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MAIN PRINCIPLES OF DYNAMIC RANDOM ACCESS MEMORY (DRAM) AND ANALYSIS OF DRAM MARKET

Abstract: *The paper will present the main principles of functioning of the dynamic random access memory, it's flaws and advantages, the way it operates and all it's main characteristics, such as all the main operations. After getting familliar with these things, the paper will be analyzing the market of DRAM through the years, also analyzing it's use in modern electronic devices. In terms of market analysis the paper points to the key factors that make the market what it represents today and also pointing on some of the biggest manufacturers of dynamic random acces memory today. It also points out the chip's market share by manufacturer worldwide through the years and how it changed for some of the biggest companies in this branch of electronic buisness. Dynamic random access memory is one of the key components in the computer system, and today thanks to the development of technology in many other systems. The development of this memory is very important because its improvements have an impact on the performance of the systems in which it is used, and that is one of the main reasons why it should be analyzed and studied.*

Keywords: *dynamic memory, market, manufacturers, companies*

1. Introduction

A digital computer represents a modern electronic machine, which should perform any task that is assigned to it. The computer is a complex system, with a hierarchical organization, composed of a large number of electronic components.

Memory is a part of a computer system that serves to store programs and data. The information stored in the memory does not suffer any change over time, and therefore we can say that memory is a passive part of the system. The computer's memory system consists of information memory units and algorithms that are designed to manage the given information. In order to enable constant operation of the processor, it is desirable that it can directly access the memory and that this approach does not interrupt. This allows the transfer of information between the processor and the memory at the speed at which the processor operates. Memories whose speed is equal to the speed of the processor are extremely expensive and not practical. Therefore, the information system is allocated to different memory units that have different physical characteristics.

The idea for DRAM technology appeared relatively early in the time frame of the semiconductor of integrated circuits. The earlier form was found in the Toshiba calculator that was made in 1966 from a

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discrete component, and then two years later the idea of DRAM as it is known today developed.

Over time, the technology that was used to create memory modules has changed constantly, with some of it being used today. On the first computers, logical bits were remembered mainly on mechanical devices such as cards and paper strips. Later, there is a change in the use of ferroelectric materials in the form of core and transferable magnetic media. As the technology progresses, the increasing frequency of application of semiconductor components and optical discs begins.

Dynamic random access memory is one of the key components in the computer system, and today with the development of technology and in many other systems. The development of this memory is very important because its improvements have an impact on the performance of the systems in which it is used.

2. Literature overview

Onur Multu and Lavanya Subramanian (2014) describe the demands and challenges faced by the memory system. They did a research on methods that are being developed in overcoming the obstacles that the memory faces. They also include a brief review of what the memory requirements are.

Bal Krishan and Meenu Rani Garg (2015) wrote a paper to help a more basic understanding of DRAM memory. It discusses the basic introduction of DRAM and it's architecture. The paper touches on four, two and one transistor DRAM cells. The most basic operations, read and write, are included in paper too. The comparison between two basic types of memories i.e. SRAM and DRAM is also discussed in the paper.

In terms of DRAM market the Yole group of companies (2018) did an research on both DRAM and NAND markets in 2018. They talk about the revenue these two types of memory generate through the year, taking into consideration the factors that might have impacted the sale. They try to answer these questions and provides its point of view on the future of the market

BCC Research (2018) did a research on DRAM global market, making predictions on it's course to 2022. This report provides an overview of the global DRAM market based on its various types, subtypes, generations and application areas available. DRAM's current market status, trends and growth forecasts are provided for the next five years. Supply and sourcing issues are also discussed, including trends in pricing and the latest developments. Manufacturers and suppliers of differrent DRAM types have been discussed and analyzed based on their market shares, product types and regions. This report discusses important manufacturers, technologies, market shares and end-user products in which DRAM is incorporated, and then provides supporting figures and insights. Key factors influencing demand have been highlighted. The report also provides a detailed patent analysis with information on various strategic initiatives attempted by market players in last five years to meet the increasing market demand for DRAM across different application sectors. Revenue forecasts from 2018 to 2022 are provided for each major DRAM type for all major application areas.

