www.ijecs.in
International Journal Of Engineering And Computer Science ISSN: 2319-7242
Volume 5 Issue 11 Nov. 2016, Page No. 18879-18885

Plastic Flexible Memory Chip Devices

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Abstract

A lines of advances in organic memory technology is demonstrated that enable an entirely new low-cost memory technology. Inventors incorporate these advances with the one of the most flexible material PLASTIC. This novel memory technology can be utilized in a 3D onetime-programmable storage array. Without the prohibitive costs of silicon processing, this memory is able of setting cost points several orders of magnitude lower than their inorganic counterparts. They have also progressively integrated this technology onto flexible plastic substrates. Combined with stacking, these vertical memory elements can create read only memory densities denser than many inorganic memories, at a fraction of the cost. A conducting plastic has the potential to put into a mega bit of data in a millimetre-square device-10 times denser than current magnetic memories. This system is cheapand fast, but cannot be rewritten, so would only be suitable for permanent storage. The system sandwiches a blob of a conducting polymer called PEDOT and a silicon diode between perpendicular connection. The key to the new technology was discovered by passing high current through PEDOT (Polyethylenedioxythiophene) which converts it into an insulator, rather like blowing a fuse .The polymer hastwo possible states conductor and insulator, that form the one and zero, necessary to put into digital data

1. Introduction

Recent advancements in flexible electronics research will enable novel applications ranging from stylish flexible gadgets for real-time monitoring of health-related vital signs to novel biological applications such as electronic skin. Critical advances have been made in recent years that rely on organic materials as active elements because of their inherent flexibility. Mainstream approaches to capitalize on naturally flexible substrates like polymers can be categorized into all-organic systems.

In addition, a complementary transfer-free approach has recently been introduced, where thinning down the inorganic substrate through traditional, standard fabrication processes improves the flexibility of the substrate. These approaches are all geared towards achieving fully flexible electronic systems. The three main components in any electronic system are [1] processing units; [2] the main memory; and [3] storage.

An objective assessment of the discussed mainstream and complementary approaches to flexible electronics must focus on their ability to provide high-performance, reliable NVM devices In this review, we present the mainstream NVM architectures and technologies with a special focus on most up-to-date techniques for producing flexible NVM devices.

There are many interesting works on flexible write-once-read-multiple (WORM) NVMs and other NVM devices that might be suitable for future applications in flexible electronics. the comprehensive scope of this review combining various flexing approaches, non-volatile memory and transistor technologies, arraying architectures with a special focus on flexibility, performance, reliability and monolithic integration ability has not been reported to date. As of today variety of materials have been used to build NVM devices. For example, NMVs based on; [i] embedded 0-dimensional gold nanoparticles. [ii] 1-dimensional zinc oxide nanowires [iii] 2-dimensional grapheme.[1]

2.NVM Operational Principles and Architectures

2.1. NVM Operational Principles

NVM Operational Principles Similar to how we define the human brain's ability to memorize as the ability to remember useful information over long- and short-term durations, electronic memories have the ability to retain stored information over various durations.

An electronic memory that is able to retain information over short periods of time (milliseconds) is identified as a volatile memory. In this case, when the power goes off, information stored in the volatile memory is lost. On the contrary, an electronic memory that is able to store information over long periods of time (~10 years is the industry standard) is called a non-volatile memory (NVM). NVMs can retain information even when no power is supplied. There are five major classes of NVMs: resistive RAM (ReRAM) also referred to as memristor, ferroelectric RAM (FeRAM), magnetic RAM (MRAM) , phase change RAM (PCRAM), and flash memory and charge trapping (CT)). Other technologies, such as nano-electromechanical (NEM) NVMs and molecular based NVMs exist but they are not mainstream.

2.2. NVM Architectures

NVM architectures are an important element in memory design that can be classified into three main categories: the 1T, where the memory cell is composed of a single transistor ('T' stands for transistor); the 1T1C or 1T1R, where the memory cell is composed of an access/select transistor and a non volatile storage structure ('C' stands for capacitor and 'R' stands for resistor); and the 2T2C (two transistors and two capacitors per memory bit).

