapors for the deposition of small molecular organic thin films for organic electronics applications and devices. The combination of OVPD technology with the patented Close Coupled Showerhead – CCS by AIXTRON, guarantees the homogeneous and uniform deposition of organic small molecule thin films over large areas without much material loss, as it stands for VTE. This technology is 2-D scalable and it has been already proven for high quality OLEDs and lab – scale OPVs.

The device size upscaling is a different story due to many limitations existing. OVPD technique has already been used for the fabrication of lab scale – small active area OPVs. In this work it is described how an OVPD system from AIXTRON was installed at AUTh and integrated to be a unique OVPD Pilot Line featuring in-situ spectroscopic ellipsometer and Raman spectrometer optical tools. The pilot line is used for the fabrication of small molecule OPVs in large scale (200 x 200mm) as one of the scopes of this work is to prove the applicability of this technique in the area of OPVs fabrication. Since the OVPD technology is 2-D scalable as realized by AIXTRON, this achievement leads the way towards the improvement of the technology in order to be ready for larger commercial applications.

Organic small molecular materials were deposited by OVPD. Investigation of the growth mechanisms, the optical and the structural properties was carried out. Spectroscopic ellipsometry, Raman spectroscopy, UV-Vis transmittance, AFM and XRD were combined for the investigation of the growth mechanisms and the deposition parameters. Copper phthalocyanine – CuPc thin films deposited at various substrate temperatures were characterized by optical and analytical techniques and revealed the growth mechanisms and the morphology – structure of the CuPc crystals.

Small molecule organic semiconductors are deposited by OVPD towards the fabrication of large active area organic solar cells. The well-known and widely used CuPc and ZnPc molecules were are used as absorbers (electron donors) while the C_{60} fullerene is used as electron acceptor. Photovoltaic devices with three different structures are fabricated. Firstly, the bilayer or flat heterojunction that is the simplest structure, secondly the bulk heterojunction – BHJ devices and finally the Planar Mixed-Molecular HeteroJunction – PMM-HJ that is a hybrid combination of bilayer and BHJ.

Several parameters were investigated concerning their effect on the devices' electrical characteristics and consequently on their efficiency. Showerhead temperature, substrate temperature, post-annealing, different material manufacturers and finally devices fabricated by OVPD compared to their VTE counterparts. More investigation is needed for the optimization of device efficiency and of the deposition process. Nevertheless, through this work it is proved that OVPD technology is applicable for the fabrication of large area organic solar cells.

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