The scope of this report is wide and includes:

- Detailed discussion of the DRAM market and technology background.
- Detailed study of different DRAM types, different generations of each type and their market potential for various end-use application sectors.
- Analysis of the market's value, with data from 2015, 2016 and 2017, and its projections for 2018, including

five-year compound annual growth rates (CAGRs) through 2022.
- Analysis of country-based DRAM manufacturing markets.
- Discussion of industry structure, key players and their market shares, technology market strategies, DRAM demand and bit volume growth, DRAM production capacities by company and DRAM pricing trends.
- Focus on other influential factors, such as patents and company profiles.

The report will mainly highlight the SDRAM market, as all earlier DRAM technology types have become nearly obsolete. The DRAM aftermarket is specifically excluded from the study, as it is considered beyond the scope of this report. Estimated values used are based on manufacturers' total revenues. Projected and forecast revenue values are in constant U.S. dollars, unadjusted for inflation.

In the report they included:
- 62 data tables
- An overview of the market for Dynamic Random-Access Memory (DRAM)
- Analyses of global market trends, with data from 2017 and 2018, and projections of compound annual growth rates (CAGRs) through 2022
- A breakdown of synchronous DRAM types in the market, such as ESDRAM, DDR, DDR2, DDR3, DDR4, and GDDR
- A breakdown of the market by application, including computers, handheld devices, wearable medical devices, networking, gaming, display devices, cameras, and automobiles
- Coverage of supply and sourcing issues, including pricing trends and the latest developments
- Relevant patent analysis
- Comprehensive company profiles of major players in the market, including Advanced Micro Devices Inc., Etron Technology Inc., Innodisk Corp., Intel Corp., Kingston Technology Co. Inc. and Micron Technology Inc.

3. Principle of DRAM operation

Dynamic RAM (Stojčev, 1999) memory has gained great popularity for predominantly two reasons:
- large capacity
- relatively low consumption

The organization of DRAMs is usually in the form of 16 M * 1, 1 G * 1, which means that they are organized to accommodate one bit per slot. This organization is called 1 * organization. Figure 1 shows the typical organization of these types of DRAMs.

The memory cell field is the most important and at the same time the main part of the chip. They are storing zero and ones. Each cell contains a capacitor, of a small capacity, and a certain number of transistors. Cell addressing is done via a series of column addresses and row adresses. We can imagine the addresses of the column and row address as the coordinates of the cells. Bearing in mind the tendency to reduce the number of external interface lines, address types and column addresses are multiplexed on the same input lines A0-AN. The address type is first placed on the address lines, and immediately after that the signal for their memory RAS (Row Address Strobe) is activated.

The row adress is first placed on the address lines, and immediately after that the signal for their memory RAS (Row Address Strobe) is activated.

DRAM responds by remembering the present address types to the internal latch of the species.

