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MISSING LINK BETWEEN CHARGE AND FLUX

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Abstract: Typically Electronics Has Been Defined In Terms Of Three Fundamental Elements Such As Resistors, Capacitors And Inductors. These three elements are used to define the four fundamental circuit variables which are electric current , voltage, Charge, and magnetic flux. resistors are used to relate current to voltage, capacitors to relate voltage to charge and inductors to relate current to magnetic flux. To Overcome This Missing Link, Scientist Came Up With New Element Called MEMRISTOR. These memristors has the properties of both a memory element and a resistor, hence wisely Named As memristors. Memristors Is Being Called As Fourth Fundamental Component, Hence Increasing the Importance Of Its Innovation. So We Can Say That "Memristors Are So Significant That It Would Be Mandatory To Re -Write The Existing Electronics Engineering Textbooks."

Keywords- Resistors, Capacitors, Inductors, memristors.

I. INTRODUCTION

Memristor is radically different from other fundamental circuit elements is that ,unlike them it carries memory of its past .when you turn off the voltage to the circuit, memristors still remembers how much was applies before and for how long. That an effect that can't be duplicated by any circuit combination of resistors, capacitors & inductors, which is why the Memristor qualifies as a fundamental circuit element.

FUNDAMENTAL ELEMENTS OF ELECTRONICS:

1) Resistor- A resistor produces voltage across its terminals i.e. proportional to electric current through it in accordance with ohm's law which states,

$$V=RI$$

2) Capacitor- In a capacitor when a voltage potential difference exists between the conductors, an electric field is present in the dielectric. This field stores energy & produces mechanical force between the plates,

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$$V=q/C$$

3)Inductor-An inductor can store energy in a magnetic field created by electric current passing through it. An inductors have ability to store magnetic energy which is measured by its inductance, in unites of henries. In accordance with Faradays law of induction,

$$v(t)= L^{di(t)}/_{dt.}$$

4)The missing link:-There are six different mathematical relations connecting pairs of four fundamental circuit variables which are current I, voltage V, charge q, & magnetic flux F.

The relation between charge & the flux was unknown & so device which describes it, this led to discovery of the fourth fundamental elements which describes missing relation between charge & flux.

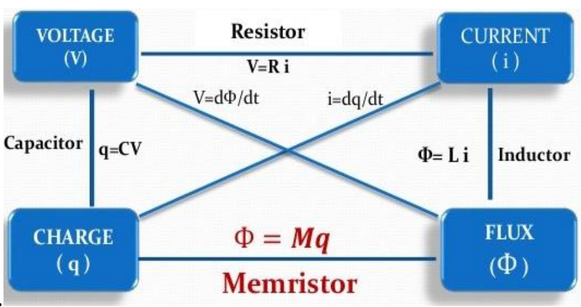


Fig.1-The relation between these three fundamental elements.

Fig.2-Symbol of memristor

HP already plans to implement Memristor in anew type of non-volitile memory which could eventually replace flash & other memory systems.

II. HISTORY

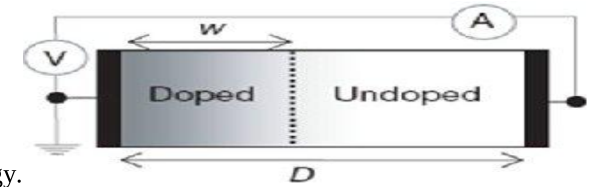
The transistor was invented in 1925 but lay dormant until finding a corporate champion in Bell Labs during the 1950s.Now another groundbreaking electronic circuit may be poised for the same kind of success after laying dormant as an academic curiosity for more than three decades. HP labs is trying to bring the memristor, the fourth passive circuit element after the resistor,& the "memory resistor" represents a potential revaluation in electronic circuit theory similar to the invention of transistor.

In 1971,Leon Chua, Engineer predicted that there should be a fourth passive circuit element called as a "memory resistors" or "Memoristors". Examining the relationship between charge, current, voltage and flux in resistor, capacitor and inductor. So that chua postulated the existence of memristor. Such a device he figured would provide a similar relationship between magnetic flux and charge that a resistor gives between voltage and current. In practice that would mean it acted like a resistor whose value could vary according to the current passing through it and which would remember that value even after the current disappeared.

In 2008, a team at HP Labs claimed to have found Chua's missing memristor based on an analysis of a thin film of titanium dioxide. Currently memristor is under development by various teams including HP, SK Hynix and HRL Laboratories.

III. DELAY IN DISCOVERY OF MEMRISTORS

Memristor was not been seen before because the effect depends on atomic scale movements, it only poped up on the nanoscale of Williams devices. Information can be written into the material as the resistance state of the memristor in a few nanosecond using a few picojoules of energy.



