prof. Xuelei Liang

Key Laboratory for the Physics and Chemistry of Nanodevices & Department of Electronics, Peking University, Beijing 100871, LR Kitajska

Razvoj visoko učinkovitega FET tranzistorja iz ogljikovih nanocevk

Sodobna CMOS tehnologija izdelave vezij se že sooča z omejitvami miniaturizacije, ki brez alternativnih rešitev ne bodo omogočale dohajanja zakonitosti rasti gostote elementov vezij, imenovane Moorov zakon. Ogljikove nanocevke (Carbon nanotubes - CNTs) so zaradi edinstvene strukture in izjemnih lastnosti tako eden izmed najbolj obetavnih gradbenih elementov za bodoča integrirana vezja. Karakteristike FET tranzistorja iz ogljikovih nanocevk (CNTFET) se od leta 1998, ko je bil zasnovan prvi, stalno izboljšujejo. Z uporabo paladijevih (Pd) elektrod in materialov z visoko dielektrično konstanto, ki omogočajo manjše tokove puščanja pri izdelavi vrat (gate) tranzistorja, so sedaj CNTFET-i tipa p presegli zmogljivosti najboljših MOSFET-ov tipa p iz silicija. Vseeno pa razvoj CNTFET-ov tipa n zaostaja, v glavnem zaradi težav pri izdelavi kontakta brez Schottky-jeve bariere med kovinskima electrodama in prevodnim pasom ogljikove nanocevke. Počasen napredek pri izdelavi CNTFET-ov tipa n je zelo oviral razvoj integriranih vezij zasnovanih na ogljikovih nanocevkah.
Nedavno smo odkrili, da lahko uporabimo skandij (Sc) pri izdelavi omskega kontakta s prevodnim pasom v ogljikovi nanocevki in tako z lahkoto izdelamo visokoučinkovit CNTFET tipa n. Na osnovi tega odkritja smo predlagali uporabo CMOS tehnologije osnovane na ogljikovih nanocevkah brez dopiranja in s tem premaknili meje zmogljivosti CNTFET-a tipa n. Nazorno smo tudi prikazali načrt tokokrogov, izdelanih v celoti iz ogljikovih nanocevk, z integracijo mnogostenskih ogljikovih nanocevk (Multi-Walled CNTs) z enostenskimi ogljikovimi nanocevkami (Single-Walled) CNTFET-i, ki služijo kot povezave. Vsi naši rezultati kažejo na perspektivno prihodnost integriranih vezij osnovanih na ogljikovih nanocevkah.

By Xuelei Liang

Key Laboratory for the Physics and Chemistry of Nanodevices & Department of Electronics, Peking University

Developments of high performance n-type carbon nanotube field-effect transistors

As scaling down with Moore's law, the modern silicon complementary metal-oxide-semiconductor (CMOS) technology is facing great challenges and people are looking for alternatives. Carbon nanotube (CNT), due to its novel structure and properties, has been regarded as one of the most promising building blocks for the future integrated circuits.
Since the first CNT field-effect transistor (CNTFET) was designed in 1998, device performance has been continually improved. By using palladium (Pd) electrodes and high-k materials (which are less prone to current leakage) as gate dielectrics, p-type CNTFETs have now surpassed the capabilities of state-of-the-art silicon p-MOSFETs. However, the development of n-type CNTFETs has lagged

behind. This is mainly due to the difficulty of fabricating a Schottky barrier-free contact between metal electrodes and the conduction band of the CNT. The slow progress in producing n-CNTFETs has greatly hindered the development of CNT-based integrated circuits.

We Recently discovered that scandium (Sc) can be used to generate an ohmic contact with the conduction band of a CNT and high performance n-type CNTFETs can be easily fabricated. Based on this discovery, we proposed an CNT-based doping-free CMOS technology and pushed the limits of n-type CNTFETs. We also demonstrated a design of whole carbon nanotube circuits by integrating Multi-Walled CNTs with the Single-Walled CNTFETs which serve as interconnects. All of our results show a prospective future of CNT-based integrated circuits.