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Semiconductor nanowire field-effect transistors gated by metal nanowires

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Abstract

Gating control of semiconductor nanowires, like ZnO nanowires, have been demonstrated for a decade. The semiconductor nanowire field-effect transistor (FET) is commonly gated by either a back gate or a top gate electrode. The back gate operation requires a high voltage to generate a high electric field whereas the top gate technique needs the insertion of a thin insulating layer. Here we propose to employ a metal nanowire as a top gating finger. Due to the ultra-small cross-sectional area and the Schottky contact between the metal and the semiconductor nanowires, a low gating voltage is enough to generate a high electric field. Moreover, the contact resistance is high thus the gating operation is realized without any insulating layers.

The zinc tin oxides (ZTO) nanowire was selected and a gold (Au) nanowire was attached on top as a gating finger. Conducting wires with four ohmic contacts on the ZTO nanowire and one ohmic contact on the Au nanowire were patterned by standard electron-beam lithography so as to make nanowire-gated FET devices. Four probe measurements on ZTO nanowires revealed intrinsic electron transport properties which were well described by the model of Mott's three-dimensional variable range hopping. Electrical characterization with one probe on ZTO and the other on Au nanowire exhibits a Schottky and nano Schottky contact features at high and low temperatures, respectively. The nanowire gating with a low voltage of ±1 V demonstrates much higher efficiencies in comparison with back gating operation. Furthermore, the device can be operated by both finger and back gates to materialize a logical operation of the tri-state buffer.

Biography

Wen-Bin Jian obtained his PhD in Physics from National Taiwan University in 2002. He worked as a postdoctoral researcher in University of New Orleans (Advanced Materials Research Institute) in 2003 and, later on, as an assistant professor in National Chung Hsing University. In 2004, he joined Department of Electrophysics, National Chiao Tung University. He got promoted to be a full Professor in 2011. Dr. Jian's current research interest is nanoscience. He was invited for more than 12 times of oral presentations and he gave more than 10 times of contributed talks in international conferences. He published more than 40 peer-reviewed papers in international journals, including Nano Lett., Phys. Rev. Lett., J. Am. Chem. Soc., and ACS Nano.