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Embracing Contact Resistance in the Design of High-Performance Low-Cost, Flexible Electronics

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Organic semiconductors (OSC) are exciting materials for incorporation of novel technologies. OSCs can be solution processed in a scalable manner, have high mechanical flexibility, tunable optoelectrical and chemical properties, and excellent biocompatibility. They enable devices like ultra-thin solar cells, flexible and bendable displays and printable communication devices. Here, we focus on the organic field-effect transistor (OFET), which can function like an electrical "on/off" switch in such applications, but there are bottlenecks that prevent its incorporation in real world technologies. For instance, an energy difference between the contacts and the semiconductor creates a Schottky injection barrier, constricting electric current flow; thus, we search for a way to minimize the effect of this barrier on the device performance. Rather than using an inefficient and expensive trial-and-error approach, we use a data-driven approach by running transistor simulations on the DEAC cluster. Our 1,800 OFET simulations showed that tuning the dielectric capacitance layer can restore performance in devices with an injection barrier. Our experimental results concurred with the simulations: in OFETs with Schottky contacts the mobility depended strongly on the capacitance, and the performance of the low-capacitance devices matched that of OFETs with high-quality contacts. These results broaden the selection of contact materials to include those that create injection barriers, which is desirable because many of the solution-processed conducting materials fall into this category. We used printed metallic polymer contacts and obtained device mobility of 5.5 cm2/Vs, the highest mobility reported for a fully printed OFET.

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