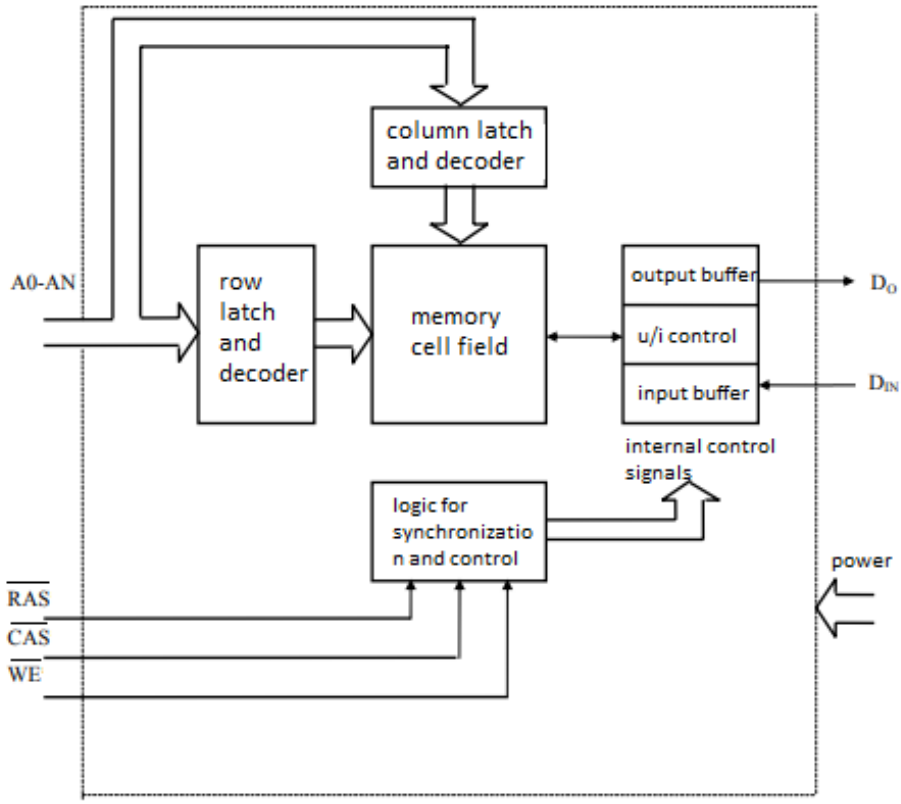

Figure 1 typical organization of DRAM

Then, the address type is deactivated, and then the address of the column is placed on the A0-AN lines. CAS (Column Address Strobe), the signal for saving the column adress is activated. DRAM response is reflected in the terms of saving the column address into the internal memory latch. Based on the total address (Stojčev, 1999), the address of the memory cell is located based on the decoding of the registered row adresses and addresses of the column. The WE (Write Enable) line indicates whether the access refers to an write operation or a read operation. DIN and D0 represent the input and output data lines of DRAMs.

DRAM memory consumes up to ten times less power while it is in standby mode compared to the active state. This means a significantly lower average consumption is achieved.

As for the required number of DRAMs, which should be incorporated in the application of the microcomputer memory, it depends on:

- the volume of the external CPU data bus,
- the desired memory capacity,
- v) capacity of DRAM and its organization

4. DRAM memory market

When we look at the dynamic RAM market (Futuremarketinsights, 2018), we have to consider the fact that manufacturers are constantly trying to improve their products,

increase their performance and reduce latency, in order to gain as much of the market as possible, and thus increase earnings. Dynamic RAM memory is cheaper to produce than static, so it's also built into mobile phones, which opens up new opportunities in terms of the market.

The DRAM market can be viewed and divided into two criteria. We can observe the market by looking at the application and the region. It is intended to mean whether the generated memory will be used in mobile devices, computers, servers or will have some special purpose. Looking deeper, we can split the mobile segment into tablets and mobile phones. The memory used for computers can be divided into the desktop and laptop computers. Memory used for special purposes refers to memory that is built for systems that are built into cars, graphics cards, smart TVs, gaming consoles (XBOX and PlayStation) and others. Each division represents a potential market for producers and an opportunity to expand production. If we look at the DRAM geographic market, it can be divided into North America, South America, Western Europe, Eastern Europe, the Middle East and Africa, East Asia without Japan and Japan.

If we focus on the regions, we can notice an increase in the dynamic RAM market due to the increased popularity of mobile phones in India, China and Brazil. It is anticipated that this market will grow in the upcoming period (by 2025). East Asia was, and remains, the region with the strongest market for dynamic RAM memory, followed by North America. In the upcoming period, the Middle East and Africa will see the largest increase in the market. The reason for this is the fact that in these places there is a poorly represented market, which implies that it has the most room for development.

With the development of mobile phones that have a relatively low price and good performance, there is a growing demand for memory that has the same characteristics. Today, the number of mobile-phone companies is the largest in Asia (India, China, Indonesia). That's exactly what will help to grow and develop the DRAM market. Another thing that is in favor of development is that it comes to the emergence of ultra thin phones of notebooks and similar devices whose speed of operation relies heavily on dynamic RAM memory.

