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Microscopy of Nanostructured Conducting Polymers for Interfacing Biomedical Devices with Living Tissue

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We are actively investigating the use of conducting polymers such as poly(3,4-ethylenedioxythiophene) (PEDOT) for functionalizing the surfaces of biomedical devices designed to interface with living tissue. These include microfabricated electrodes intended for insertion into the cortex, as well as deep brain stimulators, retinal implants, and cochlear implants. These materials must accommodate the dramatic differences in mechanical properties, biological activity, and mechanisms of charge transport across the abiotic-biotic interface from engineered device to living cells.

We have designed materials that have well-controlled structures on the nanometer scale to promote specific interactions with the tissues into which they are embedded. We have done this using a variety of processing schemes. The conducting polymers can be electrochemically deposited onto an electrode surface and the morphology tailored by using a variety of templates. These can include nanoparticles [1-2], nanofibers [3] or even living cells. We have also investigated the use of polymer counterions that create a fibrous surface with high effective surface area.

We have correlated the micromechanics of these films by nanoindentation with the electrical properties by impedance spectroscopy, and have found that those microstructures that give the highest effective surface area are both mechanically compliant and most efficient at charge transport [4].

We have characterized the morphology of these porous polymer coatings with transmitted, reflected, and confocal optical microscopy; scanning electron microscopy, conventional transmission and high resolution electron microscopy; and low voltage electron microscopy. Figure 1 shows a electrochemically deposited film of PEDOT prepared using dissolvable polystyrene nanospheres as a template. The spheres were removed after electrochemical deposition, resulting in an ordered, interconnected porous structure. Figure 2 shows a cross-section of a similar sample prepared using a Focused Ion Beam (FIB), showing that the organization is uniform and persists throughout the cross-section of the film, down to the surface of the metal electrode substrate.

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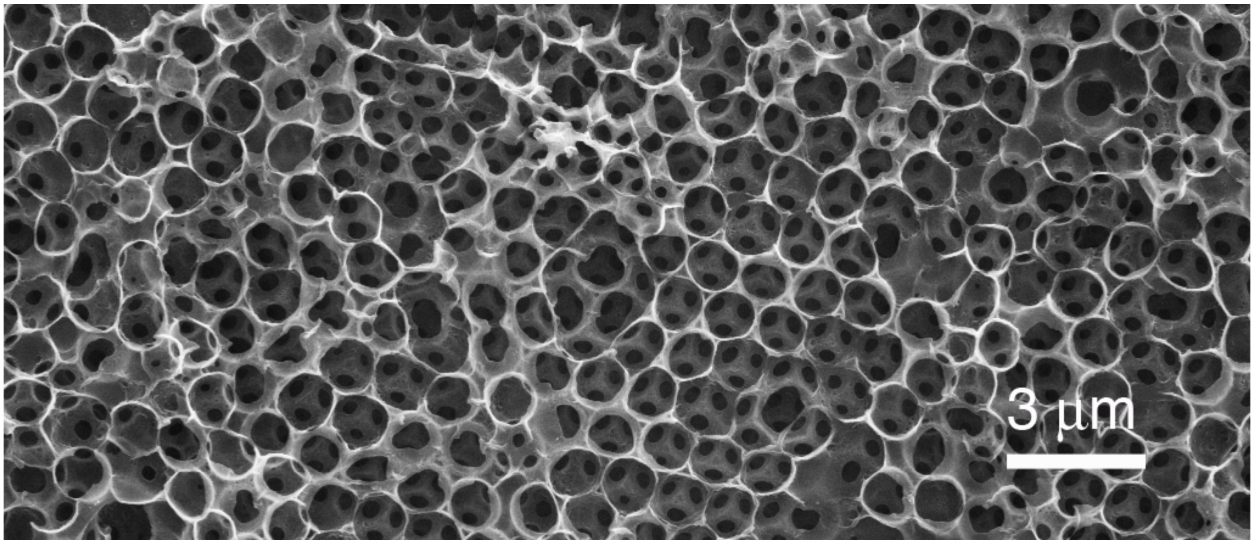

FIG. 1. SEM image of a the surface of an electrochemically deposited conducting polymer PEDOT film templated using polystyrene spheres.

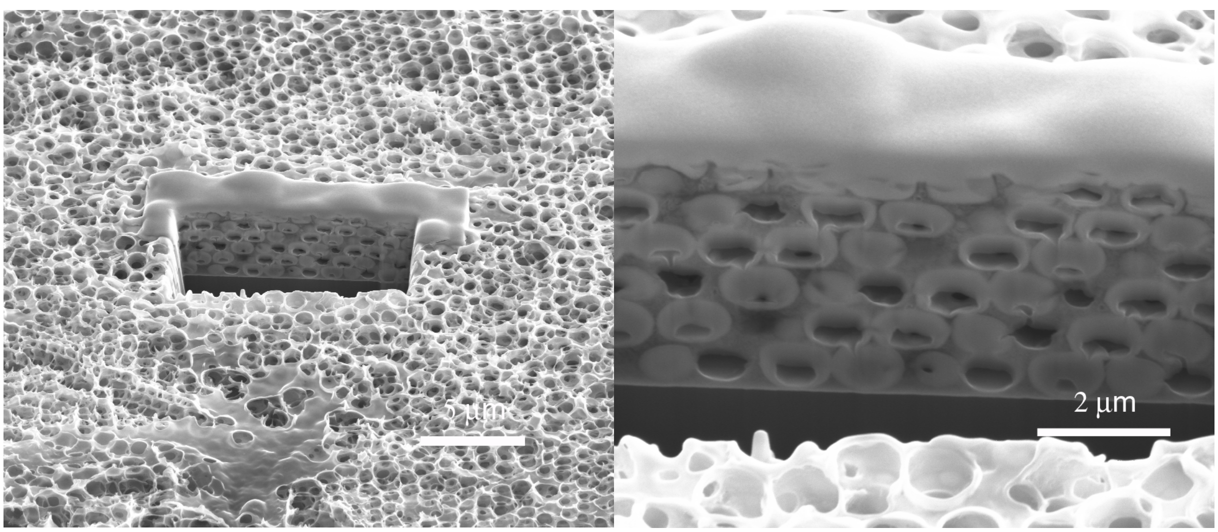

FIG. 2. Cross-section of the porous film showing that the organization and interconnected nature of the pores in the PEDOT persists down to the surface of the metal electrode.

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