Polymer Memory – A New Way of Using Plastic as A Secondary Storage

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Abstract- *The Polymer memory technology promises to store more data at a lesser cost as compared to the expensive silicon chips used by popular consumer gadgets including smart phones, digital cameras, and other electronic products. The magical ingredient is not smaller transistors or an exotic material cooked up by the semiconductor industry. It is a plastic. This new memory does not use transistors to store information. Instead, bits are written when a strong current passes through a polymer fuse, causing it to blow and change its conductivity.*

Keywords- Polymer; Electronics; Polyethylenedioxythiophene (PEDOT); plastic; Bistable switching.

I. INTRODUCTION

While experimenting with a polymer material known as PEDOT, Princeton University researcher Sven Moller determined that although the plastic conducts electricity at low voltages, it permanently loses its conductivity when exposed to higher voltages. Together with colleagues from Hewlett-Packard Laboratories, he developed a method to take advantage of this property to store digital information, which can be stored as collections of ones and zeros. The PEDOT-based memory card consists of a grid of circuits comprising polymer fuses. A large applied current causes specific fuses to “blow,” leaving a mix of functioning and non-functioning connections. When a lower current is later used to read the data, a blown fuse blocks current flow and is read as a zero, whereas a working fuse is interpreted as a one. Because the storage method involves a physical change to the device, it is a so-called WORM–write once, read many times technology.

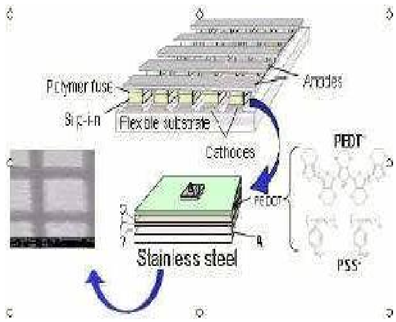
Features of Polymer Memory

1. Data stored by changing the polarization of the polymer between metal lines.
2. Zero transistors per bit of storage.
3. Memory is Nonvolatile.
4. Microsecond initial reads. Write speed faster than NAND and NOR Flash.
5. Simple processing, easy to integrate with other CMOS.
6. No cell standby power or refresh required.
7. Operational temperature between – 40 and 110°C

Plastic Memory being developed

Researchers at Princeton University working with Hewlett-Packard have invented a new form of permanent computer memory that uses plastic and may be much cheaper and faster than existing silicon circuits. By utilizing a previously unknown property of a cheap, transparent plastic called PEDOT (short name for polyethylene-dioxythiophene); the inventors say that data densities as high as a megabit per square millimeter should be possible. By stacking layers of memory, a cubic centimeter device could hold as much as a gigabyte and be cheap enough to compete with CDs and DVD.

PEDOT is an unusual plastic because it conducts electricity, a property that’s led to it being used for anti-static coatings. However, a sufficiently large pulse of current changes it permanently to a nonconducting state, just like a fuse. By putting microscopic pellets of the stuff between two grids of wires, data can be stored by blowing patterns of bits. The memory cannot be rewritten but can be read very fast and with low power consumption. The biggest challenge is developing production techniques. We are hybridizing said the leader of the research group, Princeton professor of electrical engineering Stephen Forrest. We are making a device that is organic the plastic polymer and inorganic thin film silicon at the same time.

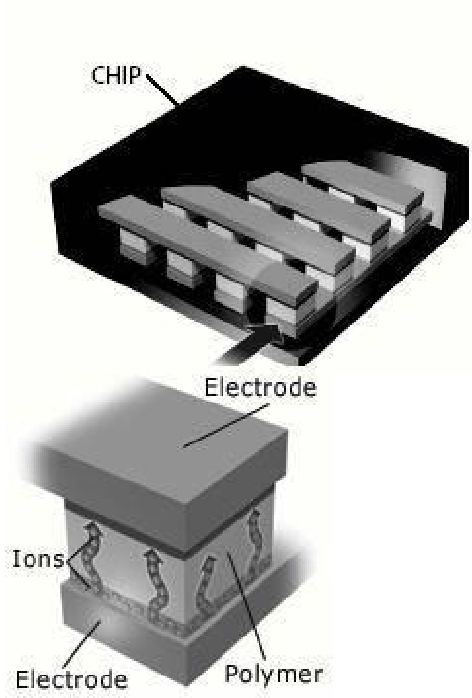


(Fig.2a,) Coatues

How does Polymer memory work?

Polymer memory stores information in an entirely different manner than silicon devices. Rather than encoding zeroes and ones as the amount of charge stored in a cell, Coatues chips(Fig. 2a) store data based on the polymers electrical resistance. Using technology licensed from the University of California, Los Angeles, and the Russian Academy of Sciences in Novosibirsk, Coatue fabricates each memory cell(Fig. 2b) as a polymer sandwiched between two electrodes. To activate this cell structure, a voltage is applied between the top and bottom electrodes, modifying the organic material. Different voltage polarities are used to write and read the cells. Application of an electric field to a cell lowers the polymer's resistance, thus increasing its ability to conduct current; the polymer maintains its state until a field of opposite polarity is applied to raise its resistance back to its original level. The different conductivity States represent bits of information.

