Vertical Organic Field Effect Transistors (V-OFETs) for Truly Flexible Displays

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Flexible electronic devices attract considerable interest in view of future revolutionizing applications such as foldable displays and wearable electronics. However, today's mainstream AMOLED backplane technologies such as low-temperature polycrystalline silicon (LTPS) or transparent conductive oxides (TCOs) are not well suited for truly flexible displays, which require bending more than 1000 times over <1 mm bending radius. Soft organic semiconductor materials are a natural choice for truly flexible backplanes on inexpensive plastic substrates [1], but the ability to uniformly drive high currents in high PPI backplanes based on organic thin film transistors (OTFTs) has not been demonstrated yet. It is commonly believed that new organic semiconductors (OSCs) with high mobilities >10 cm^2/Vs are required for this application in the conventional horizontal OTFT design.

In this contribution, we report on a novel design for organic thin film transistors, Novaled's vertical organic field-effect transistor (V-OFET) with superior current driving capabilities compared to state-of-the-art horizontal OTFTs [2]. The schematic structure of a V-OFET in staggered bottom-gate configuration is shown in Fig. 1. In contrast to OTFTs, the transistor channel in V-OFETs is perpendicular to the gate insulator surface. Thus the channel length L is not limited by the resolution of the horizontal patterning technique, but rather by the thickness of the source-drain insulator. Channel lengths in the range of 100 to 300 nm can be easily realized and, more importantly, scaled to large area substrates used in manufacturing lines.

Fig. 1 shows the transfer characteristics of a bottom-gate V-OFET device using a small-molecule commercial organic semiconductor. The same figure shows the characteristics of a reference horizontal device with same OSC and a channel length L = 30 µm. The electrical characteristics of the V-OFET device are comparable to a horizontal transistor with L = 1 µm based on an effective mobility of 0.5 cm^2/Vs. Both devices show a clear off-state, yielding similar on/off-ratios larger than 10^6, and same steep subthreshold swing .

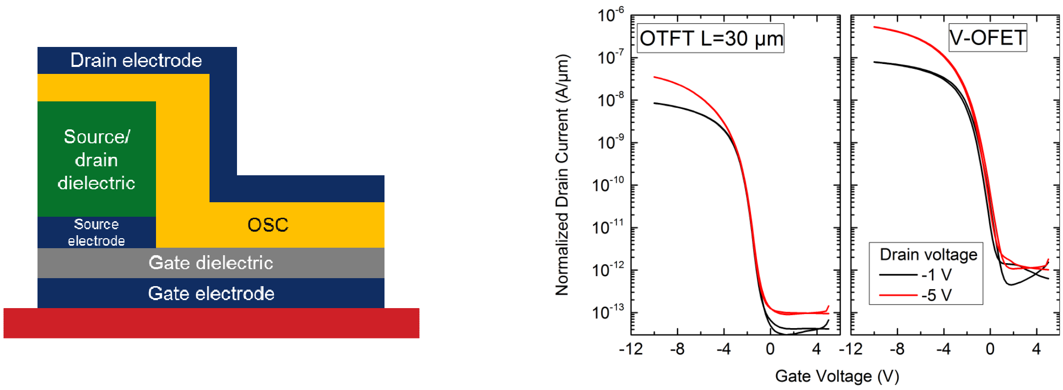

Fig. 1. Left: Schematic of a V-OFET device. Right: Transfer characteristics of a reference OTFT with channel length L = 30 µm and a V-OFET featuring the same semiconductor material.

In summary, we have presented a novel organic transistor architecture, the V-OFET. Our innovative transistor design achieves driving currents sufficient for high pixel-density AMOLED displays even with moderate-mobility organic semiconductors. Typically, on-currents of V-OFETs are more than 10 times higher compared to reference horizontal organic TFTs. Our current focus is the integration of V-OFETs into AMOLED display structures on low-cost, flexible plastic substrates.

References

1. T. Sekitani et al., *Nature Mater.* 9, 1015-1022 (2010).
2. H. Kleemann et al., *Small* 9, 3670-3677 (2013).