Organic Nanostructures with Low Band-Gap Materials: Manufacturing by Via Template-Assisted Method and Characterization for Optoelectronic Applications

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The fabrication of organic nanostructures (NS) in recently years have attracted interest due to potential application in many fields of research as flat panel displays, biological and chemical sensors, electronic and optoelectronic systems in special attention to devices such as polymer light-emitting diodes, transistors, and solar cells among others [1-3]. The organic NS can be manufactured by nanolithography [4], mechanical drawing [5], printing and spin-coating [6] and template-based methods [7]. The method frequently used to fabricate NS is the template synthesis due to its cost effective and versatile fabrication technique. The nanoporous anodic alumina templates (NAATs) is a material widely used as template because the template porous are hexagonally ordered, the geometric characteristics can be easily controlled (i.e. pore diameter, pore length, porosity, degree of hexagonal pore arrangement and thickness) and offer a higher thermal and mechanical stability. The control of its geometric characteristics previous mentioned are controllable by the anodization parameters (anodization voltage, temperature, and type and concentration of the acid electrolyte) [8]. The infiltration process of polymeric material inside of NAAT can be by wetting the template with a polymer solution or melt by direct polymerization of a monomer inside the pores of the template, etc. [9].

In this work, polymeric NS are manufactured with the used of NAATs. The fabrications of NAATs were prepared by two-step anodization process of aluminium metal in an acidic solution [8]. The first anodization step consists of applying the anodization voltage directly (194 V) in an electrolyte consisting of an aqueous solution of phosphoric acid (H_3PO_4) (0.3 M) by 24 hours at 0 ^{o}C while the second step was conducted under the same anodization conditions but for 7.5 min. The NAATs were characterized by environmental scanning electron microscopy (ESEM). Fig. 1 shows the ESEM image of the NAATs obtained with H3PO4 electrolyte. The cross section in Fig. 1 a) reveals a suitable average pore diameter of 180 nm. Fig. 1 b) is shown the top view for NAATs.

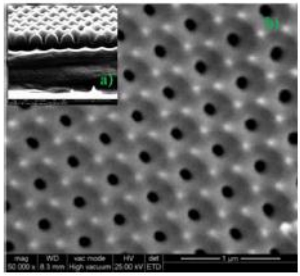

Figure 1: ESEM image of NAATs is shows the cross section view in a) and top view in b).

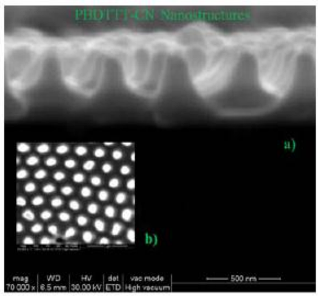

Figure 2: Cross-sectional a) and top view b) ESEM images of PBDTTT-CN nanostructures /PEDOT:PSS/ITO obtained using NAATs.

The low-bandgap polymer materials used to manufacture the NS were Poly[4,8-bis(2-ethylhexyloxy)-benzo[1,2-b:4,5-b']dithiophene-2,6-diyl-alt-(4-octanoyl-5-fluoro-thieno[3,4-b]thiophene-

2-carboxylate)-2,6-diyl] (PBDTTT-CF) [10] and Poly-(3-hexylthiophene-2,5-diyl) (P3HT). These polymers have their bandgap of 1.7 and 1.8 eV for the PBDTTT-CF and P3HT, respectively. The NS are fabricated onto Poly-(Ethylene dioxythiophene) doped with Poly-(Styrene Sulphonic acid) (PEDOT:PSS) (30 nm) /Indium-Tin-Oxide (ITO) (120 nm) / glass substrates by replicating from NAATs via spin-coating and melt-assisted wetting method. The organic NS were characterized by ESEM and UV/visible absorption spectra.

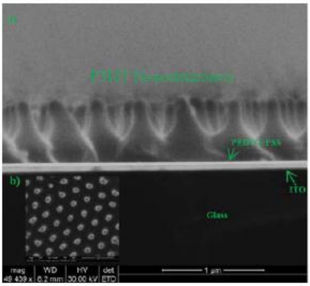

Figure 3: Cross-sectional a) and top view b) ESEM images of P3HT nanostructures /PEDOT:PSS/ITO obtained using NAATs.

The organic NS manufactured with the semiconductor polymers PBDTTT-CF and P3HT after the infiltration and removing the NAATs are show their cross sections in Fig. 2 a) and Fig.3 a), respectively. All the samples were fabricated under air atmosphere. Analysis by ESEM for PBDTTT-CF NS presents an average support base of 150 nm, pore length of 320 nm and an average interpillar distance of 460 nm and for P3HT NS has an average support base of 220 nm, pore length of 380 nm and interpillar distance of 490 nm. The pillar diameter for both structures has the similar value obtained of NAATs.

Fig. 4 shows the optical properties absorbance for the both polymer nanostructures. These NS are compared with their PBDTTT-CF and P3HT flat layers. Polymers nanostructures were obtained with an excellent replica process employing self-ordered NAATs. It is expected that these nanostructures will have potential applications as optoelectronic applications. The resulting PBDTTT-CF and P3HT nanopillars presented here these will be used to manufacture organic solar cells.

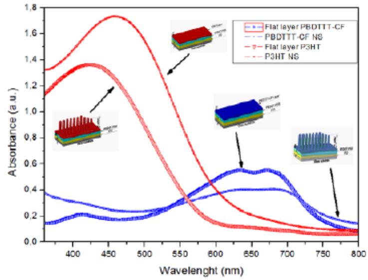

Figure 4: UV/visible absorption spectra of PBDTTT-CN and P3HT nanostructures. The NS were obtained with the used of the NAATs. These are compared with their respective flat layer made with the same semiconductor material and with similar process conditions.

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