The Memristor's Fundamental Secrets Revealed

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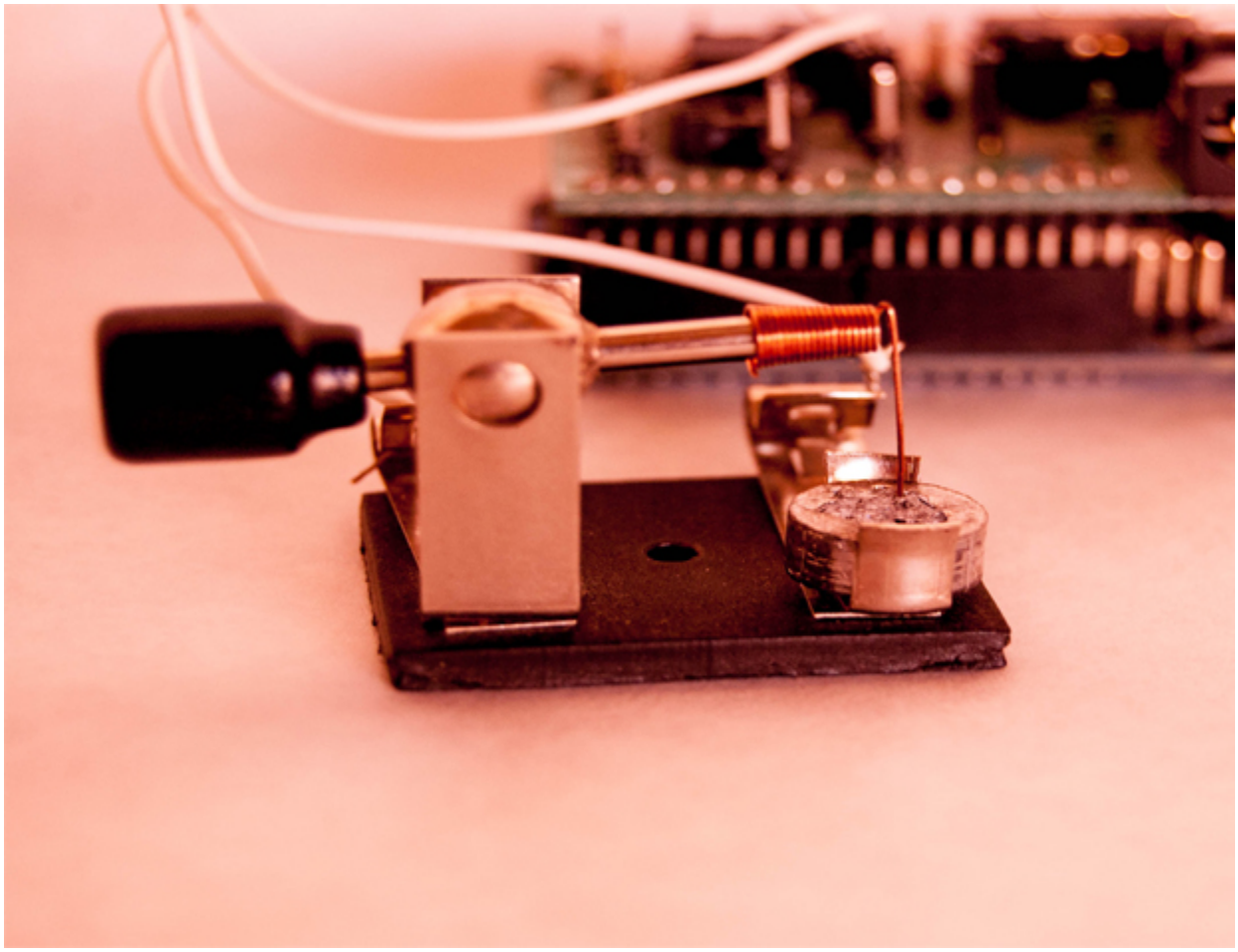

You would expect that a new fundamental passive circuit element, first postulated a mere 42 years ago, and first identified in the wild in 2008, would be as rare as hen's teeth. You'd be wrong. It turns out they're as common as cat's whiskers.

