

# MEMRISTORS

or

"Conscious Computers may  
be here sooner than you  
think"

# A Memristor is:

- A new kind electronic component
- Joins the Resistor, Capacitor, and Inductor to make a fourth new kind in over a 100 years.
- Really, really, important why?

# HISTORY first:

- HP Engineers discovered memristors while trying to discover cross-bar switches.
- Cross-bar switches are?
- Besides switches for signals they can be a great Bit Memory if small enough.

# They made some.

- Some worked, some didn't, and some were just weird.
- They couldn't figure out why for years.
- Finally one of the Engineers remembered seeing an old 1971 IEEE paper.

# The Paper

- Professor Leon Chua had looked at patterns of voltage vs. current vs. charge etc. of Resistor, Capacitor, and Inductor.
- From that there seemed to be a “missing” component.
- He called it a “memristor” or “memory resistor”.

# Memristor

- Professor Chua's plots of Voltage vs. current seemed similar to what the HP Engineer's were finding.
- It gave them a new direction to go in.

# Finally!

- They got a new tool and when they cut their flakey crossbars open they figured it out.
- They had made memristors.
- Now they could do it on purpose.

# Why would they want to?

- Memristors have three nice properties.
- Number #1:  
They change resistance depending on how much current flows into them => Big Whoop...



# But wait...

- They remember what that resistance was when you turn the power off => then on again.
- Multi-level Flash anyone?

# Nice property #2

- They can do logic gates as well as store bits.
- So the memory can also process.
- And not *\*only\** logic gate processing.

# Nice property #2a

- Run current one direction  $\Rightarrow R \uparrow$
- Run current other way  $\Rightarrow R \downarrow$
- Do this from several sources and you have a nice analog adder  
 $\Rightarrow$  looks like a Nerve cell synapse

Nanoscale Memristor Device as  
Synapse in Neuromorphic Systems -  
Nano Letters (ACS Publications)

[http://pubs.acs.org/doi/abs/10.1021/  
nl904092h](http://pubs.acs.org/doi/abs/10.1021/nl904092h)

# Nice property #3

- They can be made very very tiny.
- Advanced circuits now use 32nm for *\*just\** gate of Transistor.
- That's ~100 atoms across.
- Rest of Transistor 10's X bigger.

# Nice prop #3 cont.

- HP thinks they can get whole memristor  $\sim 5\text{nm}$  in width.
- Moore's law just got reprieve.

# Reprise part b...

- Since all memristors are is just a particular kind of Ti wire...
- They believe they can stack several layers of them above the Transistors underneath on the IC chip.

# Reprieve part b crazy

- With stacking the HP Engineers are talking about memory densities of multiple petabits (1 petabit = 128TB) to be addressed in one square centimeter of space.



# Reprieve part c...

- Anyone see the research group announcement of making a Transistor out of exactly 7 atoms?
- Of course they did it by hand but still...