NRAM and Memristors

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What is NRAM?

NRAM is a type of non-volatile random access memory that uses carbon nanotubes as its memory material rather than capacitors.

How does NRAM differ from standard RAM models?

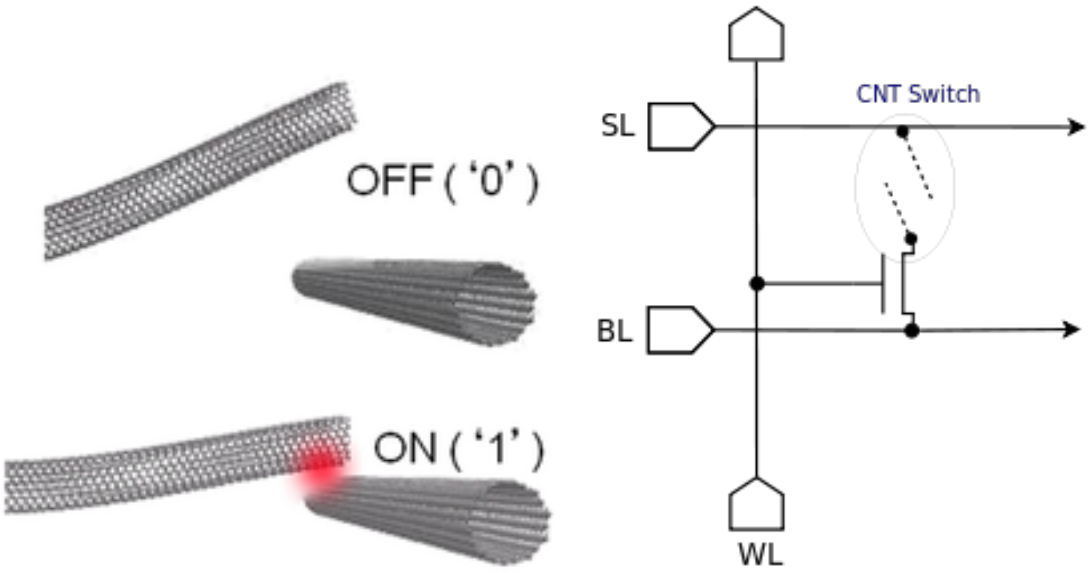
Firstly, NRAM is non-volatile. Non-volatile memory is memory that maintains its values when disconnected from power. The most everyday examples would be flash drives and solid state drives. Therefore, NRAM could be used as the medium for mass storage devices as high speed computer memory.

Standard computer memory used today is dynamic random access memory, or DRAM, which stores data bits in capacitors. These capacitors must be “refreshed” to hold a high, 1, state and thus DRAM is volatile memory.

How does NRAM operate?

The main theory behind NRAM depends on the fact that at the nanometer sizes of carbon nanotubes, Van der Waal’s forces are strong enough to have a significant effect on the system. In case it has been a while since your last physics class, Van der Waal’s forces is the name to describe the attracting force between close molecules by covalent bonds and/or ionic attraction.

Nanotubes are arranged in a grid fashion, with each data bit being stored where two nanotubes cross. The tubes are placed such that when in their low state, the brittleness of the nanotube is enough to counteract Van der Waal’s forces and keep the tubes separate and not conducting. By applying a charge, generally constructed to be much greater than the operating voltage, through one tube, and grounding the other, the two tubes can be pushed together. After the charge is stopped, Van der Waal’s forces are enough to keep the two in contact.



From reading a few papers, this process is quite difficult to perfect, and the fastest I saw for write low was 50ns and write high 500ns. The write speed is a bit slow when compared with DRAM speeds. The theoretical intrinsic set/reset speeds of NRAM is <1ns but this does not have any working prototypes.

How does NRAM compare to other memory types?

NRAM, with it's carbon nanotube design, has a very similar density to DRAM. Unlike DRAM however, NRAM does not have a lower limit on how much it can be scaled down. DRAM cannot be scaled down due to the amount of charge the capacitors can hold scaling down as well, past a recognizable amount.

NRAM also has the clear advantage in it's power consumption over volatile memory, only requiring power to read and write values, not maintain them. NRAM also holds an advantage against common types of non-volatile memory however, since it has both low energy set (push tubes together) and reset (pop tubes apart), while flash memory requires a high energy clear to reset cells.

Nantero started bragging about NRAM in 2001, where is it?

From what you read everywhere online, NRAM is a large step ahead of your computer's RAM and har drive, as well as the jump drive on your keychain. So why, at the end of 2014, is NRAM nowhere to be found?

Reading a few of Nantero's research papers, the main issue with NRAM is making it (so everything is an issue). In a 2011 paper, linked in sources, Nantero describes a 4MB piece of

NRAM they constructed, and how they were still working on a reliable way of fabricating the nanotube memory cells.

The most common method of making NRAM right now is to thread the nanotubes in during the Back End Of Line, BEOL, portion of integrated circuit construction. This is the phase after all the transistors have been laid, and the wiring structure is set in. Instead/in addition to wires, a nanotube fabric is laid in. From here the transistors are used to select and work with the nanotubes. Unfortunately, nanotube fabrication is still a bit imperfect and set pulses of 500ns must be applied to ensure the tubes switch without fail. This process is also quite imperfect and not close to ready for mass manufacturing. So though they are a promising theory, clearly Nantero's 2003 NRAM revolution prediction is still far from a reality.

Sources:

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