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Multiscale patterning of conducting polymers: applications in neurotechnology

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Micro- and nano-patterning of conducting polymers (CPs) has attracted great interest in organic electronics due to the possibility of controlling the optical, electrical and electrochemical properties of organic devices via the introduction of preferential charge transport pathways or by increasing the active area of the material [1]–[3]. Micro- and nano-patterning techniques such as inkjet printing, plasma etching, nanosphere lithography and soft-lithography have been leveraged in a number of applications, including organic photovoltaic cells (OPVs), field effect transistors (OFETs) and light emitting diodes (OLEDs) [4]–[6]. However, the patterning of CPs for bio-related applications such as multi-electrode arrays (MEA), neural interfaces, neuromorphic devices and tissue engineering scaffolds, is largely unexplored, despite the rapidly growing role of CPs in these fields [7]–[10].

At CTNSC-IIT, we study micro- and nanopatterned/nanomodulated CPs that are easy to integrate into organic devices and onto soft/flexible substrates. In this talk, I will present 3D micropillars of poly(3,4-ethylenedioxythiophene)-poly(styrenesulfonate) (PEDOT:PSS) on soft substrate (i.e. PDMS, **Figure 1, i**), capable to promote neural cell differentiation and influence neurite outgrowth, which can be easily integrated into state-of-the-art μEcoG conformable arrays to record neural signals with high signal-to-noise ratio. Furthermore, I will show how the transconductance of organic electrochemical transistors (OECTs) can be markedly increased by nanomodulating the surface of ultra-thin PEDOT channel (**Figure 1, ii**) and that high-surface-area nanoporous electrodes can be obtained by a simple soft-lithographic patterning approach (**Figure 1, iii**). Finally, I will demonstrate the advantage of using PEDOT nanopatterns to influence neuronal polarization and accelerate neurite outgrowth during cell differentiation, this being of potentially high impact in the field of spinal cord repair.

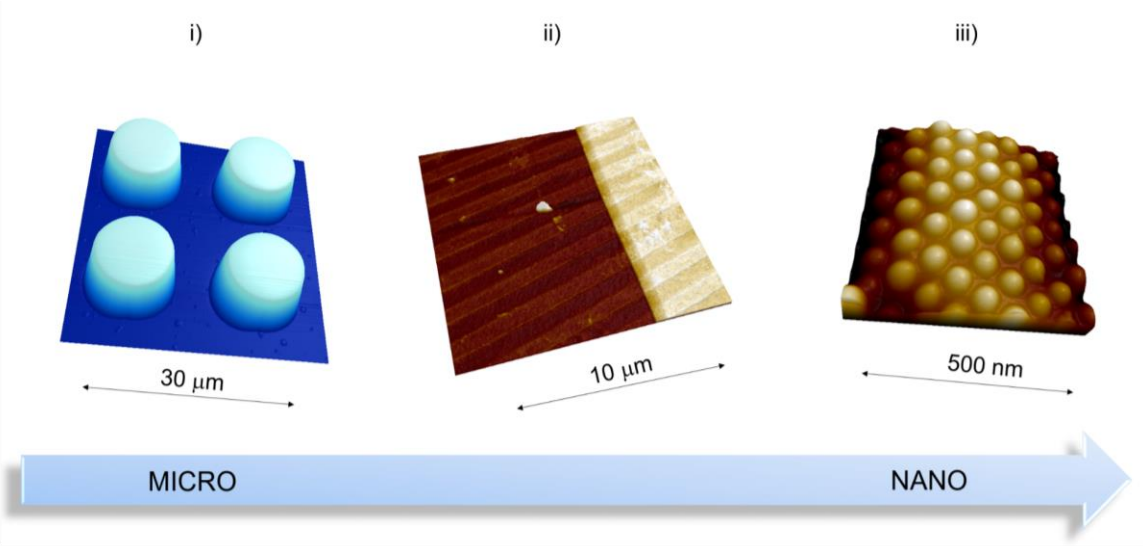

Figure 1. Examples of micro/nanopatterning of CPs at different length scales.

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