Molecular and Polymeric Organic Semiconductors and their Applications in Plastic Optoelectronic and Photonic Devices

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The use of molecular and conjugated polymer semiconducting materials represents a very attractive alternative technological approach, compared to more conventional semiconductor technologies (such as Si technology), for the fabrication of novel optoelectronic and photonic devices due to their solution processability, facile tunability of their optical and electronic properties, low-cost and large-area fabrication on flexible substrates using various processing techniques, compatible with roll-to-roll printing for large-scale manufacturing. Polymer light-emitting diodes (PLEDs) and photovoltaic cells (PVs) are the two applications closest to commercialization to date. Both devices are fabricated with a light-emitting or a photoactive layer, respectively, sandwiched between two dissimilar electrodes, one of which needs to be transparent to light, on rigid glass or flexible plastic substrates. One of the critical issues for commercialization is the high performance device operation in air that requires balanced and facile charge injection and collection, at the corresponding electrodes, for PLEDs and PVs, respectively. Air stability, typically, requires the use of high workfunction metal cathodes such as Aluminum (Al). Al, however, limits electron injection in PLEDs due to the low electron affinity of most polymers, resulting in lower electroluminescence quantum efficiency and large driving voltage. In PVs, optical interference effects at the highly reflective Al surface may also limit bulk photogeneration, due to the reduced optical-electric field near the electrode, thus reducing the produced photocurrent.

In this talk, I will focus on demonstrating two strategies that we have developed for improving PLED and PV performance with regard to the aforementioned hurdles. In particular, I will report that the combination of polymer semiconductors with either novel inorganic molecular or metal oxides that are robust, transparent in the visible spectral region and easily processable, either by solution or by vapor deposition, can result in enhanced device performance. As two examples, a family of water soluble inorganic molecular oxides (polyoxometalates, POMs) and a series of metal oxides (reduced during evaporation) that can be both deposited as thin interlayers between the active layer and Al will be reported and their influence on device characteristics will be probed by employing spectroscopic, morphological and optical-electrical measurements.