

A Generic Approach for Compact Modeling of Variability and Low-Frequency Noise in Organic Thin-Film Transistors

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SUMMARY

In organic thin-film transistors (OTFT), low-frequency noise (LFN) is dominated mainly by grain-boundary traps and mobility fluctuation [1]. Furthermore, OTFTs are sensitive to process variability. Charges being trapped in the channel region cause a local variation of the accumulated charge density, having impact on the threshold voltage of the device [2], [3] and reducing the effective carrier mobility in the channel by Coulomb scattering. Based on the results published in [3], [4], we present a generic physics-based modeling approach for drain-current fluctuations by carrier-number and correlated mobility fluctuations, which leads to similar expressions for drain-current variability and ΔN noise in OTFTs.

Measurements performed on fabricated OTFTs show drain-current variability ([5]). In [3] it has been shown that the drain-current variability in the subthreshold regime is dominated by carrier-number fluctuations, whereas for above threshold operation the mobility-fluctuation effect by correlated Coulomb scattering comes to the fore (Fig. 1).

In case of LFN, measurements on staggered DNTT OTFTs have shown that ΔN noise alone is not sufficient to describe the noise spectra in the deep subthreshold regime of operation (refer to Fig. 2) [4]. Here, LFN due to mobility fluctuation ($\Delta\mu$ noise) must be included.

In conclusion, following a generic modeling approach, the combined equations for carrier-number and correlated mobility fluctuations allow consideration drain-current variability and LFN noise in a charge-based compact model of OTFTs following similar expressions for all regions of operation. The results have been shown to be good agreement with measurements. However, for percolative mobility fluctuation dominant in operation below threshold additional expressions have to be considered for modeling LFN noise.

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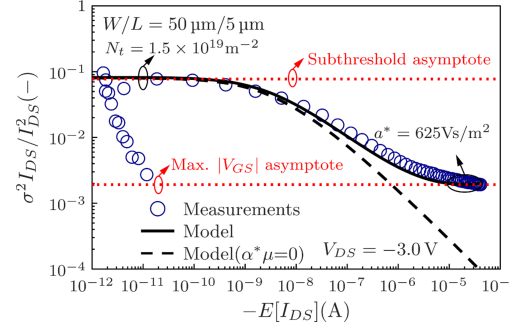


Fig. 1. Normalized drain-current variance $\sigma^2 I_D / I_D^2$ versus mean-value drain current $E[I_{DS}]$ for OTFTs with $L = 5 \mu\text{m}$, measured at $V_{DS} = -3.0 \text{ V}$ [3]. The experimental mean values were calculated over a population of 16 nominally identical transistors. Full line: model including, dashed line: without Coulomb scattering [3].

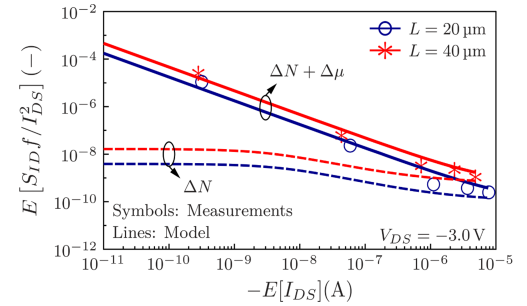


Fig. 2. Mean-value power spectral densities $E[S_{ID}/I_D^2]$ @ 1 Hz vs. drain current, measured at $V_{DS} = -3.0 \text{ V}$ [4]. Full line: model including, dashed line: without $\Delta\mu$ noise. The experimental mean values were calculated over a population of 15 nominally identical transistors [4].

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