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Carbon nanotube transistors are scaled down to record size

A nanotube field-effect transistor can now be made as short as 40 nm, less than half the size of the smallest silicon equivalent.

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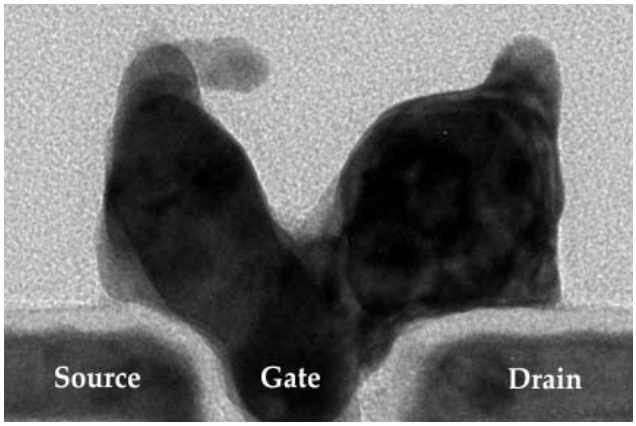
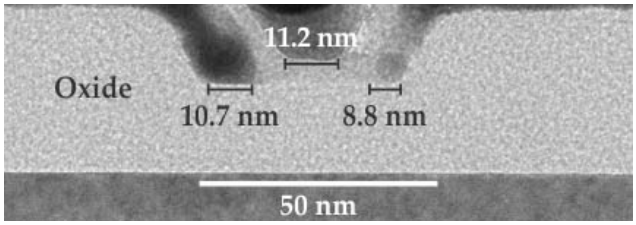
There's a limit to how small silicon transistors can be made before quantum confinement effects and the loss of electrostatic control over the current jeopardize the material's performance. Carbon nanotubes are





an appealing substitute: Their intrinsic thinness enables superb control over power dissipation in a transistor's off state and allows the transistor to switch between off and on under a much lower gate voltage than is possible using silicon. Researchers have been fabricating nanotube-based transistors for a few years by draping semiconducting nanotubes over closely spaced source and drain electrodes to create a short, ultrathin channel. But although the channels themselves can be as short as 5–10 nm, the electrodes are comparatively long—on the scale of 60–100 nm—to ensure good electrical contact. Two years ago Qing Cao and his IBM colleagues realized they could avoid the need for such large contact lengths by bonding molybdenum electrodes at each (open) end of a nanotube. But making such a bond requires an 850 °C chemical reaction; at that temperature, molybdenum is deformable, and the resulting field-effect transistors (FETs) with such ultrashort channels suffered from short circuits. Cao and company have now fixed the problem by blending molybdenum with cobalt, whose presence allows the reaction to proceed at just 650 °C. The end contacts form with little electrical resistance through the metal-carbide bond, and the metal itself remains structurally sound enough to preserve a fixed electrode gap. The researchers fabricated an FET whose components fit into a footprint of just 40 nm, as illustrated here. (In this transmission electron micrograph, all components but the nanotube channel are visible.) At less than half the size of the smallest FET made of silicon, the nanotube FET conducted twice as much current at about half the driving voltage applied to the gate. (Q. Cao et al., Science 356, 1369, 2017.)