Horizontal Orientation of Planar Type-Hole Transport Molecules and their Application for Organic Light-Emitting Diodes Aimed for Low Driving Voltage

Organic light-emitting diodes (OLEDs) continue to be of great interest because they realize not only high energy conversion efficiency but also mechanically flexible and lightweight display and lighting applications. Recently, large optical anisotropies were identified in films of hole and electron transport materials such as TPT1 and Bpy-OXD having rather long and planar backbone structures. The method of wide-range variable angle spectroscopic ellipsometry (VASE) clarified that the molecules having a long rod-like structure show horizontal orientation on any underlying layers. Also, high performance optical and electrical characteristics were demonstrated, based on the enhancement of π-π interaction between adjacent molecules. In this study, we further developed novel molecular structures of B-DDP, T-DDP, BT-DDP aimed for the enhancement of horizontal orientation by introduction of our idea of two-dimensional planar structures having rather intense π-π interaction, leading to further low driving voltage in OLEDs. S is orientation order parameter (S=−0.5: completely parallel, S=0: randomly oriented, S=1: completely perpendicular to the surface). In the DDP derivatives, the order of S is BT-DDP (−0.23) < T-DDP (−0.18) < B-DDP (−0.11) < α-NPD (−0.01). In the OLED characteristics, compared with α-NPD, the use of DDP derivatives resulted in lower driving voltage. In particular, BT-DDP showed the lowest driving voltage which is consistent with the VASE result. We clarified that the ITO/ BT-DDP interface provides small energy for hole injection probably due to the planar orientation of BT-DDP on an ITO surface.