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The Influence of Morphology and Interface Treatment on Organic 6,13-bis (triisopropylsilylethynyl)-Pentacene Field-Effect Transistors

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Abstract : For the development of electronics, organic semiconductors are of great interest due to their adjustable optical and electrical properties. Especially for spintronic applications they are interesting because of their weak spin scattering, which leads to longer spin life times compared to inorganic semiconductors. It was shown that some organic materials change their resistance if an external magnetic field is applied. Pentacene is one of the materials which exhibit the so called photoinduced magnetoresistance which results in a modulation of photocurrent when varying the external magnetic field. Also the soluble derivate of pentacene, the 6,13-bis (triisopropylsilylethynyl)-pentacene (TIPS-pentacene) exhibits the same negative magnetoresistance. Aiming for simpler fabrication processes, in this work, we compare TIPS-pentacene organic field effect transistors (OFETs) made from solution with those fabricated by thermal evaporation. Because of the different processing, the TIPS-pentacene thin films exhibit different morphologies in terms of crystal size and homogeneity of the substrate coverage. On the other hand, the interface treatment is known to have a high influence on the threshold voltage, eliminating trap states of silicon oxide at the gate electrode and thereby changing the electrical switching response of the transistors. Therefore, we investigate the influence of interface treatment using octadecyltrichlorosilane (OTS) or using a simple cleaning procedure with acetone, ethanol, and deionized water. The transistors consist of a prestructured OFET substrates including gate, source, and drain electrodes, on top of which TIPS-pentacene dissolved in a mixture of tetralin and toluene is deposited by drop-, spray-, and spin-coating. Thereafter we keep the sample for one hour at a temperature of 60 °C. For the transistor fabrication by thermal evaporation the prestructured OFET substrates are also kept at a temperature of 60 °C during deposition with a rate of 0.3 nm/min and at a pressure below 10-6 mbar. The OFETs are characterized by means of optical microscopy in order to determine the overall quality of the sample, i.e. crystal size and coverage of the channel region. The output and transfer characteristics are measured in the dark and under illumination provided by a white light LED in the spectral range from 450 nm to 650 nm with a power density of (8±2) mW/cm2.

Keywords : organic field effect transistors, solution processed, surface treatment, TIPS-pentacene
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