Univ. of Washington & Stanford Univ.: CMOS-type inverters with organic nanowires transistors

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Organic transistors and circuits based on self-assembled nanowires

The performance of organic transistors largely depends on the molecular organization of its constituent organic semiconductor. Under that respect, the process of self-assembly that characterises some structures offers a great interest. Examples of conjugated nanostructures that form through π-π interactions include (but are not restricted to) nanofibers, nanowires and nanoribbons. These structures self-assemble along the π-π staking direction, which also constitutes the direction of facile charge transport. The π-π staking is essentially encountered in two-dimensional molecules such as hexabenzocorronene and perylene derivatives. It is less common with linear molecules such as oligoacenes.

The group of **Z. Bao** at **Stanford University** with 2 teams from the **University of Washington** recently synthesized and characterized hexathiapentacene (HTP) and perylenetetracarboxyldiimide (PTCDI) nanowires. The nanowires are obtained from solution.

HTP [1] is partly soluble in benzonitrile, and its solubility increases with temperature. A certain amount of the starting powder was dissolved in hot benzonitrile, and the solution was slowly cooled down, allowing nanowires to spontaneously form. The nanowires can then be collected and transfer to a poor solvent such as chloroform or ethanol.

In the case of PTCDI [2], a solution of the molecule in chloroform is placed into a vial. The solution is covered with a poor solvent (methanol). An initial swirl of the vial immediately induced the supramolecular self-assembly, and in several minutes, the complete formation of nanowires was observed.

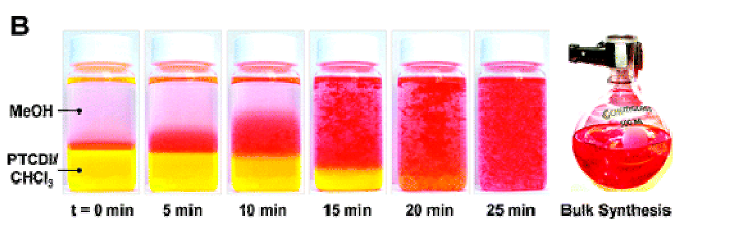

Figure 1: A series of optical photographs illustrating the synthesis of the nanowires. The top layer is methanol and the bottom layer is a solution of PTCDI in chloroform.

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Transistors were fabricated with both nanowires. As expected, HTP gave p-channel devices and PTCDI n-channel transistors. By associating both structures, the group at Stanford realized a complementary inverter (CMOS-like).

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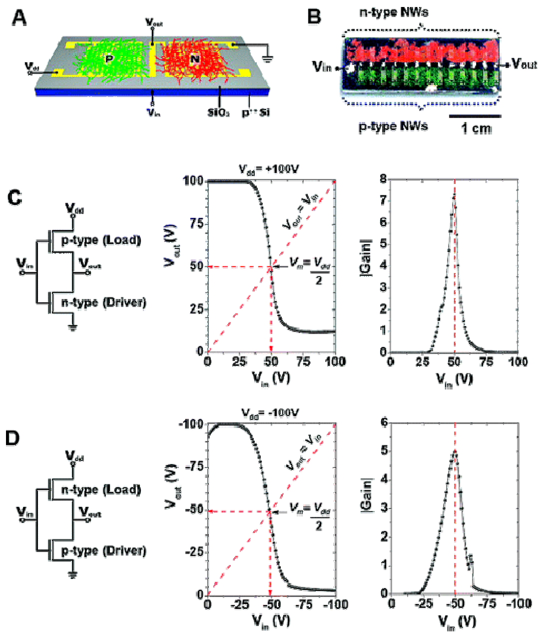

Figure 2: Complementary inverters with p- and n-channel nanowire transistors.
A) Schematic view of the device
B) Picture of a substrat with 13 devices
C) Static transfer characteristics of an inverter with p-channel load and n-channel driver
D) Same as C with n-channel load and p-channel driver.

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A major interest of the nanowires resides in their easy processing from the liquid phase and their high flexibility. Thus, flexible devices were realised on plastic sheet substrates. The question remains that the performance of the transistors has to improve to be comparable with the current state-of-the-art in organic electronics.

[1] "Fabrication of field-effect transistors from hexathiapentacene single-crystal nanowires" ; A. L. Briseno, S. C. B. Mannsfeld, X.M. Lu, Y.J. Xiong, S.A. Jenekhe, Z.N. Bao, Y.N. Xia : ***Nano Letters*** **7**, 668 (2007).
[2] "Perylenediimide nanowires and their use in fabricating field-effect transistors and complementary inverters" ; A.L. Briseno, S.C.B. Mannsfeld, C. Reese, J.M. Hancock, Y. Xiong, S.A. Jenekhe, Z. Bao, Y. Xia : ***Nano Letters*** **7**, 2847 (2007).

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