Abstract

The emergence of solution processed organic thin film transistors (OTFTs) is poised to have a significant impact on the development of many large area organic electronic applications such as displays, sensors, e-paper and identification tags. Although TIPS-pentacene is widely studied for OTFT applications but the interface formation with dielectric layer plays an important role in charge transport processes. The careful optimization of the interface formation between PVP dielectric and TIPS-pentacene (organic semiconductor) helps to increase the mobility and stability of these OTFT devices but the underlying physical mechanisms are not well understood. The scope of this thesis is to explore the charge processes at PVP/TIPS-pentacene interface by using drain current transient techniques under various bias (V_{GS} and V_{DS}) polarities and different white light illumination conditions. Throughout this work we have used bottom gate top contact OTFT structure given as: ITO|PVP|TIPS-Pentacene|Gold.

Drain-current (I_{DS}) transients have been measured to study the nature of defect states and their energetic distribution in TIPS-pentacene OTFTs. By switching V_{GS} under different OFF and ON states at constant V_{DS}, the decrease in I_{DS} has been investigated in wide temperature range (293K to 343K) and concluded that emission of trapped electrons causes I_{DS} decay when the device is switched on. Two dominant electron traps with the activation energies of 0.14 and 0.20 eV are identified of which the former is discrete and the latter continuously distributed. An isothermal Time Analyzed Transient Spectroscopy (TATS) technique has been used for detail analysis. For smaller V_{GS} values electron capture continues to occur leading to increasing I_{DS} transients. The nature of transients is observed to be change with both the change of isothermal switching conditions, and with temperature for the same switching sequence. A broad framework of trapping phenomena is developed to describe this whole range of transient behavior.

White light photoresponse on OTFTs has been studied by varying the illumination intensity using a calibrated commercial 0.5 Watt white LED. With increasing light intensity from dark to 385mW/cm^2, there is a significant shift in threshold voltage while the field-effect mobility remains unchanged. The OTFT shows large photoresponse under white light illumination due to exponential tail states with characteristic energy parameter of 86meV. Persistent photocurrent (PPC) and its quenching are attributed to negatively charged defects. Their electrical signature and possible origin has been discussed in detail. We propose that two specific defects responsible for the PPC phenomena occur at the dielectric and organic semiconductor interface in the OTFT device structures.

Long term transients following sequential biasing has been studied to distinguish between bias stress effects and degradation of TIPS-pentacene OTFT devices. We investigate the bias stress effect by taking long I_{DS} transients at various V_{GS} and V_{DS} values while degradation of OTFTs has been observed by measuring I_{DS}-V_{GS} characteristics at different intervals over a period of one month. A phenomenological model is used to explain the non-exponential decaying transients. Bias stress is a reversible phenomenon while degradation is irreversible because the molecule is chemically changed in the latter case. The possible origin of the defects responsible for the phenomena is discussed.