Photolithographically structured source/drain contacts for organic thin film transistors

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Introduction

Organic thin film transistors (OTFT) have great potential in electronic applications. For example, they find use in sensors and a variety of simple and cheap circuits. Organic electronics focuses on implementation fields, where low costs, large area production and the use of flexible and even biological substrates are essential.

Pentacene, an organic molecule consisting of five fused aromatic rings, has proven to be of great interest in TFTs. Though early attempts to employ organic active layers produced organic semiconductors with field-effect mobilities six orders of magnitude smaller than silica, pentacene TFTs with SiO_2 as gate-dielectric have recently been shown to have mobilities larger than 1 cm^2/Vs, rivalling those of amorphous silicon TFTs.

Organic dielectrics enable the use of simple processing techniques, such as spin- or dipcoating by being available in liquid or soluble form.

In this work we present organic TFTs with Pentacene as an active layer, organic and inorganic dielectric materials and a comparison of organic and inorganic source/drain contact materials. All electrodes (source, drain and gate) of the full-organic transistors were structured by photolithography.

Common inorganic gate

For these transistors, a common inorganic gate, consisting of highly doped silicon and an inorganic gate dielectric (200 nm SiO_2) was used. The Au and polyaniline source/drain contacts were structured photolithographically in bottom geometry directly on the dielectric material. A 50 nm PVCi layer was used as adhesive layer for polyaniline as well as Au. The active material of these transistors is a 50 nm thick pentacene layer on top of the source/drain contacts. The layout can be seen in side and in top view can be seen in figure 7. Figure 9 shows a comparison of the mobilities of pentacene with Au and polyaniline source/drain contacts.

Gold source/drain contacts

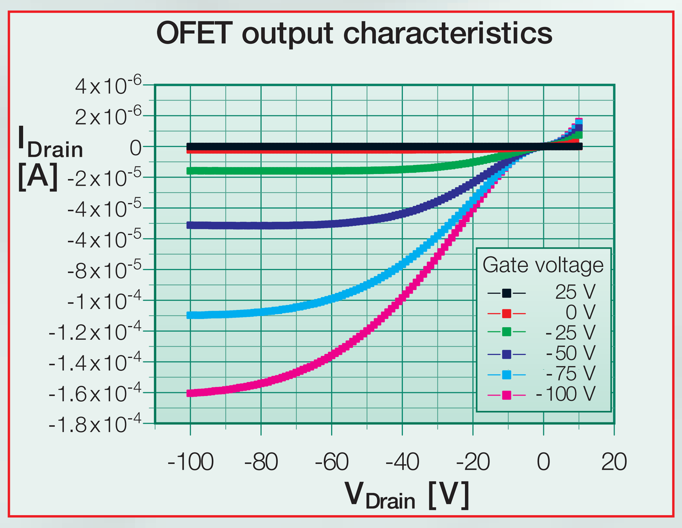

Figure 1: OFET output characteristics: gate: Si, dielectric: SiO_2 + PVCi, source-drain: Au semiconductor: pentacene

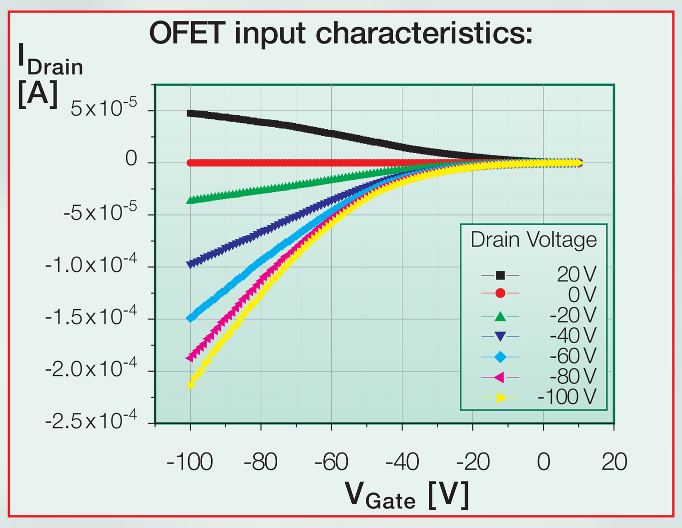

Figure 2: OFET input characteristics: gate: Si, dielectric: SiO_2 + PVCi, source-drain: Au semiconductor: pentacene

