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Normally-ON and Normally-OFF Carbon Nanotube-based Ionic-Liquid Supercapacitor-Gated Vertical Organic Field-Effect Transistors
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— We report on novel implementations of the vertical organic field effect transistor (VOFET). Instead of a typical capacitor below the organic diode, a carbon nanotube (CNT) based ionic-liquid supercapacitor (or ionic gate) is on top. The present work has been motivated by the discovery that the conductivity and work function of carbon nanotubes can be strongly modified by electric double layer charging (EDLC) in an electrolyte as much as +/-0.7eV. The conductivity of EDLC CNT is enhanced by a factor of two. By coupling the ionic gate with an organic diode, charge injection into the diode can be controlled via modulation of the workfunction of the CNT electrode, resulting in transistor-like behavior. Additionally, the high capacitance of the supercapacitor will enable the VOFET to be operated at low voltages. The entire device is processed under ambient conditions with no vacuum equipment used. We have tested VOFETs with two different materials, p-type P3HT and n-type $PC_{70}BM$. The polarity of the charge transported in the material determines the charge injection rate and whether the device is a normally-ON or a normally-OFF transistor. Both devices have high current transport, excellent output characteristics, good on-off ratios and low operation voltages. We believe that these novel VOFETs will have exciting potential for various future electronic applications.

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