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Organic Thin Film Transistors for Electronic Systems

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The surge of interest in organic thin film transistors (TFTs) has been motivated, on the one hand, by fundamental questions concerning the energetics and transport of localized carriers, and, on the other hand, by the practical advantages of electronic systems fabricated at low temperatures on flexible substrates. The overriding consideration for the usefulness of organic thin-film transistors for electronic systems has been the field-effect mobility. In this paper I will discuss materials-related factors other than mobility that influence the usefulness of organic TFTs. The subthreshold slope determines the voltage excursion that must take place below the threshold voltage to fully turn off the transistor. Typical organic TFTs have subthreshold slopes that are small compared to silicon devices, due to strongly localized states in energy gap between the more extended levels. The excursion required below threshold often has about the same magnitude as that required above threshold to reach a given level of on-current, and the speed of the system, as well as the power supply requirements, can be adversely affected by the additional required voltage swing. Organic TFTs use metallic or conducting polymer contacts that overlap the gate region, unlike the doped source and drain regions that are self-aligned to the gate in high-performance silicon technologies. A self-aligned process has not been developed for organic TFTs, and, as a result, in organic TFTs there are large parasitic capacitances that can limit system performance. If the amount of overlap is fixed by registration capabilities and can not be reduced as channel length L is reduced, the well-known silicon scaling law in which the upper frequency limit f_{max} scales as $1/L^2$ is modified to$f_{max} \sim 1/L$, altering significantly the economics of increased integration. The usefulness of organic TFTs is hindered by the lack of a technology that provides complementary n-channel and p-channel transistors on the same substrate. A good case can be made that the benefits of a complementary technology outweigh the gains achieved from modest improvements in single-channel device mobility, and that more effort to develop organic CMOS is warranted.