Synthesis and characterization of polymer nanopillars for photonic and optoelectronic applications

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Micro- and nanostructures fabricated from conjugated polymers have attracted interest due to their potential applications such as sensors, polymer light-emitting diodes, polymer solar cells, and other electronic and photonic devices [1]. Different synthesis methods have been proposed for fabrication of organic structures: nanoimprinting, nanolithography, electrospinning, template-assisted synthesis [2]. The last one has the advantage of being able to create large area and ordered arrays of structures with control over structural parameters. This method does not require specialized equipment and it is applicable to a wide range of materials such as polymers, metals and semiconductors [3]. Anodized aluminium oxide has become one of the most common nano-templates for the preparation of different nanometer-sized structures. Under appropriate anodization conditions, long-range-ordered anodic porous alumina with an ideally ordered nanopores arrangement can be obtained [4].

Herein, we report the fabrication of ordered nanostructures employing a template wetting method, which entails infiltration of a polymeric solution into self-ordered anodic aluminium oxide. Porous alumina template was prepared by two-step anodization process of aluminium metal in an acidic solution. This material is used as template because it is possible to fabricated nanoporous anodic alumina with quasi-hexagonal pore arrangement in an expensive way. The geometric features are controlled by adjusting of anodization voltage, temperature, kind of acid electrolyte and concentration. The resulting nanostructures present pore depths between 150 nm to 300 nm and pore diameters between 50 nm to 300 nm. Figure 1 shows the cross sectional and top view a ESEM images of the self ordered alumina template.

Polymer nanopillars were obtained via infiltration using different types of polymers such as poly(thiophenes) and polyfluorenes. Figure 2 shows ESEM images of poly(3-hexylthiophene-2,5-diyl) (P3HT) and poly(9,9-dioctylfluorene) (PFO) nanopillar structures after removing the alumina template by immersion in a sodium hydroxide (NaOH) solution.

The resulting polymeric nanostructures were characterized by optical (UV-Visible and photoluminescence) and electrical (current sensing atomic force microscopy) techniques. These polymer nanopillars were also analyzed by Raman spectroscopy and X-ray diffraction (μ-XRD) in order to study the orientation of the polymer chains inside the nanopillar.

The presented polymer ordered nanostructures can be used in different photonic and optoelectronic applications such as polymer light emitting diodes and nanostructured polymer solar cells. This fabrication process could be extended to other copolymers depend on later applications.

Acknowledgments

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Figures

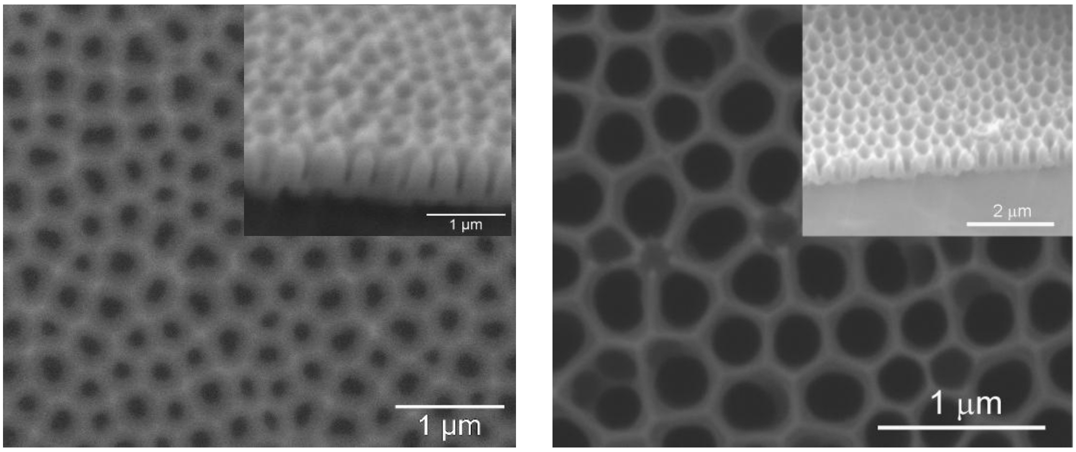

Figure 1. Cross-sectional and top view ESEM images of self-ordered alumina template with different pore depths and pore diameters.

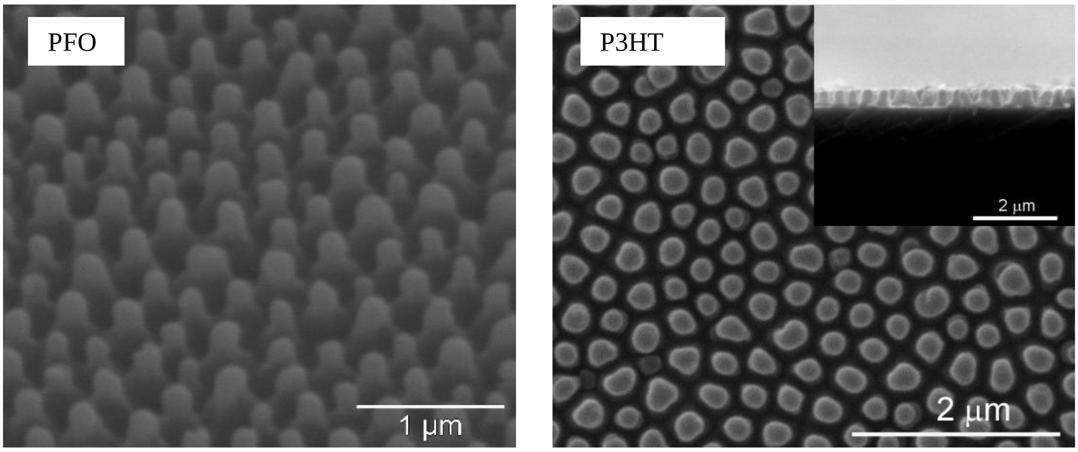

Figure 2. ESEM images of PFO and P3HT nanopillars after removing the alumina template.