Other variations of these main architectures and different arrangements, such as the 1T2C, have also been reported . Furthermore, there are differences in the way memory cells are connected to each other. For instance, NOR-type flash and NAND-type flash memories both have a 1T architecture but different cell connections .

Also, there is the crossbars configuration in which each memory cell is connected to four neighboring cells [145]. Figure 7 shows the schematic arrangements of the three main architectures, NOR and NAND flash arrangements, and the crossbars configuration.

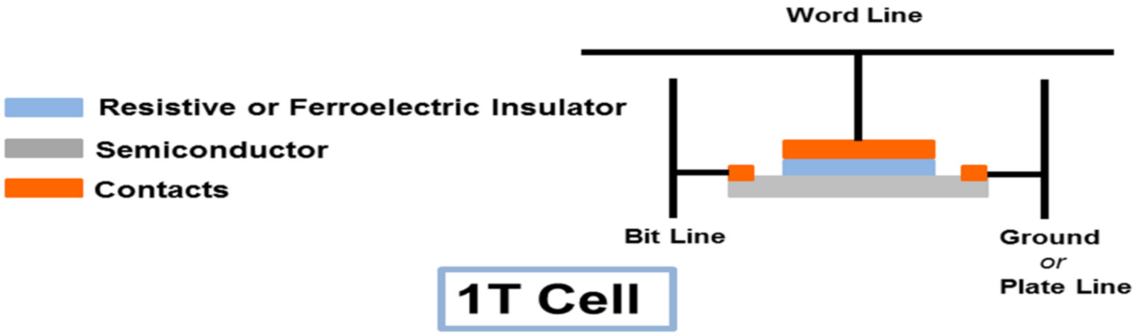

Fig.(a)

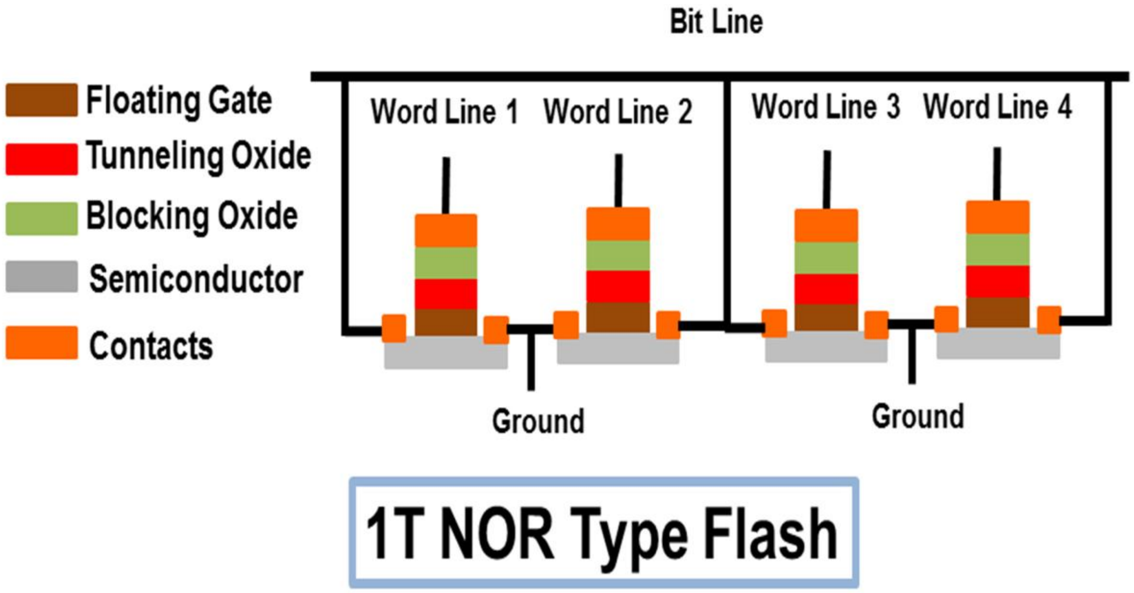

Fig.(b)

