behind the news

The latest step in the search for ever-smaller processors is a transistor no bigger than a single molecule. The tiny carbon-based nanotransistor may provide competition for IBM's nanotubes when silicon-based chips reach their limits, writes David Legard

A team of scientists at Lucent Technologies' Bell Labs recently created a transistor contained within a single large molecule. This could be a great advance to rival IBM's developments in nanotube technology early in 2001.

The 'nanotransistor', which measures one-billionth of a metre, is more than 10-times as small as any transistor previously made, Bell Labs said.

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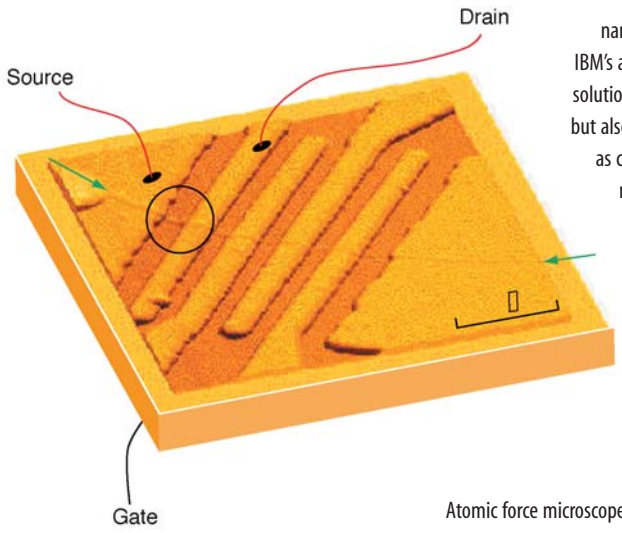
The nanotransistor consists of an organic, carbon-based semiconductor material known as thiol, thus it doesn't require expensive clean-room technology for manufacture as current silicon-based chips do. This potentially sets the stage for a new generation of faster and cheaper processing and memory chips in a few years time.

Incremental growth

The principal problems with creating such a tiny transistor – fabricating electrodes that are separated by only a few molecules and attaching electrical contacts to the tiny devices – were overcome by enabling the transistor to effectively build itself from a liquid solution.

Three Bell Labs scientists – one physicist and two chemists – carved a notch into a silicon wafer and deposited a layer of gold at the bottom to function as one of the transistor's three electrodes.



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Atomic force microscope image of a single nanotube rope (green arrows)

Angels on a pinhead

The trio then dipped the wafer into a solution that contained a mixture of thiol molecules and some inert organic molecules and, as the solution evaporated from the wafer, a film exactly one molecule thick was left behind on the gold electrode. Next, according to a Bell Labs statement, the team deposited another gold electrode on top of this film, while they built the transistor's third electrode on one side of the silicon notch.

Using two nanotransistors, the scientists built a voltage inverter, a standard electronic circuit module commonly used in a microprocessor that converts zero to one and vice versa. With further development, it may be possible to create microprocessors and memory chips using nanotransistors, squeezing thousands of times as many transistors on to each chip than is possible today, Bell Labs said.

Thin competition

The other main approach to sidestepping the limitations of silicon has been developed by IBM. The company's solution is to use carbon nanotubes, tube-shaped molecules of carbon atoms that are 100,000 times thinner than a human hair, as the basis of computer circuits (illustrated above). Eggheads at IBM created a voltage inverter out of a single strand of carbon.

At the moment, carbon nanotubes are the favourite candidate to replace silicon when current chip features just can't be made any smaller, IBM said. The company expects that barrier to occur in within 15 years. Whichever version of nanotechnology wins out, both IBM's and Bell Labs' beyond-silicon solutions promise not only smaller, but also more powerful computers, as chipmakers are able to fit more transistors on to a chip.

Silicon has been the basis of transistors since their invention at Bell Labs in 1947. Since then, improvement in transistor design has roughly followed Moore's Law, which states that the maximum number of transistors on a chip will double every 18 to 24 months. But some scientists believe that continuing miniaturisation of silicon-based integrated circuits will come to a halt a little sooner than even IBM thinks, predicting fundamental physical limits will be reached within 10 years. ■