Carbon nanotube and oxide nanobelt FETs: fabrication, characterization and applications

PENG XIONG, Department of Physics and MARTECH, Florida State University

High-performance field effect transistors (FETs) based on single-wall carbon nanotubes (SWNTs) and oxide nanobelts were fabricated and characterized. The SWNT-FETs were constructed via molecular template-directed assembly of HiPCO tubes onto pre-patterned metal electrodes on a Si/SiO$_2$ substrate. The devices exhibit operating characteristics comparable to state-of-the-art CNT FETs, and the process is amenable to large-scale functional CNT circuit assembly. Importantly, the integration of hydrophobic self-assembled organic monolayers in the device structure eliminates the primary source of gating hysteresis in SWNT-FETs, which leads to hysteresis-free FET operation while exposing unmodified nanotube surfaces to ambient air$^1$. Individual oxide (SnO$_2$ and ZnO) nanobelt FETs with multi-terminal contacts were fabricated via conventional lithography. Simultaneous two-terminal and four-terminal measurements enabled direct correlation of the FET characteristics with the nature of the contacts. Low-resistance ohmic contacts on the nanobelts result in high-performance n-channel depletion mode FETs with well-defined linear and saturation regimes, and “on/off” ratio as high as $10^7$ at ambient conditions$^2$. Intrinsic values of the carrier concentration and effective mobility for the nanobelts were consequently obtained. Channel-limited SnO$_2$ nanobelt devices show significant modification of the FET characteristics when exposed to gas flows containing 0.2-2% H$_2$ at room temperature. The gas sensitivity and response were carefully evaluated$^3$. The effort to utilize the channel-limited nanobelt FETs for protein detection will be discussed. 

$^1$S.A. McGill et al., APL 89, 163123 (2006).
$^2$Y. Cheng et al., APL 89, 093114 (2006).
$^3$L.L. Fields et al., APL 88, 263102 (2006).