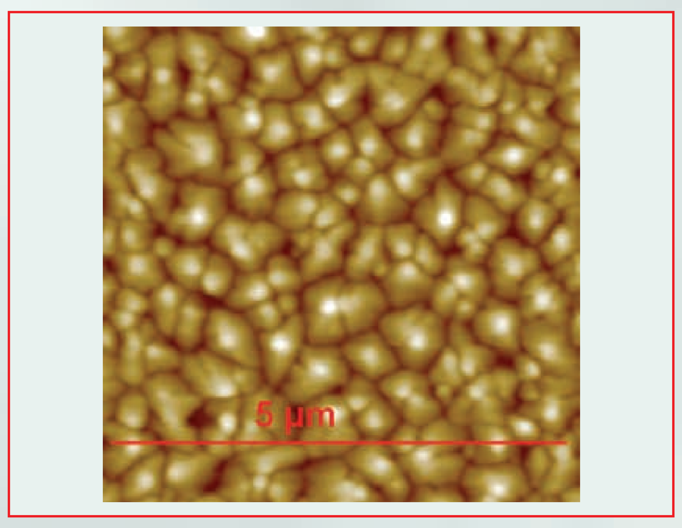

Figure 3: AFM-picture of pentacene on SiO_2 / PVCi, structured Au-s/d contacts

Polyaniline source/drain contacts

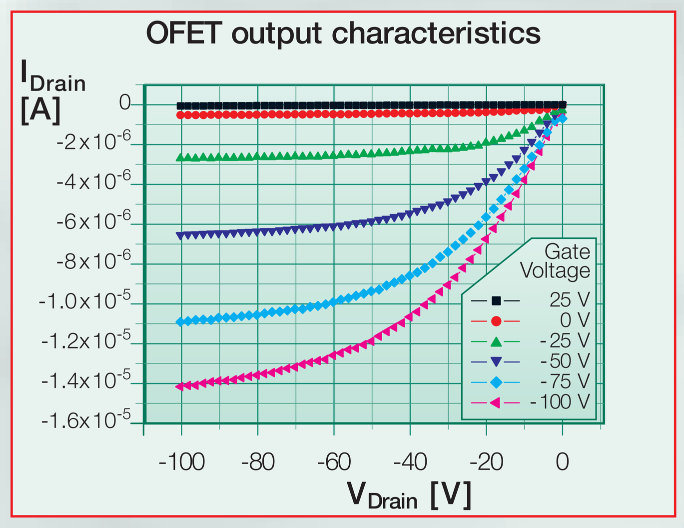

Figure 4: OFET output characteristics: gate: Si, dielectric: SiO_2 + PVCi, source-drain: Polyaniline semiconductor: pentacene

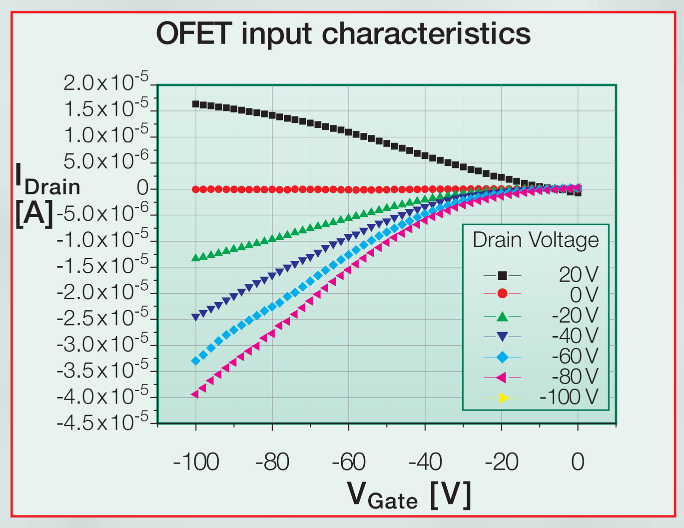

Figure 5: OFET input characteristics: gate: Si, dielectric: SiO_2 + PVCi, source-drain: Au semiconductor: pentacene

