# They are bringing back tubes

M. Simon

Yes, tubes are coming back. No, not the thermionic space bottles of my youth. These are a different kind of tube. Made of small bits of graphene. Carbon nanotubes. IBM reports on their progress [1]in the area. And it is amazing.

> IBM scientists have demonstrated a new approach to carbon nanotechnology that opens up the path for commercial fabrication of dramatically smaller, faster, and more powerful computer chips. For the first time, more than ten thousand working transistors made of nano-sized tubes of carbon have been precisely placed and tested in a single chip using standard semiconductor processes. These carbon devices are poised to replace and outperform silicon technology allowing further miniaturization of computing components and leading the way for future microelectronics.

The Z80 on its introduction in 1976 only had 8,500 transistors [2]. So IBM is already in the 8-bit microprocessor range. When they get up to 68,000, they will be in 16-bit Motorola 68000 territory. The 68000 was a very nice microprocessor with a very orthogonal instruction set. A very clean machine I loved programming in assembly language. The fact that IBM now has a viable process based on silicon processing means that they should go rapidly down the learning curve. And what an interesting process it is.

> IBM researchers developed a novel method based on ion-exchange chemistry that allows precise and controlled placement of aligned carbon nanotubes on a substrate at a high density – two orders of magnitude greater than previous experiments, enabling the controlled placement of individual nanotubes with a density of about a billion per square centimeter. The process starts with carbon nanotubes mixed with a surfactant, a kind of soap that makes them soluble in water. A substrate is comprised of two oxides with trenches made of chemically-modified hafnium oxide ($HfO_2$) and the rest of silicon oxide ($SiO_2$). The substrate gets immersed in the carbon

> nanotube solution and the nanotubes attach via a chemical bond to the HfO2 regions while the rest of the surface remains clean. By combining chemistry, processing and engineering expertise, IBM researchers are able to fabricate more than ten thousand transistors on a single chip.

IBM also claims that because of the silicon substrate, testing methods already in use can be applied to further development. I really hope they don't go down the ARM route for processor design. I do use that architecture. I don't like it. Compared to the 68000, it is quite clumsy. What would I like to see? Maybe something like the Novix chip [3]. A dual stack architecture. Well, I can dream can't I?

M. Simon's e-mail can be found on the sidebar at Space-Time Productions [4].

*Engineering is the art of making what you want from what you can get at a profit.*

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