[WB1-D-2]

Hybrid complementary inverter for solution-processed single-walled carbon nanotube and a-IGZO thin-film transistors

Yongwoo Lee, Jinsu Yoon, Bongsik Choi, Juhee Lee, Minsu Jeon, Jungmin Han, Jieun Lee

Dong Myong Kim, Dae Hwan Kim, and Sung-Jin Choi*

School of EE, Kookmin University, Seoul 136-702, Korea, E-mail: *sjchoiee@kookmin.ac.kr

Currently, carbon nanotubes and oxide semiconductor have emerged as important materials for p-type and n-type thin-film transistors, respectively; however, realizing sophisticated macroelectronics operating in complementary manners has been challenging due to the difficulty in fabricating n-type carbon nanotube transistors and p-type oxide transistors amorphous [1]. In this work, we demonstrate hybrid complementary thin-film transistors based on carbon nanotubes for p-type and amorphous indium gallium zinc oxide for n-type behaviors to achieve excellent macroelectronic applications [2]. The fabricated carbon nanotube thin-film transistors utilize the pre-separated, highly purified 99.9% semiconducting carbon nanotube network as a channel and exhibit high mobility up to 59 $cm^2/V{\cdot}sec$ and high current on/off ratio of 7.4×10^5 at an operating voltage of -0.5 V. Moreover, the fabricated amorphous indium gallium zinc oxide thin-film transistors also shows high mobility up to 6.44 $cm^2/V{\cdot}sec$ and high current on/off ratio of 4.6×10^6 at an operating voltage of 0.5 V. Finally, we also show that, when configuring the hybrid inverter through a combination of 99.9% semiconducting carbon nanotube thin-film transistors and amorphous indium gallium zinc oxide thin-film transistors, the maximum gain (dV_{OUT}/dV_{IN}) of 14.37, the power of 1.09×10^{-5} W, and the noise margins (NM_{HIGH} = 1.48 V, NM_{LOW} = 2.60 V) occurs at an operating voltage of 5 V. Therefore, we believe that the approach of hybrid integration allows us to combine the strength of p-type carbon nanotube and n-type indium gallium zinc oxide thin-film transistors for minimizing the static-state power dissipation and maximizing noise margins in the circuit.

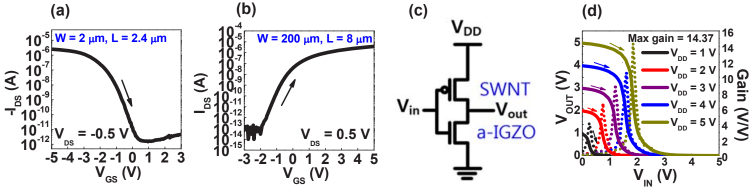

Fig. 1. Transfer characteristics of (a) carbon nanotube and (b) amorphous indium gallium zinc oxide thin-film transistors. (c) Schematic circuit diagram of the hybrid inverter. (d) Voltage transfer characteristics (solid line) and gain (dashed line) of the hybrid inverter.

[1] D. Lee, et al., Applied Physics Lett. 104, 14 (2014).

[2] B. Kim, et al., Nano Lett. 14, 6 (2014).

Acknowledgement: National research foundation of Korea (Grant 2013R1A1A1057870)