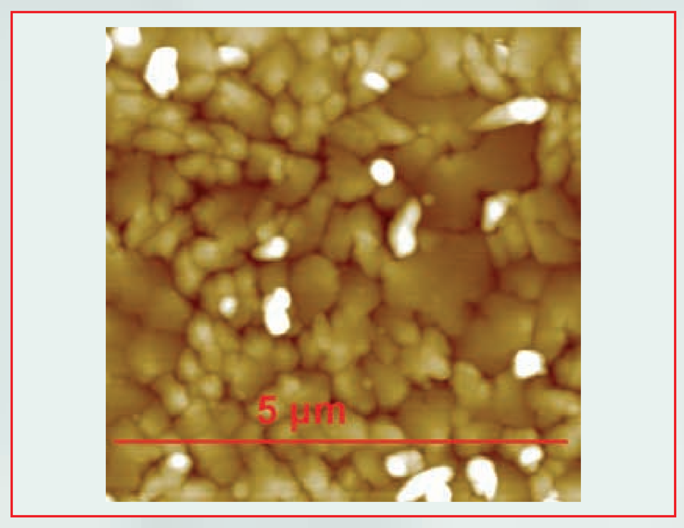

Figure 6: AFM-picture of pentacene on SiO_2 / PVCi; structured Polyaniline-source/drain-contacts

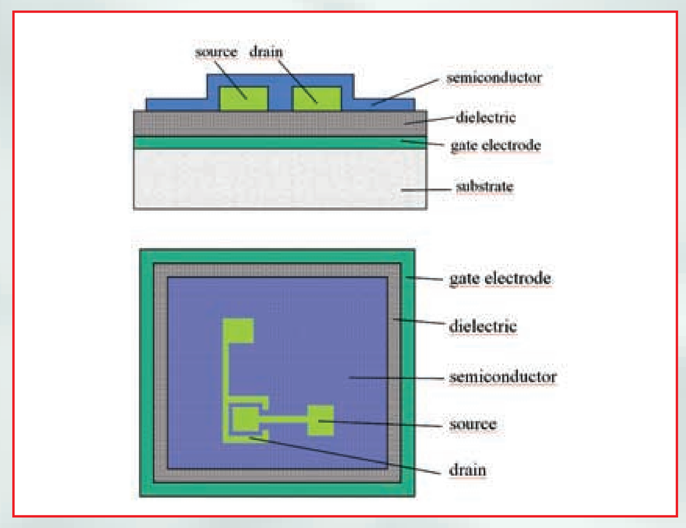

Figure 7: layout of an organic FET, source and drain contacts in bottom-geometry

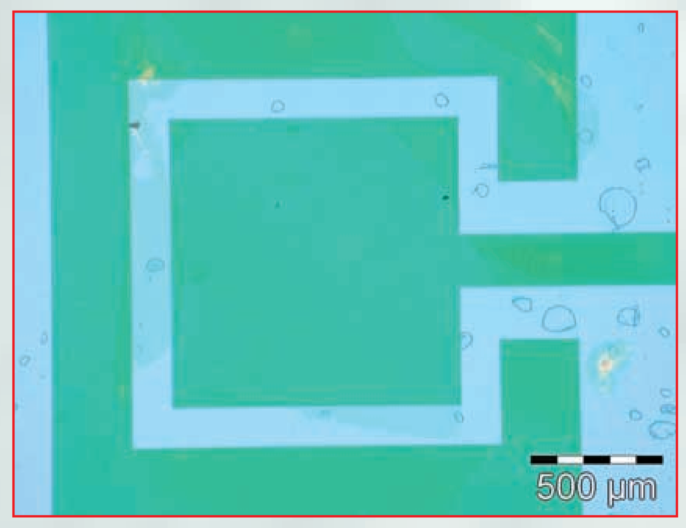

Figure 8: Photograph of photolithographically structured source/drain contacts made of polyaniline on SiO_2.

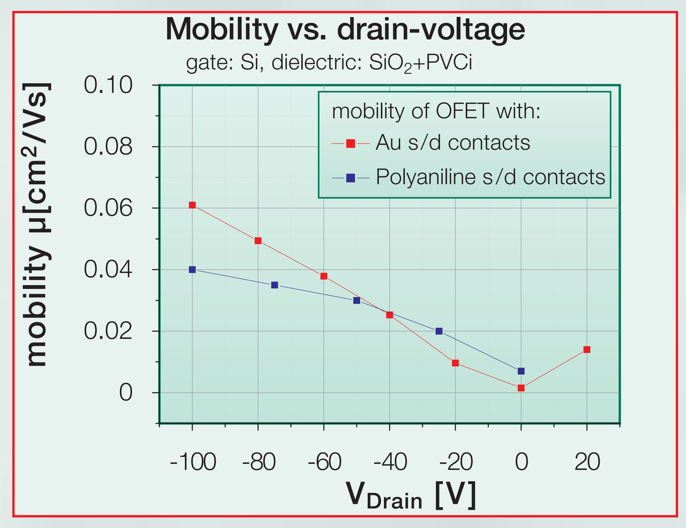

Figure 9: Comparison of mobilities of OFETs with Polyaniline- and Au- source/drain contacts in dependence of drain voltage; Si as common gate and SiO_2 as gate dielectric

