



# Advancements in SSD Technology

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# Agenda

- Introduction to SSD Technology
- Comparison with other storage mediums (Advantages/Disadvantages)
- History and Improvements
- Modern Uses
- Future of SSD Technology



# Introduction

- Solid State Drives are data storage devices with no moving mechanical components
- Usually use NAND flash memory
- Almost instant start up time (no spinning disks)
- Components of an SSD are the controller (electronics), memory, and interface



# Other storage mediums

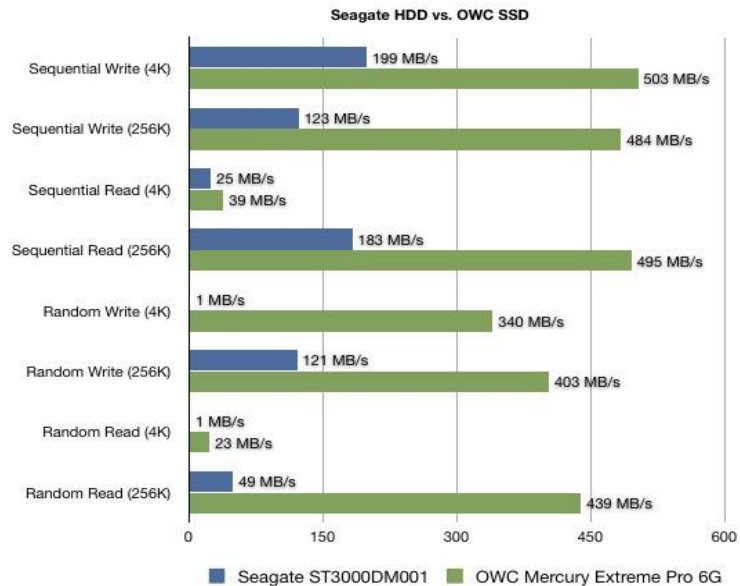
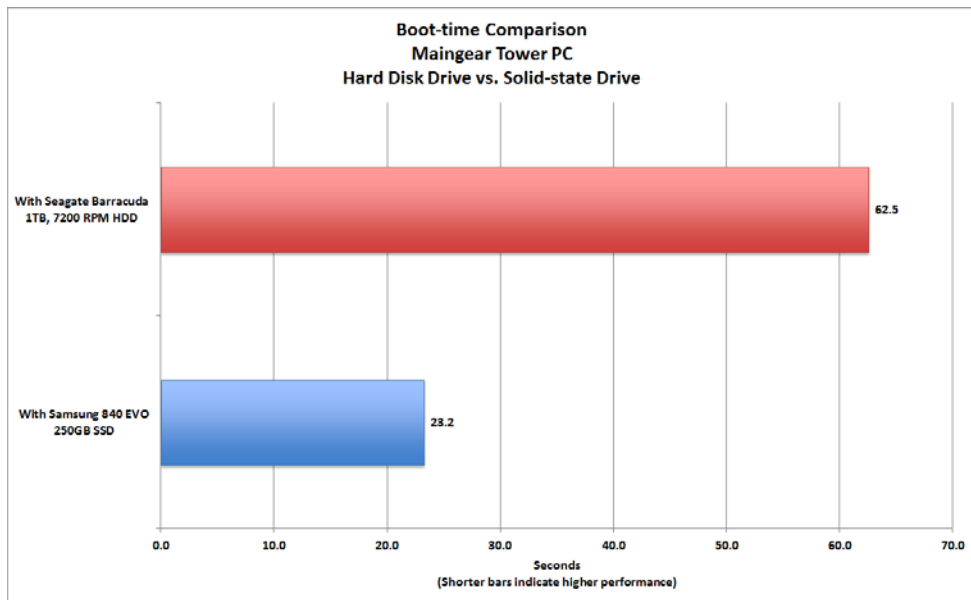
	Optical Disk (CD)	Magnetic Tape	DVD & Blu-ray	Flash drive	Hard Drive	Solid State Drive	SD card (SDXC)
Bit density (GBit/in <sup>2</sup> )	0.9	1.23	2.2 (12.5 for Blu-ray)	950	1.5 TBit/in <sup>2</sup> (1,536 GBit/in <sup>2</sup> )	2.8 TBit/in <sup>2</sup> (2,867 GBit/in <sup>2</sup> )	3.36 TBit/in <sup>2</sup> (3,441 GBit/in <sup>2</sup> )
Maximum size	700 MiB	6.0 TB	4.7 GB (128 for Blu-ray)	2TB	12TB	60TB	512GB

