

From Surface Science to Device Engineering in Organic Optoelectronics

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One of the important factors determining the performance of organic optoelectronic devices is the current efficiency of devices. We will present a systematic study on the relations between the device performance and interactions at the metal-organic and organic-organic interfaces. The effects of gap states and energy level alignments on the carrier injection mechanisms in the organic light emitting devices are investigated. The performances of devices with various combinations of anode and cathode structures are compared to find out effects of interfacial band alignments on turn-on voltages of OLEDs. To find out the key factors affecting carrier injection efficiency, the interfacial electronic structures and chemical properties were then studied with using X-ray and ultra violet photoemission spectroscopy (XPS and UPS). XPS and UPS data indicate that although energy alignments are still the keys to the efficient carrier injections, the gap states, in these cases, play more important roles to help the carriers move over the barriers and inject into the organic materials. The origins of the gap states will also be discussed.

On the other hand, while the current density versus voltage (J-V) characteristics can only evaluate the performance of OLEDs after they start to conduct current, the impedance versus voltage (Z-V) characteristic can be used to explore more electrical properties of devices even before they were turned on. It has been demonstrated that the accumulation charges at organic interfaces in OLED devices can be observed by Z-V characteristics measurement. We carried out Z-V experiments on devices with several combinations of hole transport layers (HTLs) and electron transport layers (ETLs). We found that the accumulation charges are caused by the extremely different mobility of hole and electron in HTL and ETL, respectively.