

NANO HIGHLIGHT

Assembly and Characterization of p- and n-type Silicon Nanowires

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There has been considerable interest in bottom-up integration of semiconductor nanowires for their application in future logic, memory, and sensor circuits. The ability to integrate field effect nanowire devices with p- and n-type conduction channels in the same semiconductor material system is a challenge that must be addressed to fabricate complementary logic circuits using such technologies. Researchers at Penn State University have recently demonstrated that p- and n-type dopants can be intentionally incorporated into silicon nanowires (SiNWs) synthesized by template-directed vapor-liquid-solid (VLS) growth using 10% silane (SiH_4) in H_2 as the silicon gas source, Trimethylboron (TMB) as the p-type dopant, and phosphine (PH_3) as the n-type dopant. Following synthesis, the SiNWs were removed from the template and integrated onto a back-gated test structure for electrical measurements. This was accomplished by electrofluidically assembling individual SiNWs between pairs of large area electrodes and then using e-beam lithography followed by metal liftoff of Ti /Au to define two electrodes at the nanowire tips and two additional leads along the length of the SiNW. The gate-dependent source-to-drain current of p- and n-type SiNWs show complementary characteristics that are consistent with depletion mode device operation. Independent measurements of four-point resistivity show a clear decrease in resistivity with increasing TMB: SiH_4 or PH_3 : SiH_4 gas ratios. These results confirm that p- and n-type dopants can be effectively incorporated from TMB and PH_3 gas sources during SiNW synthesis.

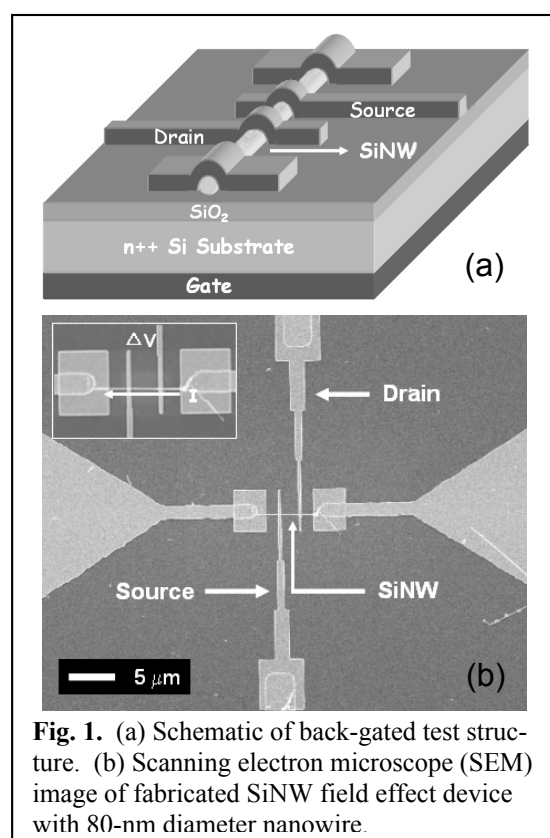


Fig. 1. (a) Schematic of back-gated test structure. (b) Scanning electron microscope (SEM) image of fabricated SiNW field effect device with 80-nm diameter nanowire.

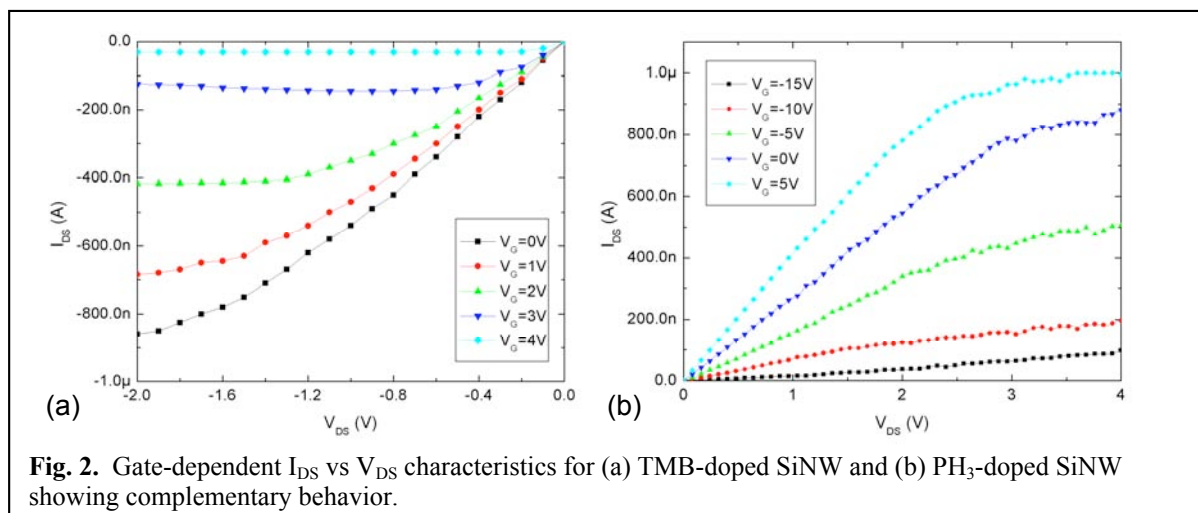


Fig. 2. Gate-dependent I_{DS} vs V_{DS} characteristics for (a) TMB-doped SiNW and (b) PH_3 -doped SiNW showing complementary behavior.