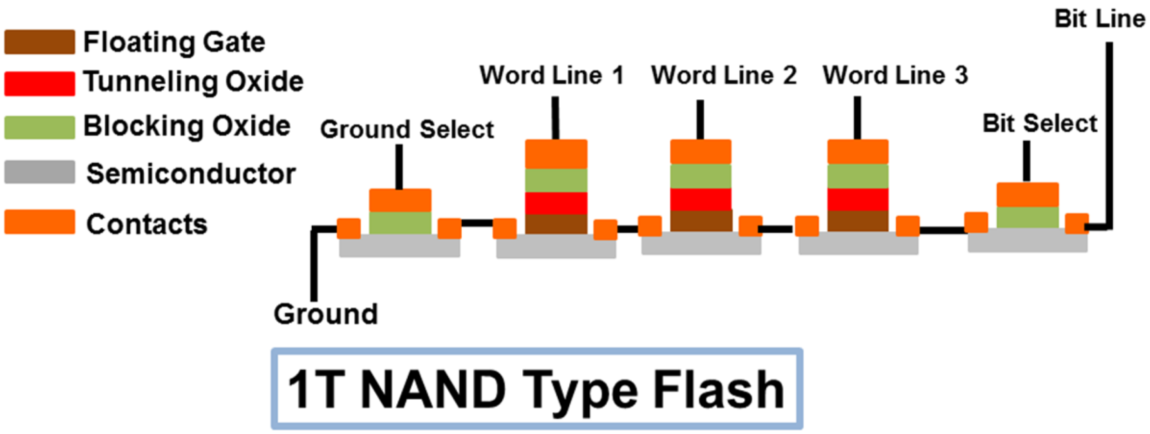

Fig.(c)

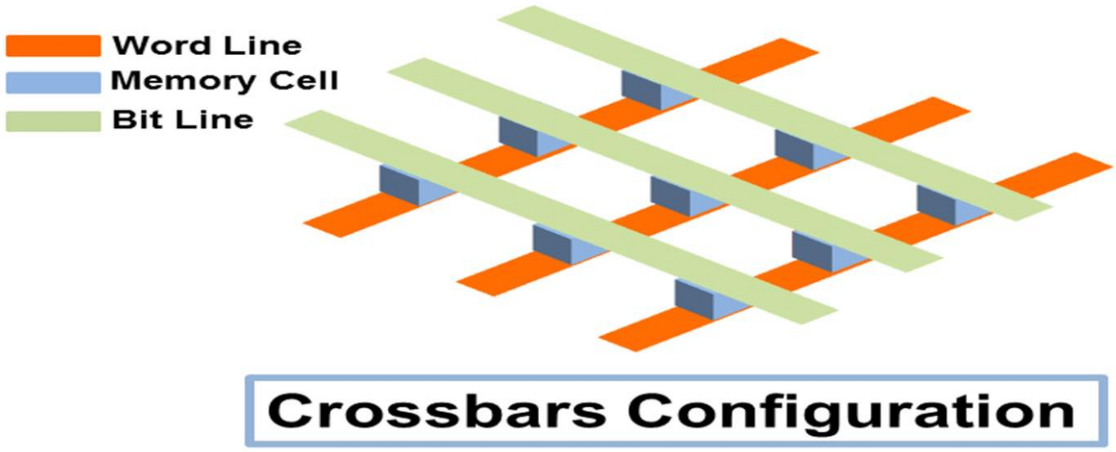

Fig.(d)

Figure 2.2.1. (a)– (d) Common memory architectures.[2]

3. Working of This New Flexible Magnetic Plastic Memory Device

This new plastic memory device performs on magnetoresistive random access memory (MRAM). This MRAM uses magnesium oxide based magnetic tunnel junction (MTJ) to store data. MRAM performs on typical RAM (NVM) in various features. The features like retaining data after the power supply cut off, high power speed and less consumption of electricity.[4]

3.1 Magnetic memory chip works within bendy plastic

A new technique implants a high-performance magnetic memory chip on a flexible plastic surface without compromising performance. This invention, developed at the National University of Singapore, brings researchers a step closer towards making flexible, wearable electronics a reality.