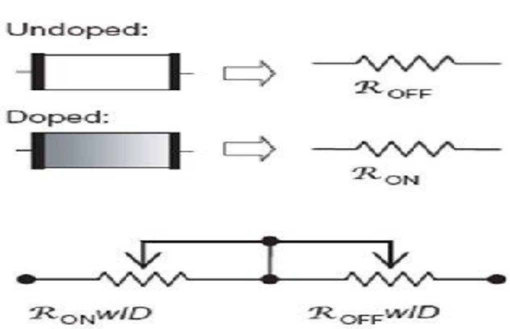


Fig.3 The coupled variable-resistor model for a memristor

The equation given below describes the memristance of any device as a function of charge:

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$$M(q)=R_{OFF}(1-[\mu_v R_{ON}/D^2]q(t))$$

Where

M(q)= Memristance of a device as a function of charge

R_{OFF}=High resistance state

R_{ON}=Low resistance state

μ_v=Mobility of charge

q(t)=Charge flowing through device at any time t

D=Thickness of semiconductor film sandwiched between two metal contacts.

For any material, this term is 1,000,000 times larger in absolute values at nanometer scale then is at micrometer scale because of factor $1/D^2$ & memristance is correspondingly more significant. So it was not possible to get the feel of memristance at millimeter scale, that is why it took 30 years to discover this nanoscale component.

IV. CRITICISM

In 2012, Meuffels and Soni discussed some fundamental issues and problems in the realization of memristor because the impact of concentration polarization effects on the behavior of metal−TiO_{2-x}−metal structures under voltage or current stress was not considered and "*The missing memristor found*"

This critique was referred by Valov in 2013.

Meuffels and Soni furthermore noted that the dynamic state equations set up for a solely current-controlled memristor with the so-called *non-volatility property*] would allow the violation of Landauer's principle of the minimum amount of energy required to change "information" states in a system: In order to exhibit the *non-volatility property* requires *"that the internal memristor or "information" states are separated from each other by Gibbs free energy barriers"*, viz. there is always a lower limit of energy requirement for changing a bit value in a binary device. This critique was adopted by Di Ventra and Pershin in 2013.Memristors whose resistance (memory) states depend totally on the current or voltage history would thus be unable to protect their memory states against unavoidable noise and permanently suffer from information loss, a so-called "stochastic catastrophe", viz. such envisioned memristor cannot exist as solid state devices in physical reality.

Other researchers noted that memristor models based on the assumption of linear ionic drift do not account for asymmetry between set time (high-to-low resistance switching) and reset time (low-to-high resistance switching) and do not provide ionic mobility values consistent with experimental data. Non-linear ionic drift models have been proposed to compensate for this deficiency.

A 2014 article from researchers of ReRam concluded that Strukov's (HP's) initial/basic memristor modelling equations do not reflect the actual device physics well, whereas subsequent models based on(physics such as Pickett's model or Menzel's ECM modelhave adequate predictability but are computationally prohibitive. As of 2014, the search continues for a model that balances these issues; the article identifies Chang's and Yakopcic's models as potentially good compromises.

In 2015, In the article "*The Missing Memristor has Not been Found*," published on Scientific Reports by Vongehr and Meng, it has been shown that the real memristor defined in 1971 is not possible without using magnetic induction. This has been illustrated by constructing a mechanical analog of the memristor and then analytically showing that the mechanical memristor cannot be constructed without using an inertial mass.

V. WORKING OF MEMRISTOR

Semiconductors are doped to make them either p-type or n-type. When we apply electric field to piece of n-type silicon, the ionized arsenics atoms sitting inside the silicon lattice will not move. We do not want them to move, in any case. Pure titanium dioxide(TiO_2),which is also a semiconductor, has high resistance, just as in the case of intrinsic silicon, & it can also be doped to maked it conducting. If an oxygen atom, which is negatively charged, is removed from its substantial site in $TiO_{2,}$a positively charged oxygen vacancies(V_0^+) can be in the direction of current applying electric field. Taking advantage of this ionic transport, a sandwich of thin conducting & non conducting layers of TiO_2 was used to release memristor.

When two thin layers of Tio2,one highly conductive layer with lots of oxygen vacancies(V0+) and other is undoped layer, which is highly resistive. Ohmic contacts are formed between two plate on either side of Tio2.

OPERATION

1)when a positive potential is applied at electrode the positive charged oxygen vacancy are repelled and moved into undoped Tio2,length of undoped region reduces due to ionic movement towards B. When there is more doping of positively charged oxygen vacancy with Tio2, potential barrier for electron is smaller and large current flows making the device turn on. When polarity are reversed, device becomes turn off storing electronic barrier at Tio2 metallic interface and reduces possibility of carrier tunneling.

2) Similarly when negative potential is applied at A, because of positively charged oxygen vacancies (Vo+) are attracted towards electrode A and length of undoped region increases. Under these conditions electronic barrier at undoped Tio2 and the metal is too wide and it will be difficult for the electrons to cross over the barrier

SPECIALITY

Memristor is not just that it can be turned OFF or ON, but that it can actually remember the previous state. This is because when the applied bias is removed, the positively charged Ti ions do not move anymore, making the boundary between the doped & undoped layers TiO_2 immobile. When we next apply a bias to the device, it starts from where it was left.

