

On the mechanism of the hysteresis and offset of current–voltage characteristics of diodes based on organic materials

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Abstract

Experimentally observed peculiar features, like hysteresis and offset of current–voltage (*IV*) characteristics, of Ag/copper phthalocyanine (CuPc)/ITO prototype devices are analyzed alternately in terms of bulk trapping of electronic charges, dielectric relaxation and reduction/oxidation (redox) reaction of mobile ionic species at the ITO electrode. Scanning the bias of the ITO electrode from reverse (negative) to forward voltages at rates corresponding to delays between successive current readings shorter than ≈ 10 s, the measured current passes through zero at significant negative potentials (offsets) before reaching zero potential. The current, however, is minimal close to zero potential when the scan direction is reversed. In order to elucidate the most probable mechanism of the offset, effects of several physical parameters have been considered: density of mobile ions or deep trap levels, delay time between two successive measurements separated by a potential step ΔV , bulk conductivity $\sigma(T)$ of the organic material and temperature T . For both the charge capture/emission at traps and the dielectric relaxation involving the capacitance C_d of a depletion region, unrealistic trap (charged defect) concentrations are needed to comply with the experiment. Oxidation of the initially reduced (neutral) species, accompanied by an irreversible homogeneous chemical reaction of the reduced species, has also been considered. Still, two consecutive voltammetric cycles provided identical results, thereby making this option questionable. The most reliable non-conflicting interpretation is the charging of a double ionic layer capacitance at the CuPc/ITO interface through the high resistance of the "neutral" bulk of CuPc. The origin of the double layer is the protonation of CuPc as a consequence of the chemical treatment of ITO prior to CuPc deposition.