“Flexible electronics will become the norm in the near future, and all new electronic components should be compatible with flexible electronics,” says study leader Yang Hyunsoo, an associate professor in the department of electrical and computer engineering.

The research team has successfully embedded a powerful magnetic memory chip on a flexible plastic material. The device could be a critical component for the design and development of flexible and lightweight devices. The work could find uses in the automotive industry, healthcare electronics, industrial motor control and robotics, industrial power and energy management, as well as military and avionics systems.

The new device operates on magnetoresistive random access memory (MRAM), which uses a magnesium oxide based magnetic tunnel junction (MTJ) to store data. MRAM outperforms conventional random access memory (RAM) computer chips in many aspects, including the ability to retain data after a power supply is cut off, high processing speed, and low power consumption.[5]

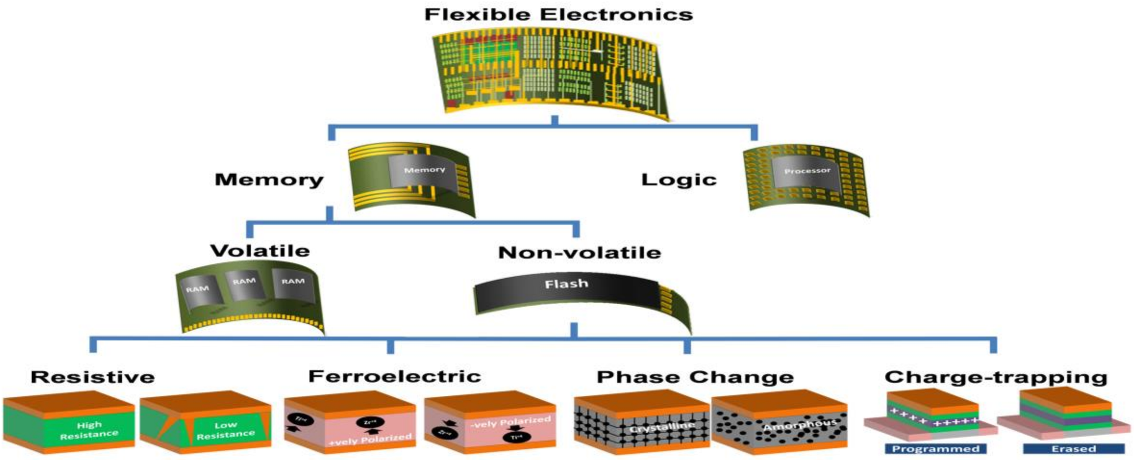

Fig. 3 Chart highlighting the focus of the review.

3.2 Volatile memory

3.2.1 Part of the Storage hardware glossary:

Volatile memory is computer storage that only maintains its data while the device is powered.

Most RAM (random access memory) used for primary storage in personal computers is volatile memory. RAM is much faster to read from and write to than the other kinds of storage in a computer, such as the hard disk or removable media. However, the data in RAM stays there only while the computer is running; when the computer is shut off, RAM loses its data.

Volatile memory contrasts with non-volatile memory, which does not lose content when power is lost. Non-volatile memory has a continuous source of power and does not need to have its memory content periodically refreshed.[7]

3.3 Non-volatile memory, :-

Non-volatile memory, NVM or non-volatile storage is a type of computer memory that can retrieve stored information even after having been power cycled (turned off and back on). Examples of non-volatile memory include read-only memory, flash memory, ferroelectric RAM (F-RAM), most types of magnetic computer storage devices (e.g. hard disk drives, floppy disks, and magnetic tape), optical discs, and early computer storage methods such as paper tape and punched cards.

