

ABSTRACT

The experimental work in this thesis is focused on the fabrication of nanostructures that can be implemented in organic solar cell (OSC) architecture for enhancement of the device performance. Solar devices made from organic material are gaining increased attention, compared to their inorganic counterparts, due to the promising advantages, such as transparency, flexibility, ease of processing etc. But their efficiencies cannot be compared to the inorganic ones. Boosting the efficiency of OSCs by nanopatterning has thus been puzzling many researchers within the past years.

Therefore various methods have been proposed to be used for developing efficient nanostructures for OSC devices such as, plasmonic structures, nanowires (NWs), gratings, nanorods etc. The nanostructuring methods applied though, do not offer the possibility of a cheap, rapid, reproducible and scalable fabrication. It is the aim of this project to develop nanostructures that can be fabricated using a cheap process, having structured patterns that can be easily reproduced and replicated. In addition, compared to present techniques the method should be relatively fast with upscaling possibilities.

Porous anodic alumina (PAA) templates, is a well-established method for obtaining nanostructures of tailored dimensions on a large scale. Yet being a novel patterning method, its abilities are not fully explored. In this context, PAA templates were prepared by anodization of aluminium (Al) on supported surfaces, and basic parameters that affect the formation of such templates was investigated.

During the formation of the PAA template it was possible to stop the anodization process and etch the PAA template selectively. This etching step exposes an underlying Al surface consisting of dimple structures of controlled dimensions. The field-enhancement of these Al dimples nanostructures has been investigated both experimentally and theoretically. For the experimental part a non-destructive laser ablation technique was adopted, and revealed field-enhancement at the ridges of the Al dimples. The experimental results were complemented by Finite-Difference Time-Domain (FDTD) simulations.

To enhance the usability of etched PAA templates for nanostructuring, imprinted structures on quartz surfaces were also investigated as possible candidates for OSC applications. In order to utilize this flexible polydimethylsiloxane (PDMS) stamps were made by simple replication technique. Resist imprinted Al dimples drag the main focus showing increase in absorption and efficiency enhancement in poly(3-hexylthiophene-2,5-diyl) (P3HT) and Phenyl-C61-butyric acid methyl (PCBM) BHJ devices. Not limited to this, nanostructures by imprinting the organic layer of P3HT:PCBM and imprinted ridges, are additional applications of the imprinting process. The structures produced from the replication of the PAA templates were compared to up to date nanostructures fabricated with more complex methods.

In conclusion this work shows the fabrication of nanostructures via a rapid, inexpensive, easily replicable and scalable technique using PAA templates. Control of the anodization parameters allows control over the dimensions of the structures and therefore easy control of the underlying dimples dimensions. The area exposed to the acidic electrolyte is the only factor limiting scalability. The structures can be easily imprinted using a flexible PDMS stamp hence the same structures can be easily replicated in a series of devices. Such structuring method, together with the analysis of the dimples' properties in this work, contributes in further improving the imprinting processes of nanostructures for organic solar cell applications, opening new patterning possibilities.