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Nanostructured interfaces for high efficiency organic solar cells: lessons and opportunities

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Heterojunctions are inherent in and essential to all molecular electronic devices. They play a widespread role in the performance of organic devices, from controlling the basic physics of solar cell operation to engineering the structure during growth to limiting the industrial potential for flexible substrates and large scale manufacturing. In organic solar cells, in particular, heterojunctions play a defining role in all of the major processes: charge separation relies on effective organic/organic interfaces; charge transport is critically determined by the structure of the thin film, controlled by the organic/inorganic and organic/organic interfaces with substrates; and charge extraction can only occur at high quality inorganic/organic interfaces at the electrodes. Nanoscale engineering of such interfaces is critical to improving the performance and stability of solar cells to the point where they can begin to be commercially viable alternatives. In our work, we are interested in the nanoscale dispersion of dielectric layers at organic-electrode interfaces, and tuning the nanoscale heterojunction morphology to regulate the device behaviour. The dispersion and organization of the nano-islands can be controlled, ranging from a random distribution to nanochain-like structures segregated at domain boundaries within the organic layer to an organized 2D array, as seen in figure 1. Using high resolution x-ray reflectivity, grazing incidence x-ray diffraction, transmission electron microscopy, x-ray photoemission and scanning probe microscopies, the nature of the nanoparticles dispersions can be quantified and their influence on the device properties extracted. Incorporation of the dispersions into devices leads to interesting effects, ranging from tuning the surface work function of the electrode to affecting the stability and dewetting of crystalline organic films, to modifying the power conversion efficiency over four orders of magnitude.

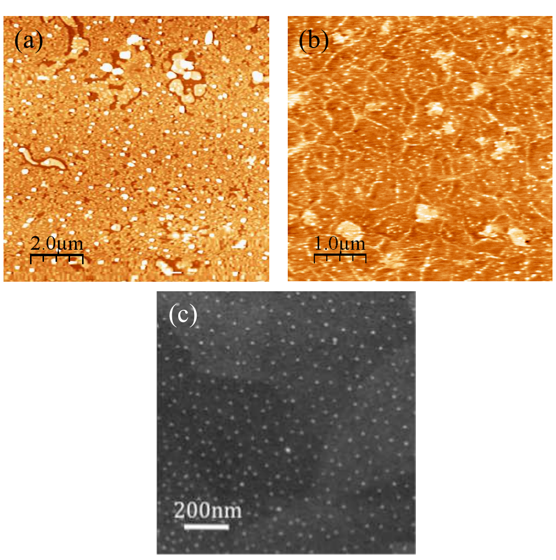

Figure 1 Nanoparticle dispersions (a) random (b) nanochaims (c) 2D array