Non-volatile memory is typically used for the task of secondary storage, or long-term persistent storage.[1] The most widely used form of primary storage today is a volatile form of random access memory (RAM), meaning that when the computer is shut down, anything contained in RAM is lost. However, most forms of non-volatile memory have limitations that make them unsuitable for use as primary storage. Typically, non-volatile memory costs more, provides lower performance, or has worse write endurance than volatile random access memory.

Non-volatile data storage can be categorized in electrically addressed systems (read-only memory) and mechanically addressed systems (hard disks, optical disc, magnetic tape, holographic memory, and such). Electrically addressed systems are expensive, but fast, whereas mechanically addressed systems have a low price per bit, but are slow. Non-volatile memory may one day eliminate the need for comparatively slow forms of secondary storage systems, which include hard disks.Several companies are working on developing non-volatile memory systems comparable in speed and capacity to volatile RAM.[8]

4. FLEXIBLE NVM TECHNOLOGIES

The most important figures of merit for assessing memory technologies are listed below*:*

a)Form Factor (F2): Although form factor usually refers to the physical lateral (length and width) and vertical (height) dimensions for memory module millimetres, at the device level, the form factor is defined as the lateral area of a single memory cell (1 bit) divided by the square of the smallest feature (technology node) and has no units

. For example, a memory cell that is 1 × 0.5 μm2built at the 0.25-μm node would have a form factor of 8F2.

b) Density: The number of memory bits that fit per unit area.

c) Cost ($/bit): The total cost to make memory modules divided by the number of integrated memory bits.

d) Endurance: The number of write/erase cycles a memory cell undergoes before its performance degrades significantly. Electronics 2015, 4449

e) Retention: The retaining ability of a memory cell to store uncompromised information over time.

f) Operation voltage: The maximum voltage required for a write/erase operation of a memory bit.

g) Speed: The amount of time the memory cell needs to switch between different memory states (‘0’ or ‘1’).

h) Memory window: Measures the distinguish ability of the different memory states. Voltage-sensitive memory is proportional to the voltage shift, while current sensitive memory is proportional to the current ratio for different states. [3]

5. ADVANTAGES

- The memory cannot be rewritten, but can be read very fast and with low power consumption.
- So this would be suitable only for permanent storage.

6. APPLICATIONS

1) Healthcare electronic
2) Industrial power
3) as automotive
4) Where you want disposable memory
5) Cameras
6) Industrial robotics and motor control.

7. FUTURE PROSPECTS

Future prospects indicate that a number of challenges will have to be overcome before flexible ReRAM, FeRAM, PCRAM, MRAM, and flash will be primed for commercialization. Flexible FeRAM has an edge because of its rigid current form that is used as an embedded NVM in microprocessors. Flash has the highest potential owing to the maturity of the technology in the rigid state; furthermore, the transfer of this technology and progress to the flexible arena will definitely speed up the introduction of commercial flexible flash NVM for various applications. On the other hand, ReRAM, PCRAM, and MRAM are still emerging technologies, even in their bulk rigid form. The potential for extreme scaling, fast speeds, and low-power operation of NVMs is attracting the attention of both researchers and industry such that they might catch up with competing mature technology in the flexible arena earlier than expected.

8. CONCLUSION

Exciting progress has been made in flexible electronics research over the past few decades. OLED flexible screens are already available in the market, and numerous novel biomedical and wearable applications using flexible electronics have been proposed. At this stage, expectations for silicon-based electronics are high and the status quois for high performance, fast, low power, compact, and reliable aspects, some of which might not cross the chasm to the flexible arena. This is the core value for which the research field of transfer-free inorganic silicon-based flexible electronics is created. However, this approach is relatively new compared to the ongoing research on flexible organic electronics, where organic materials are used as substrates or device material. In this review, we have presented a brief overview of flexible electronics research, focusing on NVM components. We listed the mainstream NVM architectures and technologies with a special focus on flexible devices and provided benchmarking tables for transistors and storage devices derived from the three main approaches:

1) All organic.
2) Hybrid.
3) Inorganic.

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