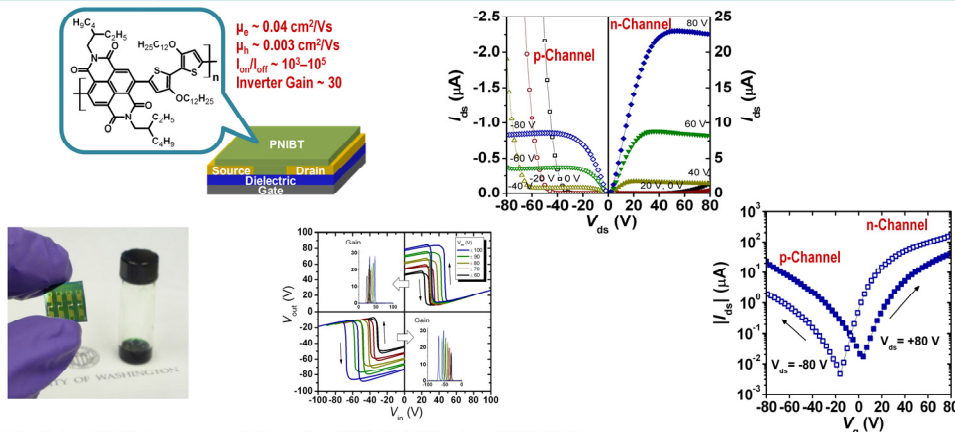




Ambipolar Polymer Field-Effect Transistors and Integrated Complementary Circuits



ACHIEVEMENTS: High-mobility ambipolar field-effect transistors and high-gain inverters have been demonstrated by simple solution casting of a new polymer semiconductor. The transistors showed high mobilities of both electrons and holes (0.04 cm²/Vs and 0.003 cm²/Vs) and high on/off current ratios (10³-10⁵). The circuit performance represented by output voltage gain of a complementary inverter (~30) is the best among reported values from such single component polymer semiconductors. This result suggests that high-performance organic electronic devices can be achieved without patterning of p- and n-type semiconductors.



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IMPACT: Ambipolar organic field-effect transistors, which are capable of both p- and n-channel operations, are gaining attention as an alternative approach to mimicking complementary metal-oxide semiconductor (CMOS) digital integrated circuits for achieving high-performance and cost-effective circuits in organic electronics. In this research, we have developed high-mobility ambipolar field-effect transistors and high-gain inverters based on a new donor-acceptor polymer semiconductor. The transistors showed high mobilities of electrons and holes and high on/off current ratios. The circuit performance represented by output voltage gain is the best among reported values from such single-component polymer semiconductors.

DISCUSSION: We have demonstrated high-mobility ambipolar field-effect transistors and high-gain inverters by a simple solution-casting of a new donor-acceptor polymer semiconductor. The new polymer semiconductor has a narrow optical band gap (~1.1 eV) and reversible redox potentials. We found that the polymer has short-range lamellar self-ordering in thin films with distinct nanofibrillar morphology. Large bathochromic shift of thin film absorption spectra after thermal annealing at different temperatures was also observed. The annealing temperature has a positive effect on the charge carrier mobility of the thin film transistors, resulting in electron mobility of 0.04 cm²/Vs and hole mobility of 0.003 cm²/Vs. On/off current ratios in the transistors were routinely observed to be as high as 100,000. We have also integrated the ambipolar transistors into a simple logic circuit such as an inverter. Sharp switching of output voltage characteristics with symmetric circuit operations of the complementary inverters was obtained without patterning of p- and n-type semiconductors. The voltage gain ($-dV_{\text{out}}/dV_{\text{in}}$) of ~30 is among the best reported values from such single-component polymer semiconductors with single metal electrodes.

More details can be found in: F. S. Kim et al. Adv. Mater. (2010), in press; available online (DOI: 10.1002/adma.200901819).

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