# SSDs vs HDDs

- SSDs are typically faster, and have low startup time
- SSDs have no mechanical parts and can be more durable
- SSDs have much faster access time (.1ms vs 2.9ms)
- HDDs are cheaper per gigabyte

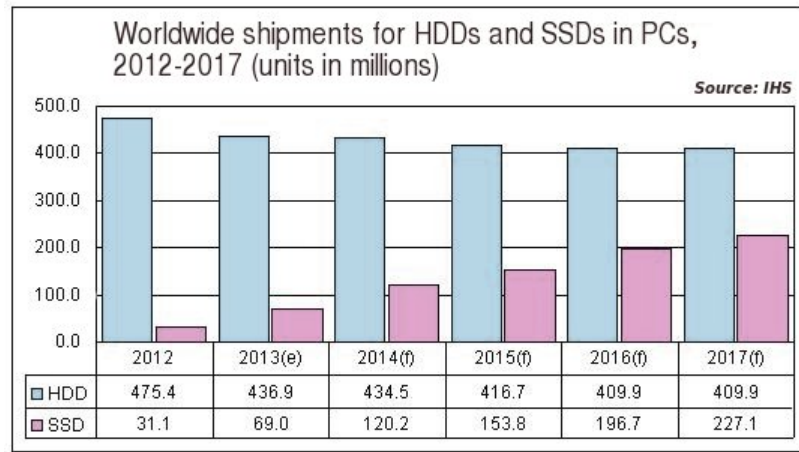


# Comparison of Speeds



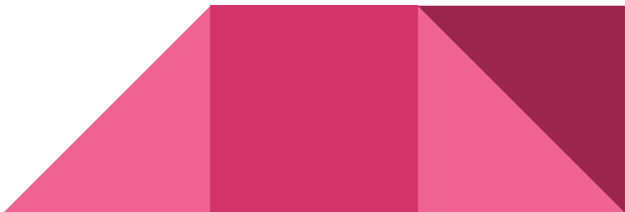
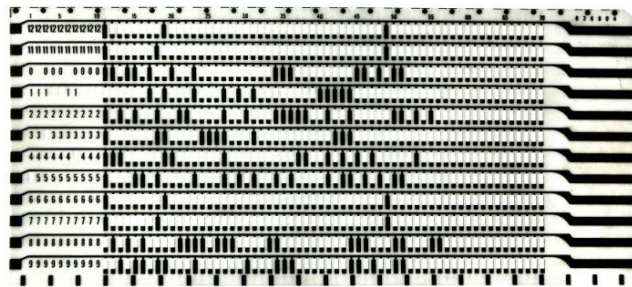
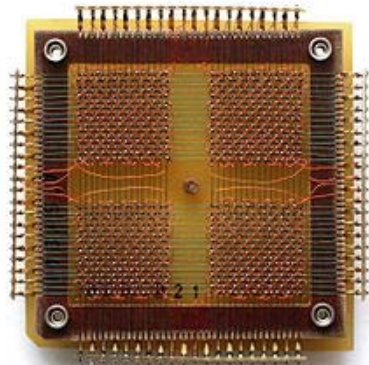
# Comparison of Sales

- HDDs have consistently outsold SSDs
- Recently SSD sales are rising



# Origin of SSDs: Precursors

- 1950s: Magnetic Core Memory and Charged Capacitor Read-Only Storage (Used by IBM)
- Non-volatile memory
- Pre-transistor technology
- Vacuum-tube era

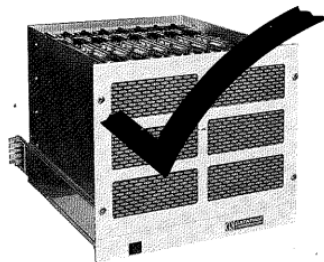
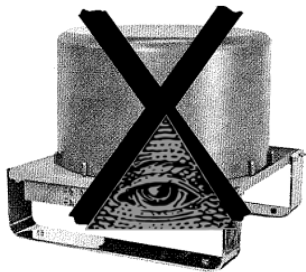




# Origin of SSDs: First SSD on the Market

- 1976: Dataram produces the first SSD, called BULK CORE
- 19 inch long rack mount, 2 megabytes of storage

Replace Fixed-Head Disc  
with Dataram **BULK  
CORE**



[Verac](#) @Ya\_Boi\_Verac · 38s

@Dataram Hey guys, reading up about the Bulk Core SSD from 1976. Was wondering how much that would cost back then in 1976 dollars. Thanks.