VI. MEMRISTORS: ADVANTAGES AND DISADVANTAGES

ADVANTAGES OF MEMRISTORS:

- Faster computers
- Smaller devices
- More brain-like computing
- May eliminate need for processor
- Greater storage capacity
- Have properties which cannot be duplicated by the other circuit elements
- Capable of replacing both DRAM & hard drives
- Smaller than transistors while generating less heat
- Works better as it gets smaller which is the opposite of transistors
- Devices storing 100 gigabytes in a square centimeter have been created using memristor
- Quiker boot-ups
- Requires less voltage

DISADVANTAGES OF MEMRISTORS

- Not currently commercially available
- Current versions only at 1/10th the speed of DRAM
- Has the ability to learn but can also learn the wrong patterns in the beginning
- Since all data on the computer becomes non-volatile, rebooting will not solve any issues as it often times can with DRAM
- Suspected by some that the performance & speed will never match DRAM & transistor when a computer is infected with a virus or is not properly functioning, the memristor may cause the computer to keep rebooting with the same problem because the memory will not be lost after reboot.

VII. POTENTIAL APPLICATIONS

NANO-SCALE NATURE

The main objective in the electronic chip design is to move computing beyond the physical & fiscal limits of conventional silicon chips.

Instead of increasing the number of transistors on a circuit, we could create a hybrid circuit with fewer transistors but with the addition of memristor which could add functionality. Alternately, Memristor technologies could enable more energy-efficient high-density circuits.

Memristor, was not been seen before because the effect depends on atomic-scale movements, it only poped up on the nanoscale. Information can be written into the material as the resistance state of the memristor in a few nanoseconds using few picojoules of energy. And once written memory stays written even when the power is shut.

REPALCEMENT OF FLASH MEMORY

The important potential use of memristor is as a powerful replacement for flash memory the kind used in applications that require quick writing & rewriting capabilities, such as in cameras & USB memory sticks. Like flash memory, memristor memory can only be written 10,000 times or so before the constant atomic movements within the device cause it to break down. It is possible to improve the durability of memristor.

REPLACEMENT FOR DRAM

Computers using conventional DRAM lack the ability to retain information once they are turned off. When power is restored to a DRAM based computer, a slow energy consuming “boot-up” process is necessary to retrieve data on magnetic disk required to turn on the system. The reason computers have to be rebooted every time they are turn on is that their logic circuits are incapable of folding there bits after the power is shut off. But because a memristor can remember voltages, a memristor-driven computer will never need reboot. “You could leave all your word files & spreadsheets open, Turn off your computer & go get a cup of coffee & go on vacation for two weeks”.

BRAIN LIKE SYSTEMS

As for the human brain-like characteristics, Memristor technology could one day lead to computer systems that can remember & associate patterns in a ways similar to how people do.

This could be used to substantially improve facial recognition technology or to provide more complex biometric recognizing system that could be more effectively restrict access to personal information. These same pattern matching capabilities could enable appliances that learn from experiences & computers that can take decisions.

CROSSBAR LATCHES AS TRANSISTOR REPLACEMENTS OR AUGMENTORS

The more power consumption of transistors has been a barrier to both miniaturization and microprocessor controller development. Solid-state memristor can be combined into devices called crossbar latches, which could replace transistors in future computers, taking up a much smaller area. Due to this difficulties development cost is more. Unless a competition war amongst industry giants becomes one of those patent showdowns, where companies buy out technological advances to bury them. Remember 3G? Well, someone bought out 4G back in 2005, before 3G even came to market, and has been sitting on it ever since. And have profited greatly.

PROGRAMMABLE LOGIC AND SIGNAL PROCESSING

A variety of Control System memristor patents are out there, waiting for the microchips to fall where they may. The memristive applications in these areas will remain relatively the same, because it will only be a change in the underlying physical architecture, allowing their capabilities to expand, however, to the point where their applications will most likely be unrecognizable as related

NEW HORIZONS

After the discovery of memristor there are new horizons having the properties like memristor.

There are two such elements which were next discovered:

1)MEMCAPACITOR

2)MEMINDUCTOR

The memcapacitor meminductor are the memdevices in which capacitance & inductance respectively depends on state & history of system. They show pinched hysteresis loop in the constitutive variables that define them:

Charge-Voltage for Memcapacitance

Current-flux for Meminductance

The difference between memristor & both these devices is that they store energy whereas memristor cannot.

VIII. CONCLUSION

By redesigning certain types of circuit to include memristor, it is possible to obtain the same function with fewer components, making the circuit itself less expensive & significantly decreasing its power consumption. In fact it can be hope to combine memristor with traditional circuit design elements to produce a device that does computation. The HP group is looking at developing memristor- based nonvolatile memory that could be 1,000 times faster than magnetic disks & use much less power.

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