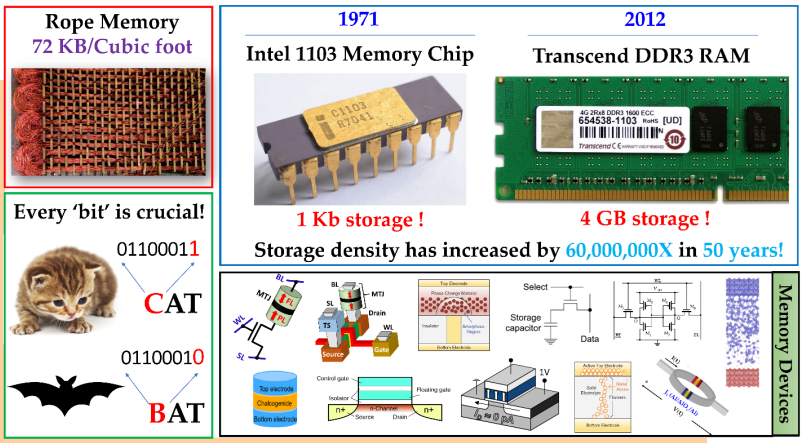
ECE 491/599 - Instructor: Ahmedullah Aziz, PhD

Advanced Memory Design



The stupendous increase in the need for data storage for technical and non-technical applications has led to a manifold increase in the demand for more reliable and denser memory devices/circuits/arrays. According to IBM analytics (in 2013), over 90% of all data in the world was created in the past two years (2012 & 2011). Large-scale scientific experiments, space exploration, social media, financial services, and interconnected smart devices create data in mind-boggling proportions.

Have you ever wondered how we manage to store, access, and manipulate (change/copy/delete) such a humungous amount of data? Hardware technologies to store digital data have existed for decades, but their storage capacities have never been close to what we have now. For example, the Core Rope Memory (top left image within the red box) was used in the Apollo Guidance Computer (Mission to the Moon) (the 1960s). This memory technology allowed only 72 KB of storage per cubic foot. In 2022, one of our selfies will take up thousands of times more memory than this. In 1971, Intel produced the '1103 memory chip' with 1 Kb storage capability. Within the next 50 years, the typical storage density of memory chips increased by more than 60 million times (top right image within the blue box)! We are now creating data at an unprecedented rate. Last year, 79 zettabytes of data were created, captured, copied, and consumed globally. Even with such a high data volume, the lapse of even a single bit of information can lead to far-reaching consequences.

Let us consider a simple example to appreciate this comment. Every letter you type and save on your computer is converted into streams of binary numbers (ASCII codes). The codes for 'C' and 'B' are identical except for a single bit (bottom left image within the green box). If the computer accidentally changes that '0' to '1', the 'BATMAN' will end up being 'CATMAN.' Of course, there could be more severe (and practical) consequences if the stored binary data is accidentally altered/disturbed/erased.

Min H. Kao Department of Electrical Engineering & Computer Science

The exponential growth in digital information demands an equally dramatic improvement in digital storage technologies. As a result, we are experiencing an ongoing revolution in the memory design industry. Several variants of memory technologies are currently being explored, tested, and used (some representative illustrations are shown in the bottom right image). People even claim that – 'Data is the new oil.' Therefore, it is high time we started educating ourselves about the mainstream and emerging technologies linked with data storage. This course will provide an overview of the significant variants of memory devices, circuits, and array architecture. In addition, we will learn about the physical phenomena that enable us to store binary information and the techniques we use to sense/read them at will.

Contents

Our discussion will comprise (but will not be limited to) the following topics:

- Mainstream Memories (SRAM, DRAM, Flash)
- Emerging Memories
  - Ferroelectric Devices
  - Spintronic Devices
  - Phase Change Memories
  - Memristive Memories
- Memory Architectures
- Cryogenic Memory Technologies
- Exploratory Memories – (science fiction materials)

Prerequisites

Prior knowledge of semiconductor physics, transistors, and other devices will be a plus. However, there are no hard requirements. I will review/cover the basics.

Others

- **Number of credit hours:** 3
- **Days & Times:** Tuesdays/Thursdays, 12:55 PM – 2:10 PM EST
- **Classroom Location:** Min Kao 406
- **Textbook:** The instructor will provide notes.

JOIN NOW!!