Structured organic gate

The gate electrode was either made of Polyaniline or of Pdot on glass and a polymer-substrate, respectively. A 900 nm PMMA-layer served as gate dielectric, source and drain contacts, made of polyaniine, were also structured photolithographically. The layout is depicted in Figure 16 and Figure 17 shows a microscope-photograph of aligned source/drain and gate contacts. Figure 18 shows the comparison of the mobilities of pentacene in dependence of both investigated gate materials.

Polyaniline gate

Polyaniline source/drain contacts

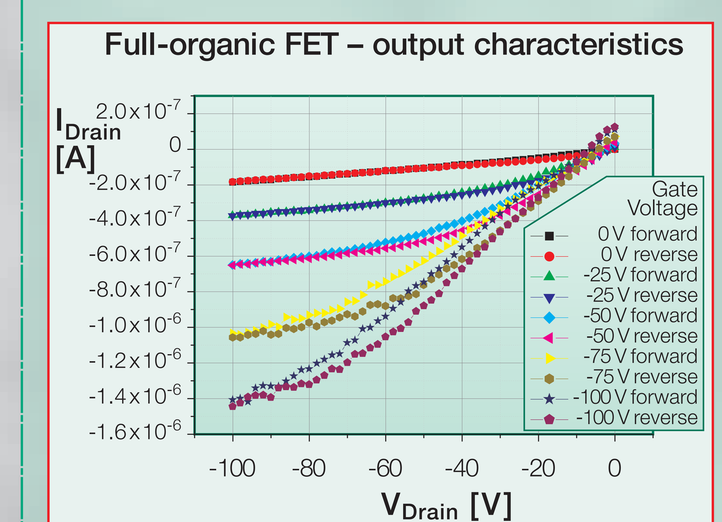

Figure 10: full organic FET output characteristics: gate: Polyaniline, dielectric: PMMA, source-drain: Polyaniline, semiconductor: pentacene

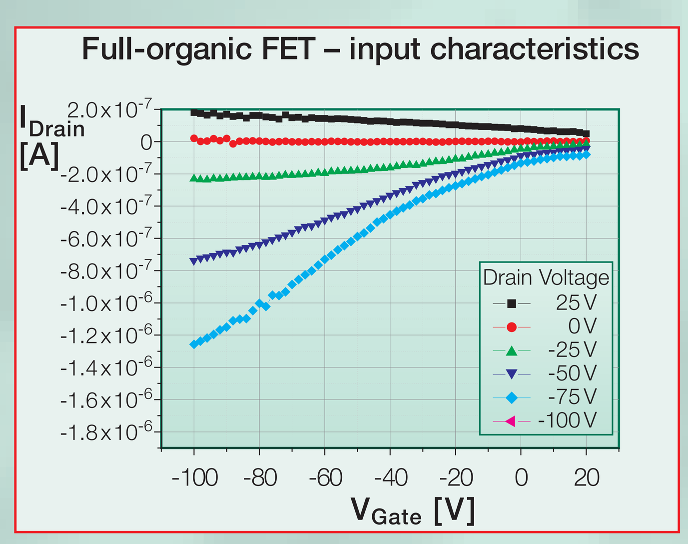

Figure 11: full organic FET input characteristics: gate: Polyaniline, dielectric: PMMA, source-drain: Polyaniline, semiconductor: pentacene

