Scaling Pentacene organic field-effect transistors down to the 20 nm regime

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Currently, there is significant interest in organic thin-film transistors (OTFT) due to their potential application in inexpensive, large-area electronics. However, carrier mobilities are typically low (<1cm^2/V s) and, to increase the OTFT drive current per unit area, there is a need for short-channel devices (below 10 μm).

Here, we report on the fabrication and electrical properties of short-channel OTFT. Palladium (Pd) source and drain electrodes were formed by e-beam lithography and lift-off, in order to obtain channel lengths down to the sub-20 nm range. Our selected organic semiconductor (Pentacene, Pc) was deposited from a Knudsen cell in a ultra-high vacuum evaporation system. Pc morphology has been optimized by varying both the evaporation and substrate temperatures. We have fabricated working devices with channel lengths from 10 μm down to 20 nm (see Fig. 1), covering 3 orders of magnitude in the channel length. The fabrication process has been optimized resulting in high (90%) yield of working devices. OTFT that employ Pc as the semiconducting layer work as p- channel accumulation- mode devices (see Fig. 2).

Similar transistors have also been fabricated using Permalloy (NiFe) electrodes. These ferromagnetic electrodes will allow us to explore spin-polarized currents in organic materials.

Figures

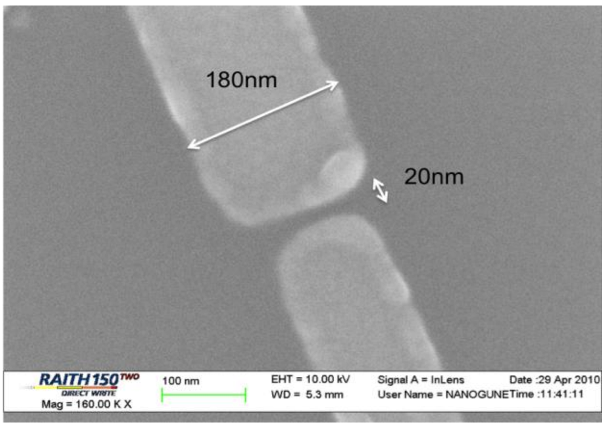

Figure 1: Palladium drain and source electrodes separated by a 20 nm gap.

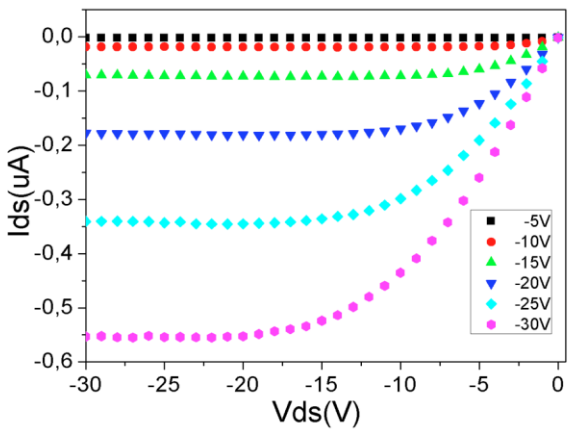

Figure 2: Drain-Source currents of a Palladium-Pentacene device, as a function of the Drain-Source voltage for different Gate-Source voltage from -5V to -30V.