Your account has been locked for security purposes

- Access time 1/10,000 of FHD
- High Throughput
- Zero Error Rate
- Self-Test for Fault Isolation
- Hardware & Software Transparent
- LED-spotlighted Fault Isolation
- 256 KB Modularity
- Non-Volatile
- Non-Mechanical
- High MTBF/Low MTTR
- Low Power
- Parity Check

# History of SSDs: Late 1970s

- In 1978 StorageTek develops the STC 4305 for use with IBM mainframe
- Device was 7 times faster than IBM's 2305 HDD.
- \$400,000 for 45MB of storage (1.5 million today)
- Contained within a cabinet, represented an increase in SSD capacity



# History of SSDs: 1980s

- SemiDisk Systems, SanDisk, and EMC entered the market
- SSD accelerators for Intel processors
- SSDs being used mostly for RAM
- EMC developed SSDs for the mini-computer market
- 20 times faster than available hard drives
- Intel begins implementing NOR flash technology



# History of SSDs: 1980s

**PION introduces the  
INTERSTELLAR  
DRIVE.**



**A solid state  
disk emulator for your  
APPLE\*, TRS80\*\*, S100,  
or S550 computer**

● A FAST mass storage device. Speeds up any program requiring disk access.

● No head seek time, no motor startup time, no moving parts.

● Standard 256K bytes of storage expandable to 1 megabyte.

● Independent regulated power supply.

● Automatic power failure detect and battery backup.

● Hardware error detection and write protect.

● Only 4 bytes-ports of address I/O space used

● Hardware optimized for block transfers and access.

● Drivers, diagnostics, and utilities software provided.

**Introductory  
Price \$1095.**

plus tax and shipping



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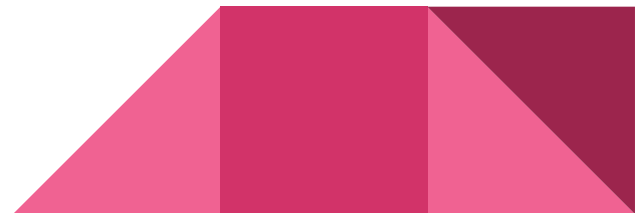
\*Trade Mark Apple

\*\*Trade Mark Tandy Corp.

- “Interstellar Drive” by PION in 1983
- 256KB of storage for \$1095 (with inflation: \$2678)
- Plugged into Apple II expansion slot

# History of SSDs: The 1990s

- Flash based SSDs become popular
- Was found useful for military applications that required durability
- SunDisk/SanDisk manufactures a 20MB 2.5 inch SSD for IBM in 1991
- Price was \$1788, adjusted for inflation
- In 1996 ATTO Technology's SiliconDisk II achieves a throughput of 80 MB/s and 22,000 IOPS



# History of SSDs: The 2000s

- Flash memory becomes more widespread due to digital cameras
- In 2003 Transcend develops flash SSDs to compete with hard drives
- 16MB to 512MB, prices significantly cheaper (\$50)
- By 2006 SSDs had become extremely popular for use in laptops
- 41 Manufacturers are now involved in SSD production
- By 2009 SSD speed begins approaching limits of SATA connection



