9th International Conference on Molecular Electronics
Paris, France
December, 17-21st 2018

Invited Keynote

Energy levels at interfaces with organic semiconductors: Fermi level pinning, doping, and heterogeneity

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Abstract:

The electronic properties of interfaces with organic semiconductors are crucial for the functionality and efficiency of electronic and optoelectronic devices. Therefore, a comprehensive understanding of interfacial phenomena is needed to push the development of superior deices. A key mechanism that can induce interfacial charge transfer, even in the absence of chemical interactions, is Fermi level pinning of the occupied/unoccupied frontier energy level manifold of the organic semiconductor. As shown for prototypical contacts with inorganic semiconductors and electrode materials, this helps realizing ohmic contacts as well as tuning the interface energy levels over extremely wide ranges. While doping of inorganic semiconductors has become a standard technological component, doping of organic semiconductors remains challenging. The impact of doping an organic layer in a hybrid inorganic/organic pn-junction is analyzed and can be rationalized within established semiconductor physics, yet considering the particularities of the organic compound.

Surface and interface lateral homogeneity is a key for determining the ionization energy of an organic semiconductor, and for robust device functionality. In practice, however, inhomogeneities are difficult to eliminate. The consequence of work function inhomogeneity of a substrate used for organic semiconductor deposition on the interface energy levels is presented, and pitfalls for reliable ionization energy determination with photoemission spectroscopy are identified.