Researchers at Northwestern University, US, have demonstrated a bistable carbon nanotube switch that they say should be compatible with current mass production manufacturing techniques. The device could have applications in nanoelectromechanical systems switches, random-access memory elements and logic devices.

"The advantages of nanotube-based devices include high integration level (up to 10^{12}/cm^2), high working frequency (~100 GHz), and low energy consumption (as low as 10 atto-watts) to name just a few," Horacio Espinosa of Northwestern told nanotechweb.org. "The goal of this research is to design and demonstrate a nanotube-based bistable electromechanical nanoswitch suitable for real commercial applications by solving the challenges in terms of the device design, manufacturing and testing."

The Northwestern team's device consists of a multiwalled carbon nanotube supported at one end that interacts electrostatically with an underlying electrode. According to the researchers, this design means that there is no need for a gap of less than 10 nm, as some other nanoswitches require.

The device is based on current tunnelling. Applying a voltage above a certain threshold causes the nanotube to deflect towards the bottom electrode. When the gap between the nanotube and electrode is less than a nanometre, a tunnelling current flows through the circuit. This current, in combination with the presence of a resistor in the circuit, causes the voltage drop across the nanotube tip and bottom electrode to decrease, creating an alternative equilibrium position for the nanotube.

"There is a resistor in series with the nanotube, which plays an important role in the functioning of the device as a bistable switch by adjusting the voltage drop between the nanotube and the underlying electrode," said Espinosa.

Reducing the applied voltage below a certain value – the "pull-out voltage" – causes the nanotube to return to its original position.
"The most significant features of [our] bistable tunnelling device include its scalability to massively parallel device arrays, which is key for applications such as memory elements and logic devices and its compatibility with the current manufacturing technique for mass production, which is essential for real commercial applications," said Espinosa. "All of these unique features originate from the unique design and working principle of the device."

Now the team plans to investigate manufacturing of two-dimensional massively parallel arrays of the devices and to assess their reliability. "We think these are two key steps towards real commercial success," said Espinosa. "Looking forward, we will continue our effort to exploit the unique behaviours of the device and its applications."

The researchers reported their work in Small.

About the author

Liz Kalaugher is editor of nanotechweb.org.