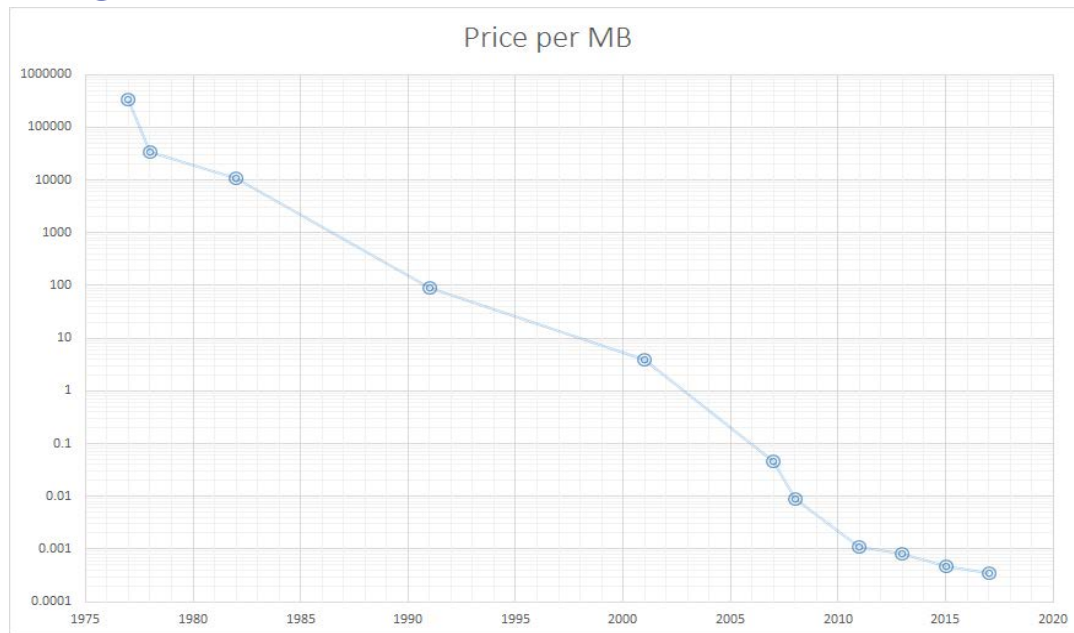
# History of SSDs: 2010 - Current Year

- PCIe SSDs start to become popular in 2013
- 2.0 Gbit/s vs 1.5 Gbit/s with SATA
- In 2014 Samsung 2.5" SAS SSDs achieve a speed of 12Gbps
- AFA (All Flash Array) vs Hybrid approach
- In 2016 Seagate unveils 60TB SSD with 12 Gbps SAS interface



# Price per MB over time

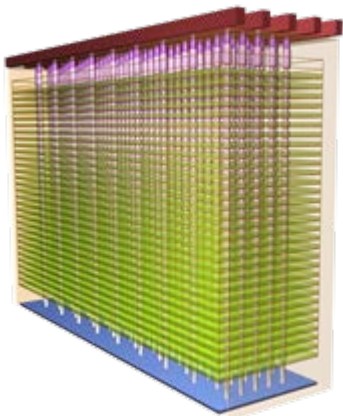
- 1977: MM-S100 - 8KB \$650
- 1978: STC 4305 - 45MB, \$400,000
- 1982: S-100 form factor - 512KB, \$1,995
- 1991: First Flash-based SSD - 20MB, \$1,000
- 2001: S35PC - 14GB, \$42,000





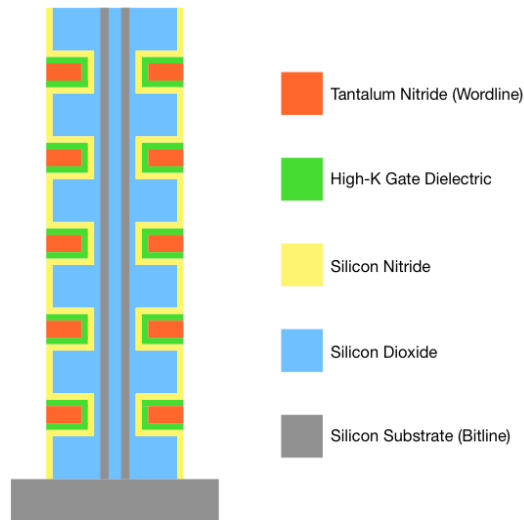
# 3D NAND

- The most important SSD innovation of the last decade
- 3D NAND technology in use by Micron and Intel
- Process involves stacking memory cells vertically to increase density
- Three times increase in storage space



Intel: Ultimate SU800 - up to 1TB for \$280

Micron: 1100 SATA SSD - 2TB for \$570



# Future of SSDs

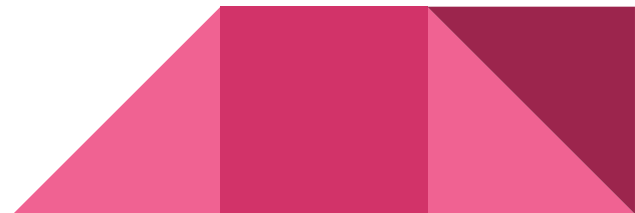
- 3D NAND expected to become mainstream, greatly increasing SSD storage capacity
- ReRAM - Resistance based memory that some anticipate will replace NAND flash

4D NAND?



# Conclusion

- Approaching Cost of Hard drives
- Significantly better performance
- More durable than Hard drives
- High information density
- 100 Million times cheaper now compared to 1976



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