

Researchers realize vertical organic permeable dual-based transistors for logic circuits

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a,b, Circuit diagram (a), static transfer characteristics (b) of the organic complementary inverter measured with VCC = 3.5 V and VControl = 0.5, 1.0,



1.5 and 2.0 V. c, Photographs of a seven-stage ring oscillator fabricated by integrating seven complementary inverters. d, Oscillation frequencies and signal propagation delays per stage of a seven-stage complementary ring oscillator plotted as a function of the supply voltage VCC. The circuit can operate with supply voltages as low as 2.0 V and with signal propagation delays as short as 11 ns per stage. Credit: Guo et al.

Integrated circuits (ICs) based on organic transistors have many valuable applications, for instance, in the fabrication of paper-like displays or other large-area electronic components. Over the past few decades, electronics engineers worldwide have developed a variety of these transistors.

A promising alternative to these transistors are vertical-channel dual-gate organic thin-film transistors. These transistors have several advantageous properties, such as short channel lengths and tuneable threshold voltages (VTH). Despite these advantages, due to a lack appropriate p- and n-type devices, developing complementary inverter <u>circuits</u> for these transistors has so far proved challenging.

Researchers at Technische Universitat Dresden, Helmholtz-Zentrum Dresden Rossendorf (HZDR) and Northwestern Polytechnical University have recently developed vertical organic permeable dual-base transistors that could be integrated in logic circuits. In <u>a recent paper</u> <u>published in *Nature Electronics*</u>, they evaluated the potential use of these transistors in complex integrated circuits.

"The dual-gate transistor we developed as part of our previous research in *Nature Communications* consists of a single vertical-channel thin-film transistor with an additional second gate and second dielectric, which can be used to tune its <u>threshold voltage</u>," Erjuan Guo, one of the



researchers who carried out the study, told TechXplore. "In our new study, we studied the function and benefit of the vertical-channel dualgate transistors in more complicated integrated circuits, for example, organic complementary inverters and ring oscillators, further.

Guo and her colleagues created integrated complementary inverters by connecting vertical n-channel organic permeable dual-base transistors (OPDBTs), and vertical p-channel organic permeable base transistors (OPBTs). Notably, the second gate in the OPDBTs can control the on and off-states of the transistors, thus influencing the states of the inverters.

"Based on the measurements we collected, we find that dual-base transistors enable a wide range of switching <u>voltage</u> controllability of a complementary inverter over 0.8 V, at an input voltage of

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