

High Resolution KPFM investigation of nanoscale phase segregated organic heterojunctions

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A comprehensive high resolution Kelvin probe force microscopy (KPFM) investigation was performed on the active layer of an organic solar cell (OSC), a 100 nm bulk hetero-junction (BHJ) blend of poly(3-hexylthiophene) (P3HT) and phenyl-C61-butyric acid methyl ester (PCBM). This P3HT/PCBM blend has been optimized for use as an OSC with an overall power conversion efficiency of 4.25%¹. Chemical phase separation of the P3HT clusters is shown to be on the order of the exciton diffusion length, ~10 nm, as seen using non-contact atomic force microscopy under UHV in the frequency modulation mode². KPFM measurements were performed in dark and under illumination at 532 nm. Local surface contact potential measurements are recorded with a resolution of a few nm. In dark, a clear contrast (~100 mV) of the local surface potential between P3HT and PCBM is seen. However, under illumination, there is a global negative shift of the local surface potential and the difference between P3HT and PCBM is significantly reduced. Furthermore, analysis of the surface photovoltage, obtained from contact potential images, reveals a spatial resolution of the space charge region, where exciton dissociation takes place, at the donor/acceptor interfaces to be no more than ~3 nm. The resolution achieved in this work demonstrates that electrical properties can be directly visualized in highly efficient organic BHJ blends at the true nanometer scale by KPFM³. In addition, new results on OSC's composed of novel BHJ blends will also be presented.

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[2] B. Grévin, R. Demadrille, M. Linares, R. Lazzaroni, and P. Leclère, *Adv. Mater.*, **21** (2009) 4124-4129

[3] E. J. Spadafora, R. Demadrille, B. Ratier, B. Grévin, *Nano Letters*, **10** (9), (2010) 3337-3342

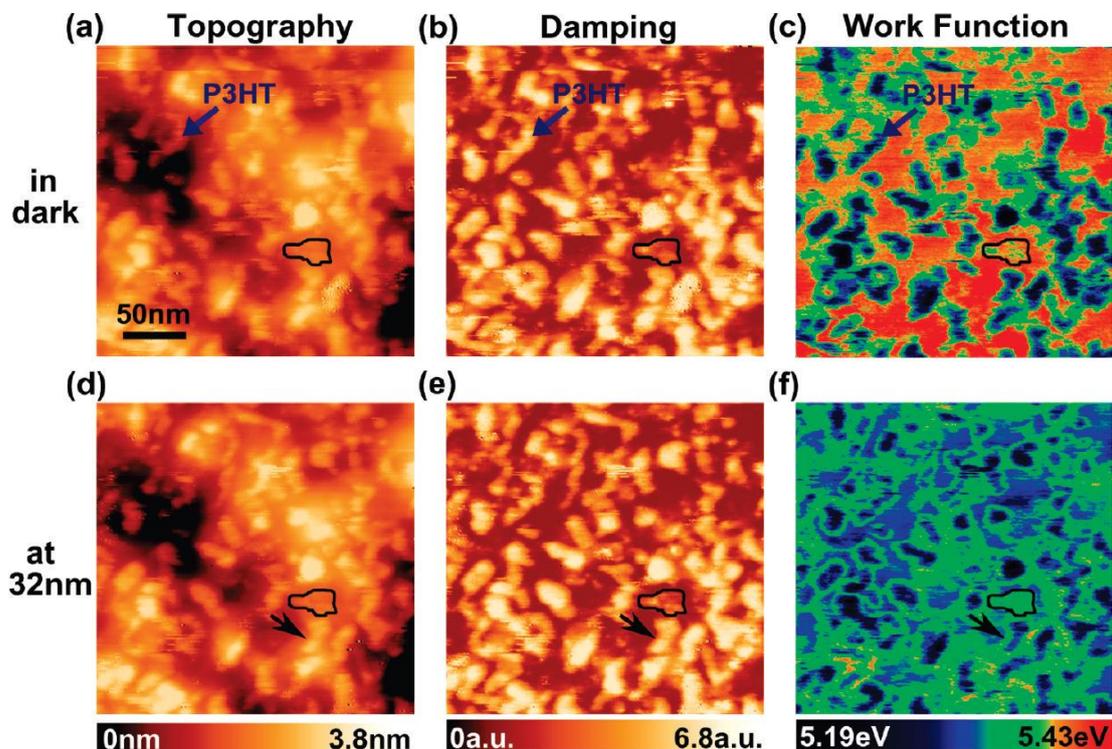


FIGURE 1. (a-f) FM-AFM (UHV, 300K) 2D images (250 nm x 250 nm, 300 x 300 pixels, $\Delta f = -19$ Hz, $A_{\text{vib}} = 44$ nm, scan speed = 50 ms per pixel) of the P3HT-PCBM sample recorded in dark (a-c) and under illumination at 532 nm (d-f). (a,d) topography, (b,e) damping, and (c,f) work function calculated from the Kelvin compensation potential. For a direct comparison, the z-values have been coded by using the same color scales in (a,d), (b,e), and (c,f). The dark-blue arrows in (a-c) indicate a P3HT crystallite. The dark arrows in (d-f) pinpoint the interface between an emerging P3HT crystallite and the surrounding PCBM. A nearly buried P3HT crystallite (partially or totally covered by a ultrathin layer of PCBM) is outlined in black.