INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Programme of Study	:	Ph.D.

Thesis Title : Design and Synthesis of Perylenediimide, Naphthalenediimide Based n-Type Organic Semiconducting Polymers, Small molecules: Fabrication of High Performance Organic Field - Effect Transistors

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SHORT ABSTRACT

Four new n-channel naphthalene diimide (NDI) and perylene diimide (PDI) copolymers (NDI-Ph, NDI-BT, PDI-Ph, and PDI-BT) were synthesized and their solution processed organic thin film transistor (OTFT) devices fabricated. These copolymers possess crystalline domains, annealing their films induced crystalline phases in the thin film structures with a very high degree of enhancement in crystallinity. Remarkable enhancements in the electron transport behavior for all the four copolymers were achieved on improving the intermolecular interactions in their thin film structures. The intermolecular interactions in the thin film state on the macro scale, facilitating improved and higher charge carrier transport in annealed devices as compared to the as-spun devices that have lesser crystalline phases. These copolymers demonstrated electron mobility enhancement of several orders and are reported to be as high as 0.8 $cm^2 V^{-1} s^{-1}$ and 0.2 $cm^2 V^{-1} s^{-1}$ with I_{on}/I_{off} ratios 10^5 for NDI-Ph and NDI-BT, while those of PDI-Ph and PDI-BT are 0.04 $cm^2 V^{-1} s^{-1}$ and 0.032 $cm^2 V^{-1} s^{-1}$, respectively, with I_{on}/I_{off} ratios of 10^3–10^4.

1,7-Dibromo - N,N'- bis (octadecyl) -3, 4, 9, 10- perylene tetracarboxylic diimide (Br_2PTCDI-C18) molecule based n-type organic field-effect transistors (OFETs), on low cost glass substrate at different channel lengths were fabricated. Anodized alumina (Al_2O_3) along with polymer dielectric films, viz. Poly vinyl alcohol (PVA) or Poly methyl methacrylate (PMMA) were used to fabricate the devices. The effects of a thin Hexamethyldisilazane (HMDS) layer on the performance of OFETs including the contact resistance were studied with the channel length variations. The devices with PVA dielectric material exhibited the highest mobility of 0.012-0.025 $cm^2 V^{-1} s^{-1}$ irrespective of varying the channel length from 25 μm to 190 μm. The on/off ratios and electrical stabilities of these devices were significantly enhanced by the surface modification of the PVA or PMMA dielectric layers with a thin layer of HMDS. The stability of the devices with respect to the bias stress measurements for devices with varying channel length and

surface modification were systematically investigated. A detailed analysis of the contact resistance, oxide gate dielectrics modified with polymer dielectric materials, influence of thin HMDS layer on the electrical properties and other parameters on top-contact bottom-gate configured n-type OFETs were studied.

Low cost, flexible, ambient stable, low operating voltage and balanced ambipolar organic field-effect transistors were fabricated with plastic over-head projector (OHP) sheets as transparent substrates using laminated Al foil as a gate electrode without any mechanical or electrochemical polishing, using Br_2PTCDI-C18 (n-channel) and copper phthalocyanine (CuPc) (p-channel) as the active materials and PMMA/PVA or C-PVA (cross-linked PVA) as the dielectric material. Hetero-structured OFET devices exhibited an ambipolar nature with operating voltages of 10 V and 3 V for the PMMA/PVA and C-PVA dielectric materials respectively. The electron and hole mobilities achieved are as high as 1.2 x 10^2 cm^2 V^{-1} s^{-1} and 5.5 x 10^3 cm^2 V^{-1} s^{-1} respectively. Electrical, environmental and long-term stabilities of the devices were studied.