Public Abstract
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Title:Low dielectric constant-based organic field-effect transistors and metal-insulator-semiconductor capacitors

Until recently, semiconductor optoelectronics research has been restricted to the conventional inorganic semiconducting materials. But lately, owing to the discovery in 1977 of the first highly conductive polymer â€“ polyacetylene, by A. J. Heeger, H. Shirakawa, and Alan G. MacDiamid (Nobel Prize in Chemistry in 2000), intense research efforts have been directed at organic semiconductors and devices resulting in the birth of organic electronics. Organic electronics is basically electronic devices made using organic materials (organic dielectrics, conjugated and small molecule semiconductors). Typical organic electronics include organic field-effect transistors (OFETs), organic light-emitting diodes (OLEDs) and organic photovoltaics. The interest and increased research activities in solution-processable organic devices are due to their promise in large-area electronics fabricated on flexible substrates using low-cost and unconventional means such as spincoating, low/room temperature printing, and roll-to-roll processing. Interestingly, some of the best OFETs have shown performances that compare favorably well with amorphous silicon (inorganic) thin film transistors. However, considerable challenges still need to be addressed in order to reap the full benefits of organic electronics. Such challenges include the inherent problems of polymer dissolution and solvent-selectivity particularly encountered in the fabrication of all-polymer devices as well as the difficultly in fabricating stable and low-operating voltage OFETs owing to the low dielectric constants of conventional polymer dielectric materials.

This work describes a study of PFB and pentacene-based organic field-effect transistors (OFET) and metal-insulator-semiconductor (MIS) capacitors with low dielectric constant poly(methyl methacrylate) (PMMA), poly(4-vinyl phenol) (PVP) and cross-linked PVP (c-PVP) gate dielectrics. A physical method â€“ matrix assisted pulsed laser evaporation (MAPLE) â€“ of fabricating all-polymer field-effect transistors and MIS capacitors that circumvents inherent polymer dissolution and solvent-selectivity problems, is demonstrated. Pentacene-based OFETs incorporating PMMA and PVP gate dielectrics usually have high operating voltages related to the thickness of the dielectric layer. Reduced PMMA layer thickness was obtained by dissolving the PMMA in propylene carbonate (PC). The resulting pentacene-based transistors exhibited very low operating voltages (below -3 V), minimal hysteresis in their transfer characteristics, and decent electrical performance. Low-voltage (within -2 V) operation using thin (â‰¤ 80 nm) low-k and hydrophilic PVP and c-PVP dielectric layers obtained via dissolution in PC, is demonstrated to be a robust means of achieving improved electrical characteristics and high operational stability in OFETs incorporating PVP and c-PVP dielectrics.

In summary, this study demonstrates that with a proper choice of solvent, thin, non-crosslinked and single PMMA dielectric layers could be used to achieve stable and very low-operating voltage OFETs (below -3 V); hence, opening up the prospects of a possible utilization of less-polar and lowâ€“k dielectric polymers in realizing device-quality, stable, and low-voltage transistors that could be employed in the design of practical circuits.