Integration of self-assembled gold nanoparticles in organic thin-film transistor for non-volatile memory devices

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A self-assembled monolayer of gold nanoparticles is integrated into the gate dielectric of an organic thin-film transistor to produce memory effects. The device is fabricated on a heavily doped N-type silicon substrate, which also serves as the gate electrode. On the silicon substrate a 100 nm oxide layer is thermally grown as the gate dielectric. Gold nanoparticles are deposited on the oxide surface by electrostatic layer-by-layer self-assembly method. Then, a thin poly(4-vinylphenol) layer (~10 nm) is spin-coated to cover the gold nanoparticles, working as the tunneling barrier between the nanoparticles and the channel. After that, PEDOT/PSS source/drain electrodes are inkjet-printed over poly(4-vinylphenol) layer. Finally, the semiconductor polymer poly(3-hexylthiophene) is spun on as the channel material.

Applying different voltage to the gate electrode charges/discharges the gold nanoparticles so that the channel conductance is modulated at an on/off ratio over 10^3. The threshold voltage shift is about half of the program voltage. For example, $\Delta V_T = -25$ V when the device is programmed at Vg = -50 V. The memory retention time is about 100 seconds, which needs to be further improved. All processes are completed at low temperature compatible with plastic substrates such as PET, PEN and polyimide. Therefore, this device opens a new pathway toward low-cost and flexible plastic memory circuits.