High resolution KPFM investigations of photovoltaic materials and interfaces

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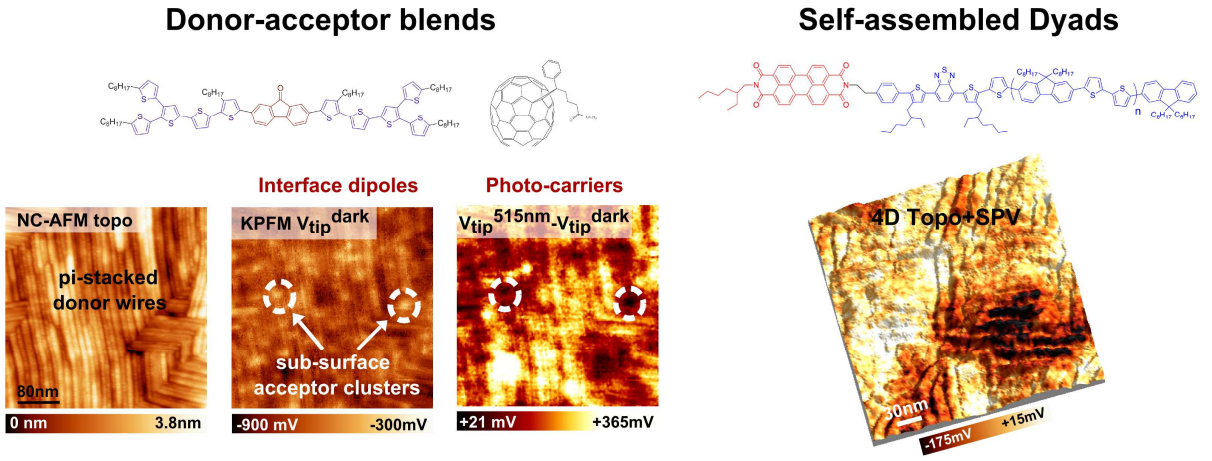
Nowadays, Kelvin Probe Force Microscopy (KPFM) is a well-established technique in the field of organic, hybrid and inorganic photovoltaics. Several reports have already demonstrated that the local surface photovoltage (SPV) of photoactive thin films and devices can be mapped by analyzing the surface potential (SP) shift upon illumination. Besides, SP images recorded in dark can be used to investigate the permanent charges, electrostatic dipoles and band bending effects at various interfaces and defects, such as the grain boundaries in polycrystalline materials or the donor-acceptor interfaces in organic bulk heterojunctions. However, imaging the surface potential and SPV with a sub-10nm resolution remains often a challenge even in the case of investigations carried out in ultrahigh vacuum (UHV) by non-contact AFM (nc-AFM). This is especially true in the case of complex materials such as nano-phase segregated organic donor-acceptor bulk heterojunctions (BHJ).
In this lecture, we will show how nc-AFM/KPFM can be used to investigate photoactive organic self-assemblies and organic solar cells at the relevant scales. First, an introduction to the basic concepts of charge generation at donor-acceptor interfaces, electronic transport and recombination mechanisms in organic solar cells will be given. In a second part, nc-AFM/KPFM technical issues/hints will be discussed, including: illumination setup geometry, cantilever calibration, artifacts, SPV images calculation and lateral resolution. In a third part, we will review the recent literature and will present our recent achievements on BHJ thin films[1] and self-assembled donor-acceptor dyads[2]. Last, beyond the current state of the art, we will introduce ongoing and future developments towards time resolved imaging of the photo-carrier dynamics, yielding a direct access to the charge generation, trapping and recombination mechanisms at the nanometer scale.



[1] F. Fuchs, F. Caffy, R. Demadrille, T. Mélin, B. Grévin ACS Nano **10**, 739, (2016).
[2] B. Grévin, P.O. Schwarz, L. Biniek, M. Brinkmann, N. Leclerc, E. Zaborova, and S. Méry, Beilstein J Nanotechnol. **7,** 799, (2016).