Abstract

Organic Field Effect Transistors (OFETs) have attracted tremendous research interest due to their low cost, flexible, large area and environmental friendly electronic applications. In this dissertation, we have focused on the development of novel techniques to enhance the electrical and optical performance of the OFET devices with polymer gate dielectrics and low-cost source and drain metal electrodes.

High leakage current and presence of numerous polar hydroxyl groups have often appeared as severe performance obstacles for polyvinyl alcohol (PVA) on its application in OFET devices. A novel functionalization and chain structure modification technique have been demonstrated to enhance its efficiency as a gate insulating layer through the use of glyoxal crosslinker. Solvent induced dielectric property modulation of poly (methyl methacrylate) (PMMA) gate dielectric has been studied and its impact on the electrical and optical performances of the transistors has been explored. Detailed investigations on the polymer bulk and surface properties revealed that the choice of solvents can strongly influence its micro-molecular structure, dipolar orientation and surface chemical composition which consequently, affect the device performance and stability by controlling the leakage characteristics, capacitance density, trap formation mechanism and charge trapping behaviour at dielectric/semiconductor interface.

We have investigated on another major limitation of the OFET devices, high contact resistance and poor charge injection at the metal/semiconductor interface. We've demonstrated a simple yet highly efficient contact modification approach to enhance the carrier injection efficiency through the incorporation of a vacuum sublimated TPD interlayer between the electrodes and the active semiconducting layer. The efficacy of TPD has been studied in the context of the change in active layer morphological properties and energy level alignments. The role of substrate temperature in the pentacene grain structure and its electronic states distribution has been investigated and also correlated with the interfacial contact resistance and photoresponse of the OFET devices.

Our investigations revealed the efficacy of high molecular weight PMMA and its plasma treatment in effectively improving the low light detectivity of the phototransistors. Plasma treatment induced improvement in the device photoresponse has been attributed to the generation of polar surface functionalities which efficiently enhance the number of free holes in the channel region by trapping the photo-generated electrons at the interface.