TTP-119

Effects of multi-stacked hybrid encapsulation layers on the electrical characteristics of flexible organic field effect transistors

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One of the critical issues for applications of flexible organic thin film transistors (OTFTs) for flexible electronic systems is the electrical stabilities of the OTFT devices, including variation of the current on/off ratio (I_{on}/I_{off}), leakage current, threshold voltage, and hysteresis, under repetitive mechanical deformation. In particular, repetitive mechanical deformation accelerates the degradation of device performance at the ambient environment. In this work, electrical stabilities of the pentacene organic thin film transistors (OTFTs) employing multi-stack hybrid encapsulation layers were investigated under mechanical cyclic bending. Flexible bottom-gated pentacene-based OTFTs fabricated on flexible polyimide substrate with poly-4-vinyl phenol (PVP) dielectric as a gate dielectric were encapsulated by the plasma-deposited organic layer and atomic layer deposited inorganic layer. For cyclic bending experiment of flexible OTFTs, the devices were cyclically bent up to 10^5 times with 5mm bending radius. In the most of the devices after 10^5 times of bending cycles, the off-current of the OTFT with no encapsulation layers was quickly increased due to increases in the conductivity of the pentacene caused by doping effects from O_2 and H_2O in the atmosphere, which leads to decrease in the I_{on}/I_{off} and increase in the hysteresis. With encapsulation layers, however, the electrical stabilities of the OTFTs were improved significantly. In particular, the OTFTs with multi-stack hybrid encapsulation layer showed the best electrical stabilities up to the bending cycles of 10^5 times compared to the devices with single organic encapsulation layer. Changes in electrical properties of cyclically bent OTFTs with encapsulation layers will be discussed in detail.