Small Molecule Organic Photovoltaics at the Nanoscale

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Abstract

Organic photovoltaics (OPVs) are a sustainable method of solar energy harvesting with possible fabrication advantages over more developed inorganic semiconductor solar cells. However, the power conversion efficiency of OPV devices is currently about 8.6%, compared to over 20% for crystalline silicon and up to 43.5% for triple junction inorganic solar cells [1-4]. The structure of solar harvesting device active layers is crucial to performance [5-7], but little is currently known about the specific loss mechanisms responsible. We present a preliminary study of structure-function relationships in thin films of organic photovoltaic materials by simultaneous non-contact atomic force microscopy (NC-AFM) and Kelvin probe force microscopy (KPFM).

Thin films of small electron donor and electron accepter molecules were thermally evaporated on KBr (001) surfaces under ultra-high vacuum. Local contact potential difference and topography were mapped with simultaneous KPFM and NC-AFM to investigate corresponding optoelectronic and structural properties at the nanometre scale. Light may be coupled into the UHV AFM system to illuminate samples during imaging, thus allowing characterization of active OPV materials during the generation of excitons and charge carriers. Our early results demonstrate that combined NC-AFM and KPFM is a powerful approach to studying fundamental physical processes in photovoltaic power generation. Understanding structure-function relationships in OPVs will contribute to the advancement of renewable energy light harvesting devices that are clean, efficient and affordable.

References

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Figures

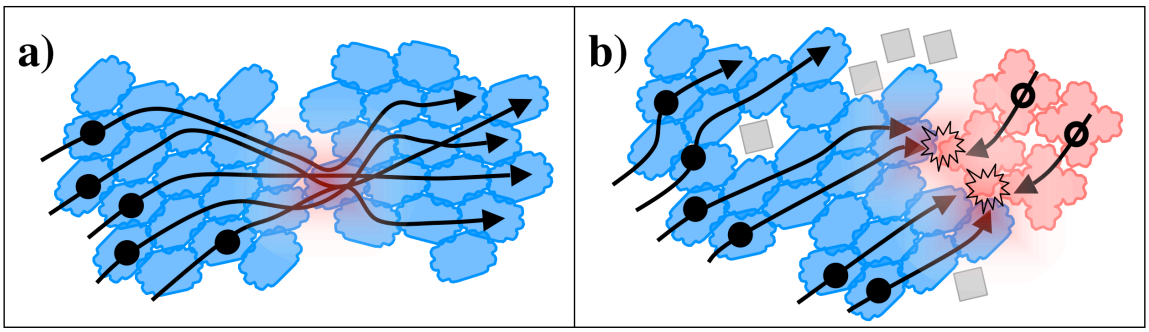

Figure 1. Illustration depicting possible structure-dependent OPV efficiency loss mechanisms under investigation. (a) Charge flow dependent on molecular anisotropy and bottleneck structure, (b) recombination loss structure and the influence of defects.

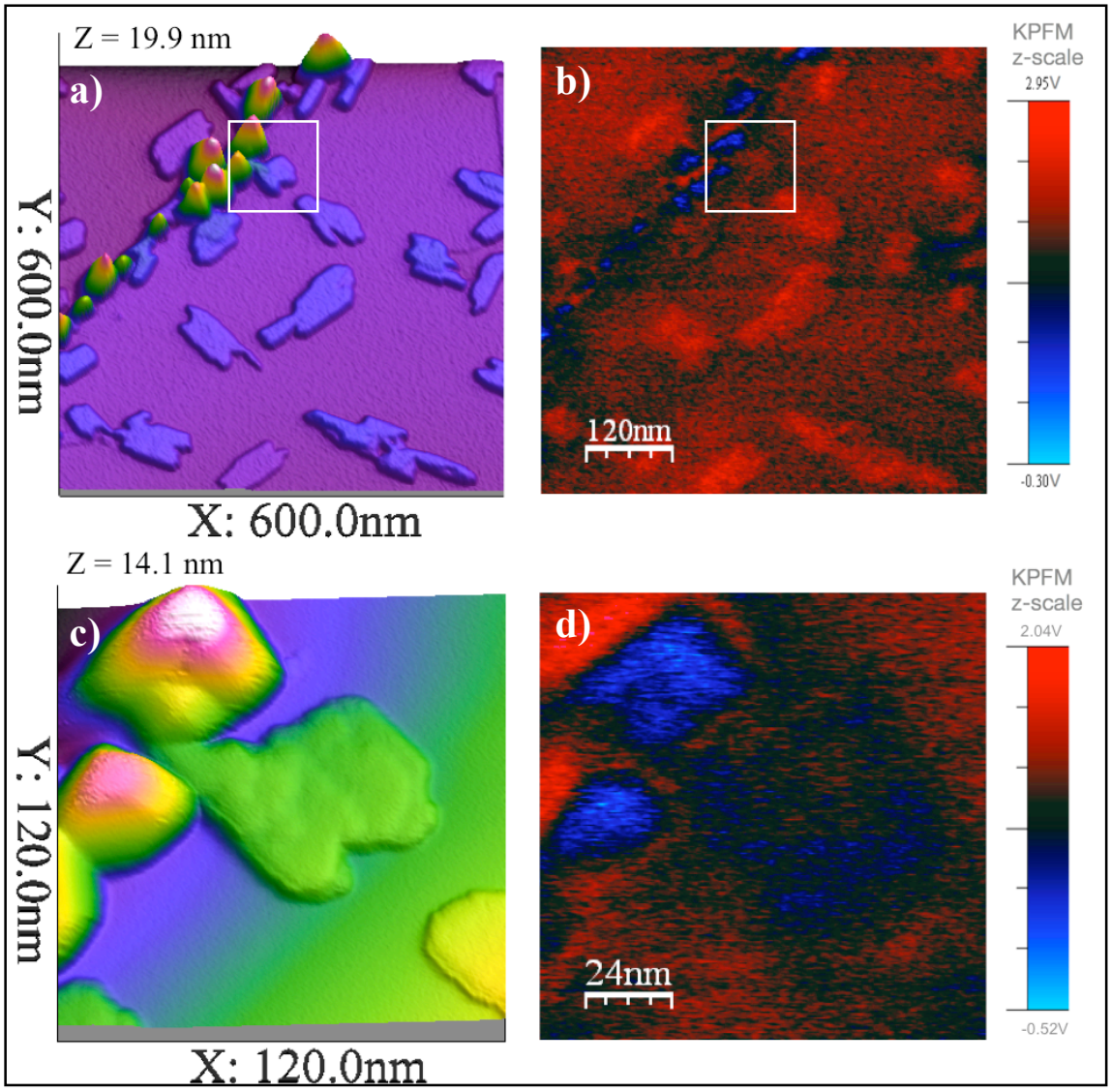

Figure 2. Volmer-Weber growth of islands of CuPc (electron donor) and PTCDI (electron accepter) molecules on KBr (001). (a,c) 3D-rendered topography imaged by NC-AFM, (b,d) local contact potential difference imaged by KPFM.