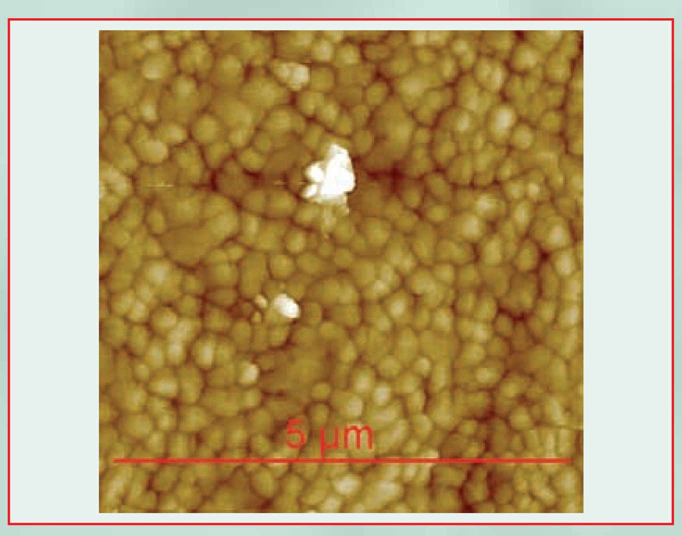

Figure 12: AFM-picture of pentacene on PMMA, Polyaniline source/drain contacts

Pdot gate

Polyaniline source/drain contacts

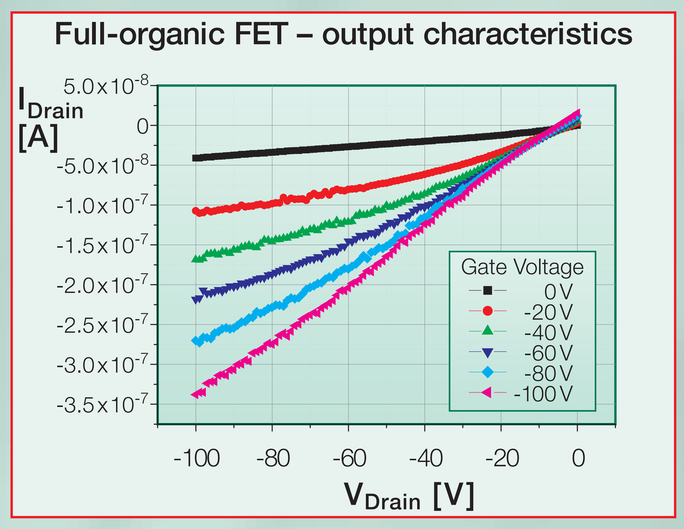

Figure 13: full organic FET output characteristics: gate: Pdot, dielectric: PMMA, source-drain: Polyaniline semiconductor: pentacene

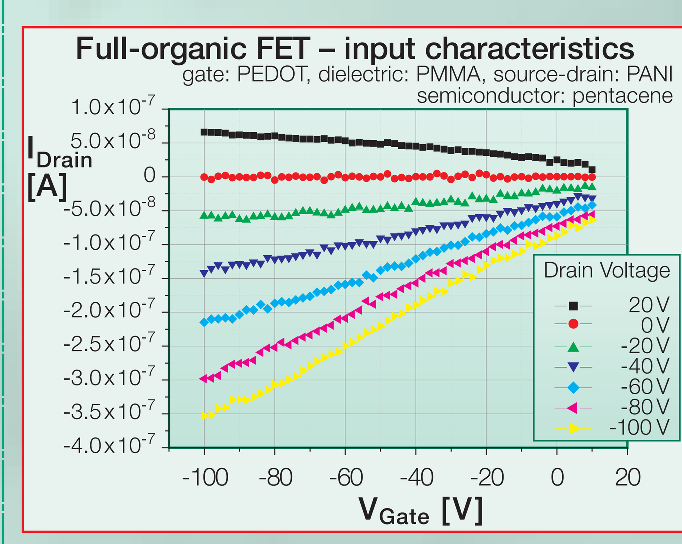

Figure 14: full organic FET input characteristics: gate: Pdot, dielectric: PMMA, source-drain: Polyaniline semiconductor: pentacene

