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First nanotube computer: A Carbon revolution

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Computers have been redesigned from several years since their invention, shifting to more advanced materials as they become available. A series of developments occurred in this process. Alan Turing developed the bombe in 1939, a device combining moving parts with electrical circuits, to analyze Nazi codes during the Second World War. Charles Babbage published designs for the analytical engine, a general-purpose computer based on rotating gears, but he died before he was able to build it. The US army's electronic numerical integrator and computer (ENIAC), which contained more than 17,000 tubes, became the first fully electronic general purpose computer in 1946. Bell labs developed the first silicon transistor in 1954.

In carbon nanotubes, Dekker and colleagues made the first practical carbon nanotube transistor in 1998 at Delft University of Technology, which led to the invention of first carbon nanotube computer. The long-touted potential of carbon nanotubes over silicon benefitted the society. It was a step that could spark a major revolution in computing, akin to the switch from vacuum tubes to silicon around 50 years ago. Carbon nanotubes have continued to excite the material science field because of their proliferating array of allotropes (different forms of the material), all with potential. Dr. Guha complimented the Stanford group for maintaining its focus on a single engineering advance. Currently, semiconductor industry leaders can make integrated silicon circuits with a feature size of 22 nanometers, roughly 4,000 of which could be spread across the width of a human hair. With the arrival of a new generation of smaller transistors roughly every two years, the industry believes that silicon will be scaled down to a limit of 5-nanometer transistors sometime after 2020.[1]

Carbon nanotubes electrical properties provide faster and more efficient transistors, the semiconducting switches to create logic gates and allow computation. Digital circuits based on transistors fabricated from carbon nanotubes (CNTs) have the potential to outperform silicon by improving the energy–delay product, a metric of energy efficiency, by more than an order of magnitude. But difficulties manipulating the tiny molecular rods left many doubting their usefulness. Because they are so small, nanotubes can slip out of place and connect parts of a circuit that are not meant to touch. Mitra and colleagues guided their tubes by growing them on quartz wafer, aligning 99.5% of them along the crystal's regular structure.[2] Once the nanotubes were in place, they etched out any misaligned tubes. CNTs are exciting complement to existing semiconductor technologies. However, carbon nanotubes (CNTs) are subject to substantial inherent imperfections that pose major obstacles to the design of robust and very large-scale CNFET digital systems: (i) It is nearly impossible to guarantee perfect alignment and positioning of all CNTs. This limitation introduces stray conducting paths, resulting in incorrect circuit functionality. (ii) CNTs can be metallic or semiconducting depending on chirality. Metallic CNTs cause shorts resulting in excessive leakage and incorrect circuit functionality. Carbon nanotube FETs (CNFETs) are excellent candidates for further energy reduction, as CNFET-based digital circuits are projected to achieve an order of magnitude improvement in energy-delay product compared with silicon-CMOS at highly scaled technology nodes. However, carbon nanotubes (CNTs) are inherently subject to imperfections and variations such as those induced by mispositioned and metallic CNTs. These substantial imperfections and variations have prevented the demonstration of complex CNFET circuits until now.[3]

Carbon nanotubes, each skinnier than a strand of DNA, have been engineered into semiconductors that release less heat than those made from silicon. Because heat limits the size and speed of a chip, carbon nanotube semiconductors could lead to smaller and faster computers.[4]

Once it had a working chip, the team programmed it to run a counting program and a sorting algorithm. The computer can switch between the two programs, allowing it to multitask like more sophisticated machines. Its basic design is what is known as turning complete, which means the carbon nanotube machine can theoretically compute anything a regular PC can just much, much more slowly.

Even once the technology is ready, high costs mean you are unlikely to see a carbon chip inside your laptop or smartphone any time soon.

References:

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