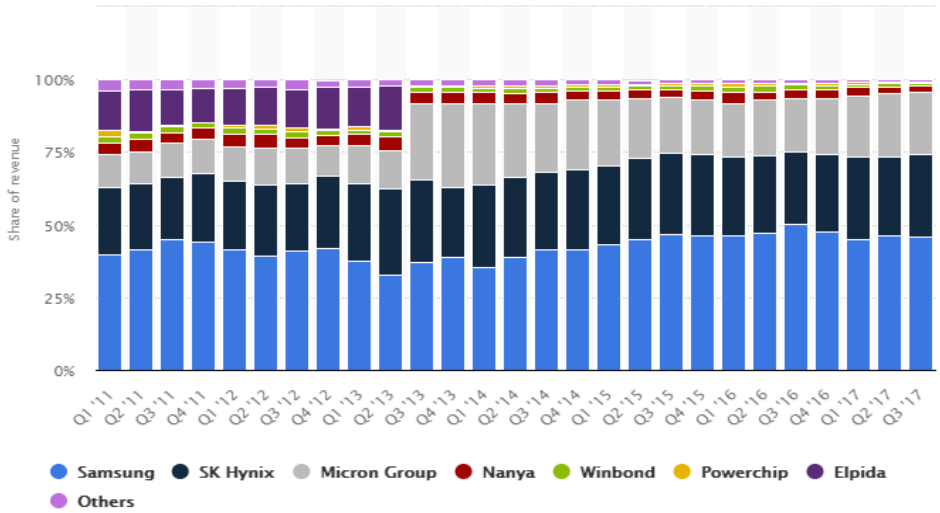

Figure 2 The quarterly part of the global DRAM market, for leading manufacturers

The world's largest manufacturers of dynamic RAM memory (Statista, 2018) are Samsung, SK Nyph, Micron group, Nanya, Windbond, Powerchip, Elpida and others. The focus of these companies is on the production of memory that is not expensive to make their products as affordable to a large number of customers. In order to gain the greatest advantage over the competition, companies cooperate with the world's largest mobile phone manufacturers, making memory specific to them.

The graphic (Statista, 2018) shows the quarterly part of the global DRAM market for leading manufacturers in the period from 2010 to 2017. As can be seen, most of the market is taken by Samsung, which over the years has managed to retain the title of the largest manufacturer. The second largest manufacturer is SK Hynix. Together, these two companies hold almost 75 percent of the market, of course, we take into account that the Samsung company has almost 50 percent of the market. By the last quarter of 2014, Samsung had an oscillation, but after 2015, when it won the CES Innovation Award for the third time, it gained half of the total market.

5. Conclusion

In this paper, we learned how Dynamic Random Access Memory (DRAM) works. The role played by this memory is extremely important for the operation of computers. The memory stores every bit of data in a special capacitor within an integrated circuit. The capacitor may be full or empty; these two states are two bit values, commonly referred to as 0 and 1. As the capacitors are leaking the charge, the information would ultimately disappear if the capacitor was not refreshed periodically. Because of these refresh requests, dynamic memory is the opposite of SRAM and other static memory.

Dynamic RAM memory does not have the speed to rinse the processor in terms of performing tasks, i.e. providing specific data in the time periods in which the processor requires it. This leads to the occurrence of a delay. In order not to waste time there are processes that memory "cheats" the processor and avoids bringing the processor to absolute state of play. Another drawback is the appearance of errors in dynamic RAM memory. However, with different methods of detection and correction, most errors are prevented, or if an error occurs corrected.

The dynamic RAM market is changing from year to year depending on demand. As the high-performance mobile devices reach the market in recent years, the need for memory that can handle this performance is growing. Due to the emergence of NAND flash memory, the dynamic RAM market experienced a small drop, but despite this it is recovering due to the high demand for the latest generation memory (DDR4, GDDR5, LPDDR4). As time passes, memory is getting faster and manufacturers are trying to produce memory that will have a speed that is closer to the speed of the processor. The world's largest manufacturers are striving to make their memory as quick as possible and cost-effective to make it available to as many customers as possible, and of course, to maximize profits.

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