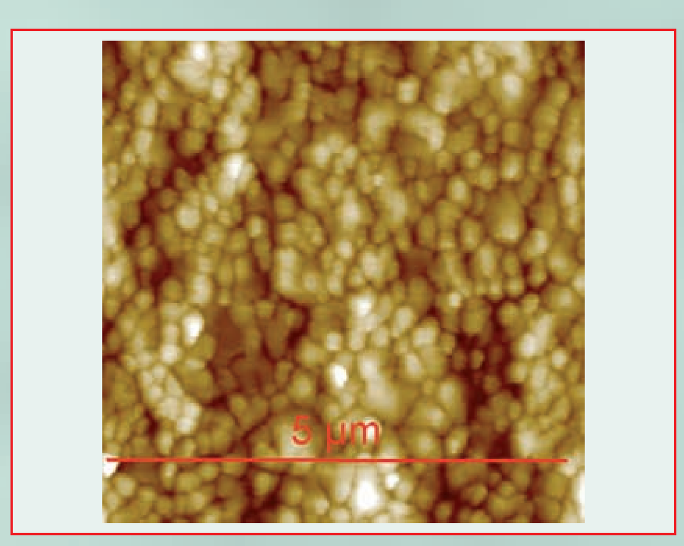

Figure 15: AFM-picture of pentacene on PMMA, Pdot source/drain contacts

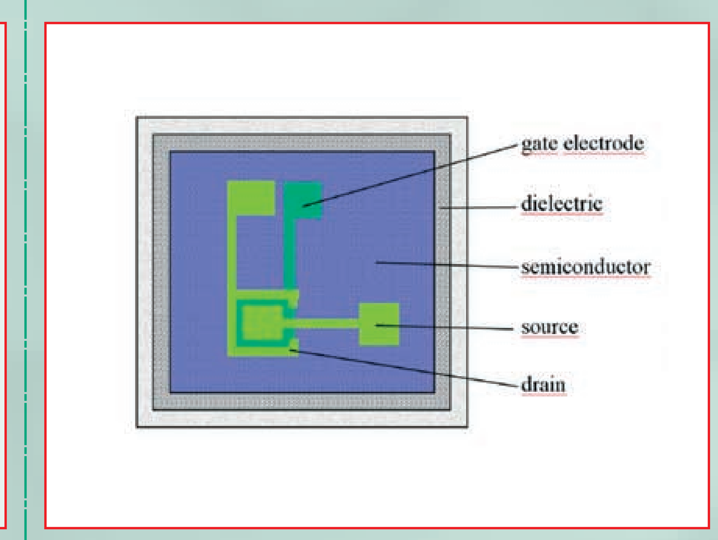

Figure 16: layout of an fully organic FET, structured gate, source and drain contacts in bottom-geometry

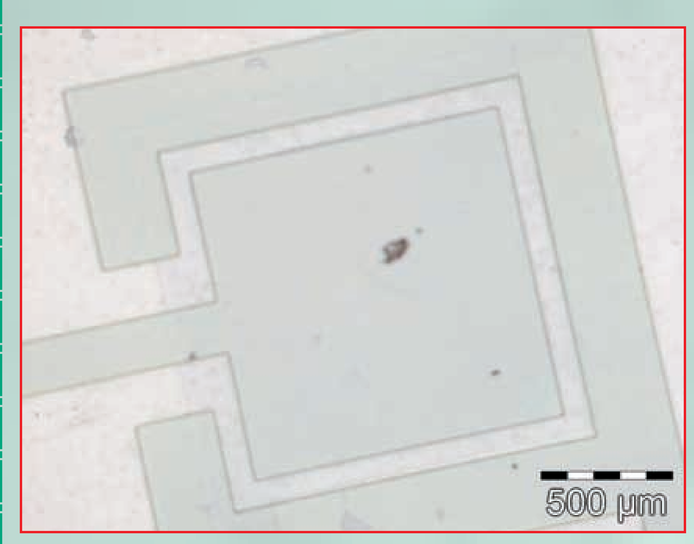

Figure 17: Photograph of aligned source/drain and gate contacts made of Polyaniline, PMMA as dielectric.

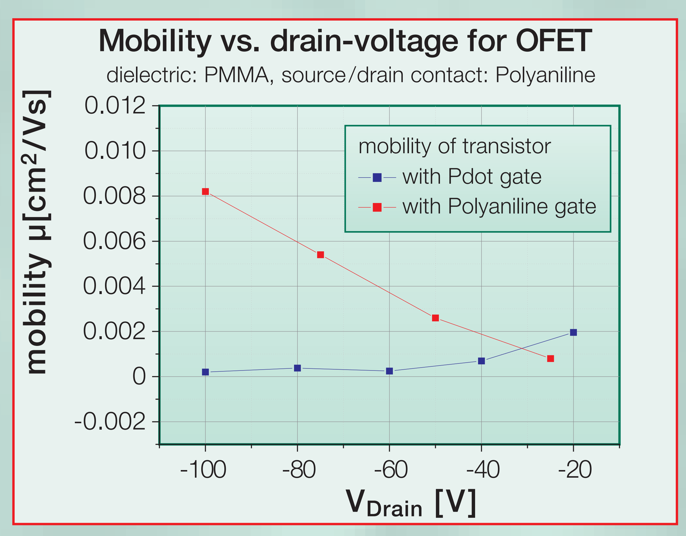

Figure 18: Comparison of mobilities of fully organic FETs of Polyaniline- and Pdot- gate-contact with Polyaniline as source/drain contacts and PMMA as gate dielectric in dependence of drain voltage

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