A polymer retains space charges near a metal interface when there is a bias, or electrical current, running across the surface. These charges come either from electrons, which are negatively charged, or the positively-charged holes actuated by electrons. We can store space charges in a polymer layer, and conveniently check the presence of the space charges to know the state of the polymer layer. Space charges are essentially differences in electrical charge in a given region. They can be read using an electrical pulse because they change the way the device conducts electricity. The basic principle of Polymer-based memory is the dipole moment possessed by polymer chains. It is the reason by which polymers show the difference in electrical conductivity. As explained earlier implementing a digital memory means setting up a way to represent logic one and logic zero. Here polarizations of polymers are changed up or down to represent logic one and zero.



(Fig.2b,) Coatues memory cell

Advantages of Polymer memory

1. Plastic memory is fast. Lab built devices with a 1GB storage capacity have yielded read/write cycle times that are 10 times faster than CompactFlash, which are typically 2- 10MB/s read, 1-4MB/s write.
2. Memory is Nonvolatile
3. Fast read and write speeds
4. It requires far fewer transistors, typically only 0.5M (million) for 1GB of storage compared to silicon's 1.5-6.5B (billion).
5. It can be stacked vertically in a product, yielding 3D space usage; silicon chips can only be set beside each other.
6. Very low cost/bit, high capacity per dollar
7. Low power consumption
8. Easy to manufacture: use ink-jet printers to spray liquid-polymer circuits onto a surface
9. Thin Film system requires about 0.5 million transistors per gigabit of memory. The traditional silicon-based system would require between 1.5 to 6.5 billion transistors for that same gigabit.

Expanding memory capability by using stacked memory

Expanding memory capability is simply a matter of coating a new layer on top of an existing one. The footprint remains the same even after expansion because each new layer adds the same capacity as the first one. This stacking is a fundamental strength of the Thin Film technology. A layer may include a self-contained active memory structure with on-layer TFT circuitry or share circuitry with all other layers. Both approaches offer true 3D memory architecture. This means that the new technology is not just for saving space, but also the option of using different, and optimized software architectures.

The driver circuitry, comprising column and row decoders, sense amplifiers, charge pumps and control logic, is located entirely outside the memory matrix, leaving this area completely clear of circuitry, or be 100% built underneath the memory array. This is the fundamental factor which enabled the stacking option. With no circuitry in the memory plane, it is possible to build the polymer memory on top of other chip structures, e.g. processors or memory.

If you want to add more memory with silicon-based technology, you move in a two-dimensional space. Put simply, the area taken, 128 MB RAM, is more than the area occupied by 64 MB RAM. With the new polymer-based technology, you will move in a three-dimensional space.

That is, you move from talking about the area to talking about volume. Put simply, a 128 MB RAM module will have the same footprint as a 64 MB module, but slightly thicker (or higher). This difference in thickness or height will be so small, that we may not even be able to tell the difference by just looking at it. If a 64 MB silicon-based module takes up 20mmx10mmx6mm (1200 cubic mm of space), then 124 MB occupies approximately double that volume. However, with polymer-based memory, the footprint (length x breadth) will remain the same (200 sq mm) but the height would increase only by about 1/10000th of a millimeter, which adds practically nothing to the volume. Polymer memory layers are just 1/10,000 of a millimeter or less in thickness, autonomous and easy to deposit. Layer upon layer may be coated on a substrate. A layer may include a self-contained active memory structure with on-layer circuitry and TFT, or share circuitry (as in hybrid polymer over- silicon chips). In the latter case, stacked layers may be individually addressed from the bottom circuitry, giving three-dimensional storage capacities. The Thin Film memory system is expandable by the addition of new layers manufacturers will be able to gain previously unattainable storage capacity within a given footprint.

Examples: The equivalent of 400,000 CDs, or 60,000 DVDs, or 126 years of MPG music may be stored on a polymer memory chip the size of a credit card.

Limitations of Polymer memory

Turning polymer memory into a commercial product is not an easy process. Memory technologies compete not only on storage capacity but on speed, energy consumption, and reliability. The difficulty is in meeting all the requirements of current silicon memory chips. Until new memory materials are able to compete with the high performance of silicon, their notes, they are likely to be limited to niche applications. One likely use is in disposable electronics, where cost, rather than performance, is the deciding factor.

Researchers at Lucent Technologies Bell Laboratories are working on polymer memory devices for use in identification tags. The polymer memory made at Bell Labs is still relatively slow by silicon standards, and anticipated capacity is only on the order of a kilobit. But, says Bell Labs chemist Howard Katz, the flexible and low-cost polymer memory devices could be very attractive for, say, identification tags meant to be thrown away after a few uses.

II. CONCLUSION

Plastic memory is considerably cheap and fast as compared to the silicon memory. This memory can be easily developed as the material required is easily available and the process of manufacturing is also simple. No huge investment is required as compared to its counterpart. The power consumption is very less and the memory device is highly dense which can accumulate a large amount of data in small space. The data is maintained in memory even when the power is off. As the technology is still in development phase it does not enjoy large business in the market. It needs a lot of efforts by researchers and the marketing section to make this particular concept of memory popular and enjoy it is really worth.

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