From Ambipolar to Unipolar Organic Field-Effect Transistors: A Strategy Towards CMOS Technology

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Organic CMOS technology is a requirement for the overall success of organic electronics due to the necessity of reduced energy consumption in electrical circuits. This technology requires purely unipolar transistors to realize the unique properties of such complementary circuits. Since today most organic semiconductors exhibit ambipolar transport properties, strategies have to be investigated how such ambipolar characteristics can be engineered into purely unipolar transport [1]. In the present talk different strategies will be outlined that allow for the realization of such properties in an organic CMOS inverter through a suited design of the organic field-effect transistors. The importance of the electrode materials as well as the electronic structure of the gate insulator surface will be highlighted. It will be demonstrated how electron and hole transport can be initiated and suppressed by interface modification of the gate dielectric and how this modification can be utilized to generate pure unipolar p- and n-type OFETs [2,3]. Three different routes, all based on pentacene as the ambipolar semiconductor, will be discussed: (1) the route by choice of suited source- /drain-metals, (2) a chemical modification of the SiO_2 surface by passivation of electron traps through traces of Ca [2,3,4] and (3) by UV-modification of a polymer dielectric [5]. Finally a simple fabrication technique based on PMMA as gate dielectric, pentacene as semiconductor and Ca as source and drain electrode metals for both transistor types will be suggested. It will also be shown how scanning-Kelvin-probe-force-microscopy can be utilized to improve the understanding especially of the charge injection, transport and trapping in unipolar and ambipolar devices [6].

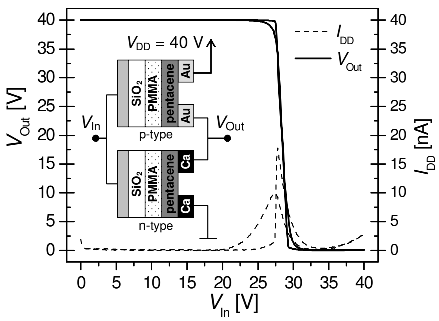

Fig. 1: Schematic setup of an organic CMOS inverter and the resulting inverter characteristics. The device consists of a PMMA gate dielectric, pentacene as the common semiconductor and either Ca/Ca electrodes for the n-type and Au/Au electrodes for the p-type transistors as source and drain metals, respectively.

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