High-performance top-gated 99% semiconducting carbon nanotube network transistor with high device yield and uniformity

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Carbon nanotubes (CNTs) have been considered as an excellent channel material to build field-effect transistors (FETs) for future applications in integrated circuits (ICs) with exciting advantages as high speed, low power dissipation, and potential applications in flexible or transient electronics [1, 2]. In particular, the development of solution-processed CNTs with high semiconducting purity has allowed large-area deposition of CNT films, leading to extensive studies of CNT FETs in a variety of device structures [3, 4]. However, the CNT FETs usually suffer from low device yield and uniformity [5], originated from non-optimized fabrication processes. Fabrication of CNT FETs with high device yield and uniformity is necessary for designing and constructing complicated ICs.

In this work, we fabricated top-gated p-type FETs based on the 99% semiconducting CNT network thin films prepared from the solution-process, such as density-gradient ultracentrifugation (DGU). The fabricated CNT FETs presented high device yield and uniformity performances. Specifically, we used the 10-nm thick yttrium oxide (Y_2O_3 with the relative permittivity of 15, EOT: 2.6 nm) with excellent uniformity and insulativity as gate dielectric and palladium (Pd) was used as the contact to form good p-type contact in CNT FETs. Previously, high quality and uniform HfO_2 or Al_2O_3 deposited from atomic layer deposition (ALD) has been utilized as gate dielectric for top- or bottom-gated CNT FETs, but it has been reported that the growth of uniform thin high-k film directly onto the CNT surface was very difficult [6]. However, Y_2O_3 film used in this work showed excellent wetting with CNTs through the simple e-beam evaporation, providing high gate efficiency for CNT FETs. We believe that this contributes to improve the uniformity and performances of devices.

References

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