Ink-jet printed ambipolar transistors and inverters based on semiconducting carbon nanotubes with chemical doping technique

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Carbon nanotubes have attracted extensive interests in electronic device applications because of high carrier mobility, excellent mechanical flexibility, and solution-based processability at room temperature. To efficiently fabricate various circuits based on carbon nanotube transistors, recently CMOS-like circuits consisting of ambipolar carbon nanotube transistors have received significant attentions due to their ease of fabrication and adaptiveness of more circuit design [1]. In this work, we demonstrate the ink-jet printed ambipolar transistors based on pre-separated, semiconducting carbon nanotube network as a channel by employing solution-based chemical doping technique with polyethyleneimine (PEI). The PEI has been reported as efficient electron dopants that exhibit stability in air and the adsorbed PEI on carbon nanotubes can readily overcome p-doping effects by oxygen molecules and have the electron-donating ability of amine groups in polymer [2]. Firstly, we present a solution-based doping technique for converting ink-jet printed p-type semiconducting carbon nanotube network transistors into ambipolar transistors by coating PEI on top surface of devices. Secondly, the electrical performance of ink-jet printed PEI coated ambipolar carbon nanotube network transistors is characterized by controlling the polyethyleneimine (PEI) concentration. Finally, the logic inverter consisting of two identical ambipolar carbon nanotube transistors is also demonstrated with a gain of 10 and power dissipation of 1.4×10^{-5} at operating voltage of 10 V. We expect that the concept presented here will be benefitial for development of various future electronic applications.

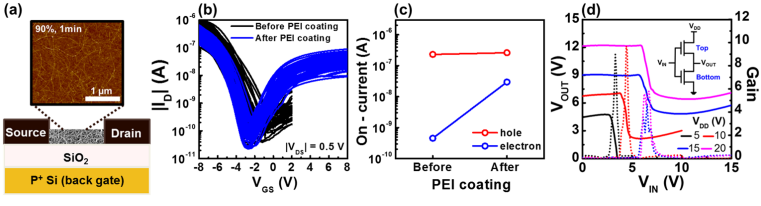

Fig 1. (a) Schematic of ink-jet printed, ambipolar carbon nanotube network transistor with PEI coating. (b) Transfer characteristics and (c) on-state currents before and after PEI coating on carbon nanotube network transistors. (d) Voltage transfer characteristics of inverter with two idential ambipolar carbon nanotube network transistors and circuit diagram (inset).

[1] W. J. Yu, et al., Nano Lett. 9, 4 (2009)
[2] M. Shim, et al., J. Am. Chem. Soc. 123, 46 (2001)

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