Two researchers from mLabs in India (http://mlabs.in/memristor/), along with Prof. Leon Chua at the University of California Berkeley, who first postulated the memristor in a paper back in 1971 (http://spectrum.ieee.org/semiconductors/design/the-mysterious-memristor), have discovered the simplest physical implementation for the memristor, which can be built by anyone and everyone.

In two separate papers, one published in arXiv ("Bipolar electrical switching in metal-metal contacts (http://arxiv.org/abs/1306.0942)") and the other in the IEEE's own *Circuits and Systems Magazine* ("The First Radios Were Made Using Memristors! (http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=6518277)"), Chua and the researchers, Varun Aggarwal and Gaurav Gandhi, discovered that simple imperfect point contacts all around us act as memristors.

"Our arXiv paper talks about the coherer, which comprises an imperfect metal–metal contact in embodiments such as a point contact between two metallic balls, granular media or a metal–mercury interface," Gandhi explained to me via e-email. "On the other hand, the *CAS* paper comprises an imperfect metal–semiconductor contact (Cat's Whisker) which was also the first solid-state diode. Both the systems have as their signature an imperfect point contact between two conducting/partially-conducting elements. Both act like memristor."

Gandhi says that this ubiquitous presence of memristors in simple physical systems around us strongly points towards the fundamental nature of the memristor.

While the two papers are connected via their similarity in construction, there is also a historic connection, according to Gandhi.

"Whereas coherers were used for radio-signal demodulation till the early 1900s (including Marconi's famous Transatlantic radio experiement and Tesla's Colarado Spring Experiment), Cat's Whiskers (the first diode) followed it as a more efficient alternative," Gandhi explained to me. "Thus both the devices were historically developed and used for receiving radio signals. Interestingly, both are memristive, but got forgotten due to the invention of the vacuum tube. Thus, 100 years back, in our quest of finding a diode, we missed the memristor."

Until now, there has not been what is known as a "canonical implementation" of a memristor. For the three other passive components—resistor, capacitor, and inductor —there have been canonical implementations. For a resistor it is a simple wire; for a capacitor it is parallel plates; and for an inductor it is a coiled wire. There was no counterpart for the memristor.

"We have found that imperfect point contacts comprise the memristor," says Gandhi. "Cat's whisker and coherers are both imperfect point contacts. Thus imperfect point contacts comprise the canonical implementation of memristors. This completes the set of canonical implementations for the four passive components."

By last account, it seems HP is moving along on pace to commercialize the memristor by 2014 (http://spectrum.ieee.org/nanoclast/semiconductors/nanotechnology/mapping-of-memristor-could-speed-its-commercialization)with memristors finding their way into electronic devices found on store shelves.

As memristors speed towards commercialization, the researchers believe that their work will contribute significantly to further developing memristor technology.

"Stan William's 2008 *Nature* paper had helped unite two different fields: resistive RAMs and the memristor," says Gandhi. "Now, our work unites these two fields with a third one: granular media. Understanding of granular media [anything that is made up of distinct grains such as ball bearings] over a period of various decades by physicists will aid memristor research and vice versa. Learnings from both together shall help advance science faster."

Perhaps the clearest impact that this work will have on future memristor research is

that it opens up the field to just about everyone to experiment with.

“Till now people have been talking of building better computer architectures, better circuits and even emulating the brain using memristors,” says Gandhi. “Now, they can actually implement these, test their hypotheses and yield a break-through. Our research brings memristors within the reach of everyone: scientists at the most sophisticated lab, students in institutions and the garages of the hobbyists. We are keen to see how everyone uses this new device to do new electronics.”

Image: mLabs