3D imaging of polymer solar cells

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The structure and architecture of polymer solar cells on scales from nm to mm have crucial impact for the device performance. With standard X-ray scattering techniques, we may determine donor and acceptor domain sizes in polymer solar cells, crystalline structure and characterize the dimensionality of the interface, but to quantify the capability of the nanostructure for separating electron-hole pairs and for transporting free charges, we need access to the 3D structure on the nm scale. X-ray ptychography has the potential to allow these investigations, and has the further advantage that it is a reasonably mild technique, due to the weak interaction of hard X-rays with the material, as compared to electron and soft X-ray transmission microscopy, where dose loads are much higher. We have carried out experiments at the P06 beam line at PETRA III [1], where we with reasonable ease achieve a 3D spatial resolution close to 20 nm or better.

We have successfully imaged a complete tandem polymer solar cell in 3D, demonstrating the capability of ptychographic tomography. The sample was cut out from a working roll-coated polymer solar cell, using focused ion beam milling (FIB). The 3D reconstruction shows interesting details of the bottom electrode and the intermediate layer, that is will be presented soon in a publication.

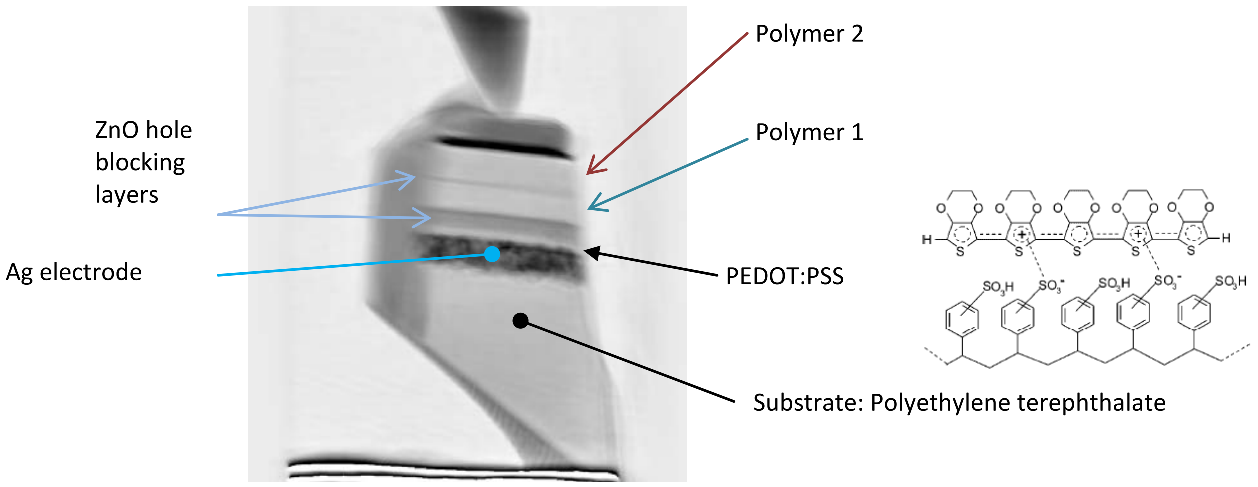

Figure 1: 2D projection of a complete tandem polymer solar cell. The coarse granulate layer at the bottom is a silver electrode. At the top is a nanoporous layer of platinum and a tungsten needle tip. In between are several polymer layers, separated by a recombination layer, part of which is a 40 nm ZnO layer, clearly resolved in the middle of the stack.

References

[1] Schroer, C. G., Boye, P., Feldkamp, J. M., Patommel, J., Samberg, D., Schropp, A., Schwab, A., Stephan, S., Falkenberg, G., Wellenreuther, G. & Reimers, N. *Nucl. Inst. Meth. A* **616,** 93 (2010)