RAMIFICATION OF IOT AND ML ON MEMORY DEVICES AND MATERIALS

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Abstract*— *In the recent era of modernization, the "Internet of things" (IoT) is becoming ubiquitous. IoT as technology has given pathway to smart products which are revolutionizing the normal lives in an unprecedent manner. The success of these products is heavily dependent on their cost to market. The prime requirement for any IoT based application is the huge memory to store the data, it's been observed that around 60 to 80% area of any IOT product is consumed by memory itself. There are different memories available in the market like DRAM, SRAM, NOR and NAND flash and charge based memories. Most of the time on chip memory is required for fast processing such memories are embedded in the chip itself and SRAM is the choice due to its fast access time. The SRAM is either four or six transistors circuit and in order to decrease die size area and in line with Moore's law, the channel length of transistors is being decreased giving rise to issue of leakage currents. There are billions of transistors in a huge memory all of them leaking together threaten the integrity of the chip and thus IoT application seems to be non –feasible with current set of memories in hand. The intend of this paper is to cover the technological changes on the memory devices and materials due to upsurge in IOT and ML applications.

***Keywords*— IOT, memory, NAND, NOR, PCM, RRAM**

I. INTRODUCTION

The monumental statement by the Gordon Moore that "the number of transistors that can be put on a microchip doubles every year" had such an economic impact that this statement was being considered as law till recent times. The ramification of this statement led to considerable decrease in die size or in other terms led to exponential growth in complexity and computing power without much economic impact to customers and manufacturer. To quote processor speed were in range of kHz to MHz in 1970s, moving 20 years ahead this speed range was in range of GHz. In the beginning of 21st century the number of transistors in the CPU numbered 37.5 million, and in matter of ten years the number unprecedently went up to 904 million.
But since last few years it's been iterated time and again that Moore Law is a dying statement.
As was predicted by Moore's law the size of transistors continues to decrease, they have gotten so small that leakage has become an issue. For IOT related devices the memory is becoming main issue the on-chip memory for IOT devices is small and hence there is need to go for off chip memories which is increasing the product cost and area. So, this led to the need of newer technologies which can overcome the detrimental impact of Moore's Law. Even if we accept this leakage power, and assume that we can move forward with Moore's Law for next 30 years, then this will mean that in order to maintain the same complexity transistors size has to be smaller than a single atom of hydrogen, the fabrication cost is going to be huge so the idea is simply not feasible. In the next few sections, we are going to discuss the devices and the upcoming memory technologies which can lead to rampant development of IOT and ML based products at low cost.

II. CURRENT DEVICES AND MATERIALS

The leakage current and hence the off-chip power can be reduced at device level by using modern devices such as DG-MOSFET also known as double gate-metal oxide semiconductor field effect transistor, fin-FET that is fin-field effect transistor and Si-nanowire MOSFET are the most prominent ones. Others include DMSG which is Dual material surrounding gate MOSFET which by using the effective gate material engineering have been able to reduce the short channel effects by improving the carrier transport efficiency. The latest to join the bandwagon is CNTFET which stands for Carbon nano-tube field effect transistor. This is a nanodevice whose structure is similar to widely used and accepted technology which is (CMOS). The two most important parameters for the designing of analog circuits which forms the essential part in memory design are transconductance and power consumption. The CNTFET has both high transconductance and low power consumption and hence ensuring It higher performance, than conventional CMOS technology. All the technologies discussed so far leads to volatile logics that is as soon as power goes off the data is no longer available causing a major concern for IOT and ML application.

III. Future of Memory Devices IN THE ERA OF IOT AND ML

The Major market players have realized the end of Moore Law is inevitable and they have already been working on the solution, one of the possible solutions was that instead of reducing transistor size we focus on things like improved battery life and Multi core chips. These are temporary fixes and are of limited scope. Research are going in arenas of Quantum computing and Nanoelectronics materials and devices which can render to the needs of IOT and ML, the most upcoming ones along with their advantages and disadvantages are discussed henceforth.

Phase-change memories often known as PCM are developed using chalcogenide glass which have the property of being into two states amorphous and polycrystalline thus giving possibility of storing a 1 or 0.These memories are considered to be the best candidates in replace Flash memories as they are non-volatile, bit alterable, fast read/write access time and most advantageous is that they can be scaled down unlike FLASH memories which re difficult to shrink due to their floating gate structure .PCM are considered to be the memories which can bridge the gap between volatile and non-volatile memories and can be very well used for neuromorphic and artificial intelligence applications. But PCM have one major limitation they require high programming currents for changing the states of chalcogenide glass. This may lead to threshold changes in PCM memories and in long run the circuit might not be able to detect 1 and 0. Moreover there are large number of thermal effects owing to high programming current which have not yet been fully understood thus limiting PCM.

Another upcoming non-volatile memory which is creating a spur in technology markets is Spin-Transfer Torque (STT) MRAM this memory is based on the magnetic properties of electron spin in an orbit. One of the primary concern for most of the IOT based product is power, almost all the products have low power as their main specification and this is where STT fits effectively as STT based memories have low current requirements, this improves the battery life by consuming less power from portable devices hence making them as the emerging technology for IOT based product lines. In fact, STT based memories are found to be the amalgamation volatile memories like DRAM, SRAM in terms of scalability and performance, with non-volatile memories like FLASH in terms of low power and low cost. The STT MRAM primary advantage over CMOS technology is its ability to operate in ultra-low power region approximately in range of 10mV and lower along with capability of scaling down to 10nm that to at low fabrication costs. Another major requirement of IOT product line is that data should be available even if power switch off since STT-MRAM being non-volatile, retains its data indefinitely when the power is gone and thus becoming the best choice amongst all the memory technologies discussed so far.
Since STT MRAM scores on every criteria being it performance ,scalability and most importantly cost, several companies like Ever spin, Spin-Transfer Technologies, IBM, Samsung and Crocus are developing STT-MRAM chips.

IV. Conclusion

The latest memory on the block with huge potential is RRAM. The reason for the preference of RRAM over charge-based storage memories are smaller size, multi bit capability as well as less energy per bit hence make it denser and less power consuming. However, this technology lacks accurate device models as the device physics of these devices are still under research. The future of all the mentioned memory technologies and devices depends on the extensive characterization and optimization of nano devices through accurate modelling and simulations along with low power consumption by these memory cells.
Another question which often bothers the people is which memory is going to rule the market the answer is there is no one particular memory technology which will dominate the market, in fact the answer to this is that it will depend on the application of IOT,ML and the cost for instant in case of wearable products based on IOT the preference will be given to ,ow power ,low cost non-volatile memories which will determine the future of the memory technology.
In the words of Mike Mayberry, manager of Intel's components research "It's the equivalent of a turn, not a step off a cliff," Hence though it’s the end of Moore’s Statement specifically for the memory devices to be used in IOT and ML application but this certainly is a “New Beginning”.

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