Interface Engineering in Organic Devices

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Interfaces are ubiquitous in nature and play a key role in many fundamental physical and chemical processes. In organic electronic devices, where charge injection, charge transport, and trapping are indeed interfacial phenomena, the intrinsic properties of the active materials, their processability and their response in devices can be modulated and even disguised by mismatched interfacial properties, sometimes hampering the concept of “properties by molecular design” which is one of the pillars of organic electronics.

Tailoring the interface and thus achieving full control over their properties in fabrication processes of organic devices, and optimizing them for device response, is technologically challenging due to the intertwining of complex phenomena during the assembly of molecular and supramolecular architectures on technological surfaces. Examples include the control of molecular orientation, nucleation and growth of molecularly ordered domains which affect the surface roughness and lateral morphological correlations, as well as the coexistence of misoriented crystalline domains, their size distribution and the extent of domain boundaries. Dynamic processes such as wetting, dewetting and ripening govern the occurrence of (re-)crystallization yielding the formation of inhomogeneous thin films on specific length scales during the device fabrication, and can also be subjected to re-adjustment while the device is “in-action” thereby affecting its time-stability. From the more functional viewpoint, the boosting of charge injection can be attained via the optimization of energy level alignment and the minimization of energy barriers through the physisorption or chemisorption of suitably designed molecular building blocks. Moreover, density of charged surface states, (local) doping and trapping can be modulated via non-covalent surface interactions.

The bottom-up engineering of the physical chemistry of the interfaces is an effective approach towards the multiscale control of supramolecular organization and energy (dis-)order of the device interfaces, such as organic/dielectric, organic/electrode, organic/organic, and organic/ambient. The approach is also central to the design of chemo- and biosensors, as it endows them with sensitivity and selectivity towards specific analytes. Interface engineering has to be regarded, therefore, as an enabling strategy for achieving unprecedented multifunctional and multi-responsive organic devices with full control over the correlation between structure and function.

This special section of Advanced Materials Technologies reports a few enlightening recent experimental and chemical-design approaches aimed at controlling and tuning some technologically
relevant interfacial properties in organic devices, including field-effect transistors, solar cells and light-emitting diodes.

We briefly overview below the five contributions to this special section, sorting them according to a logical sequence, from charge-injection interfaces, to transport-layer interfaces, to novel low-dimensional architectures for organic devices.

Work function modification is the central topic of the article by V. Diez-Cabanes and co-workers, as a joint collaboration between Université de Mons (Belgium), ICMAB-CSIC and CIBER-BBN Barcelona (Spain), Università di Parma (Italy), and Universidad de Ambato (Ecuador). Self-assembling monolayers (SAMs) are a vastly explored topic both experimentally and theoretically in organic electronics devices, and SAMs are already consolidated in the manufacturing technology of organic devices. Here the authors report a not-so-well investigated effect, viz. the role of molecular polarizability of SAMs on the work function modification of Au electrodes, and in particular, using a donor-acceptor paradigmatic dyad, ferrocene (D) and PCTM radical (A), they rationalize the effect of charge transfer and spin states on determining the work function and level alignment at the charge injection interface, also suggesting routes for tailoring the work function shift.

The article by F. Hermerschmidt, S. A. Choulis, and E. J. W. List-Kratochvil from Humboldt Universität Berlin (Germany) addresses a nowadays relevant technological problem which is the availability, processing and replacement of ITO in conductive transparent electrodes for optoelectronics applications such as OPV and OLED. The authors discuss the potential of the use of metal nanoparticles that are inkjet-printed, how to process them to control conductivity and interfacial properties, to show how the manufacturing of organic optoelectronics devices can be aligned to a whole-additive printing platform.

The article by Weining Zhang, Hongliang Chen, and Xuefeng Guo, from Peking University (China) reviews the recent developments and challenges of interface-engineered organic optoelectronic devices for future applications in electronics and optoelectronics. They emphasize the control of interfacial charge transport for building functional optoelectronic devices, by means of the finest control of individual layers of materials and their interfaces in devices, to design functional transistors, biodetection devices, and flexible electronics, as well as other types of traditional optoelectronic devices, such as photodetectors, photovoltaic devices, and light-emitting devices, with unprecedented characteristics or unique functionalities.

The group of Yun Li from Nanjing University (China) presents an overview of the technology of field-effect transistors based on solution-processed two-dimensional molecular crystals (2DMCs), as a route to overcome the limits in the charge transport properties imposed by the heterogenous nature of active layers and thin films. They highlight the present capability of upscaled manufacturing of OFETs with 2DMCs, which shows how the field has moved in recent years from the very fundamental field of organic single crystals for studies of the transport physics, towards an enabling technology that may lead to high performance back-end panels and logic circuits that consumer electronics requires.

The contribution by Zhengbang Wang and Christof Wöll from Karlsruhe Institute of Technology (KIT) (Germany) introduces an emerging class of low-dimensional nanomaterials, metal-organic frameworks (MOFs), that are encountering the interest of materials scientists for the next generation of hybrid organic/inorganic optoelectronics, photonics and sensing devices. In particular, the authors discuss the approach to MOFs based on the programmed layer-by-layer assembly technique, which enables exquisite control over the MOF architecture on surfaces (SURMOFs) across large areas and with very high control of order and orientation. The relevant properties and device applications are finally reviewed.

This special section well reflects the breadth of this burgeoning and interdisciplinary field of science, which holds great potential for technological breakthroughs. We hope the readers of *Advanced Materials Technologies* find these contributions inspiring in terms of the importance of devising novel approaches, based on both knowledge and chemical creativity, for the technology of organic devices.

With best regards,
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