Architecture contributions and attenuation of short channel effects in organic transistors

Anton Fernandez Fernandez*†1, Karin Zojer[1], and Egbert Zojer[1]

[1]Graz University of Technology (TU Graz) – Petersgasse 16/II 8010 Graz, Austria

Abstract

Organic thin film transistors still suffer from an insufficient stability and cannot compete with the performance of their inorganic counterparts. Nevertheless, highly promising advances in switching speeds were achieved upon aggressive scaling of device dimensions such as the channel length and the gate dielectric thickness [1]. The benefits of reducing the channel length, i.e., the separation of source and drain are, however, counteracted by non-desired short channel effects and increasingly dominant contact resistances. Introducing local doping near the metal electrode – semiconductor interface has been demonstrated to efficiently suppress the latter.[1] Theoretical work indicates that, without the benefit of doping, the contact resistance is strongly related to the efficiency of injection at the metal-semiconductor interfaces and depends not only on the carrier mobilities and injection barriers, but also on the device dimensions, the orientation of the injecting surface with respect to the semiconductor-insulator interface, and the point of operation. [2]

To provide a solid basis for a deeper understanding of the doping-induced effects at the contact interface, we investigate the interplay between short channel effects and injection for undoped devices. We utilize two-dimensional drift-diffusion-based simulations including the self-consistent consideration of thermionic and tunneling injection, interface recombination, and back drift, to determine the contact resistance and short channel effects directly from the simulation of the device at a given point of operation. The considered channel lengths vary by three orders of magnitudes, i.e., range between several micrometers to 300 nanometers and below. We particularly focus on how the onset and the extent of short channel effects for given material properties depend on the injection barrier and the actual device architecture, i.e., the staggered (top-contact bottom gate) or the coplanar (bottom-contact bottom-gate) device configuration.

Accepting bulk current as the source of saturation loss, we achieve a modest suppression by introducing a mesa/dielectric body in the active region to reduce the channel width and eliminate bulk current [3]. Further variations of this mesa structure are presented, pointing at which ones are desired to get closer to the ideal Gradual Channel Approximation behavior.

F. Ante et al. Small 7 (2011) 1186-1191, DOI: 10.1002/smll.201002254

M. Gruber et al., Adv. Funct. Mater. 23 (2013) 2941-2952, DOI: 10.1002/adfm.201203250.

J. Z. Wang et al. Appl. Phys. Lett. 89 (2006) 083513, DOI: 10.1063/1.2234724

*Speaker

†Corresponding author: anton.fernandez@tugraz.at