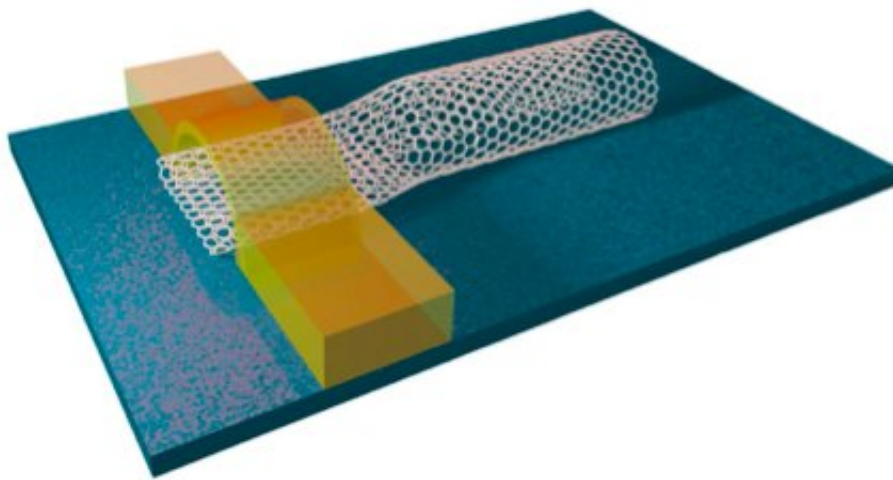


# How carbon nanotubes could be used in future electronic devices

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Schematic of a carbon nanotube field-effect transistor contact. Credit: Skoltech

A team of Skoltech scientists, in collaboration with researchers from the IBM Watson Research Center, have shed light on the behavior of electrical contacts in carbon semiconductor nanotubes, which could pave the way to next-generation electronics.

In the past, silicon digital electronics were made possible by a reduction in transistor size, but the possibilities of silicon have effectively reached their limit. Thus, it is necessary to search for new opportunities to reduce costs and increase performance in electronic devices. Toward this end,

technology giants like IBM are actively investigating their potential to replace silicon in next-generation computers and other electronics.

The primary challenge in this regard is [contact resistance](#), a feature of the low resistance of nanotube channels. "Transistor resistance includes both channel and contact resistance. The channel resistance of carbon nanotubes is better than that of silicon, but no one needs transistors made of [nanotubes](#) with a long channel, and when the tube size decreases to several tenths of a nanometer, the contact resistance begins to dominate," said Skoltech Professor Vasili Perebeinos, the study's lead author.

Semiconductor tubes are used to manufacture transistors. But [metal](#) is used for contacts. Metal exerts pressure on the tubes, which comes at the expense of [surface tension](#). Previous research in the field revealed that this pressure is high enough to flatten the tubes. "In our latest research, we predicted that semiconductor tubes flattened by a metal contact become metallic. In this case, the contact resistance increases, and does not subsequently decrease. This is due to the breaking of the axial symmetry of the deformed tubes under the metal contact," Perebeinos said.

The Skoltech-led team's research has helped elucidate the steps that can be taken to reduce contact [resistance](#). They determined that for purposes of manufacturing transistors, it's preferable to use tubes with relatively small diameters. To put this into context, imagine a large pipe instead of a nanotube, and a hammer pounding against the pipe instead of metal exerting pressure. It immediately becomes clear why a diametric reduction would help; it would be easier to flatten a pipe with a large diameter than one with a smaller diameter.

It is also possible to use metals with a [lower surface tension](#); the "hammer blow" in this case would be weaker and the nanotube would not be flattened.

The study has been published in *Physical Review Letters*.

**More information:** Roohollah Hafizi et al, Band Structure and Contact Resistance of Carbon Nanotubes Deformed by a Metal Contact, *Physical Review Letters* (2017). [DOI: 10.1103/PhysRevLett.119.207701](https://doi.org/10.1103/PhysRevLett.119.207701)

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