Memòries d'estat sòlid (SSD)

- In 1995, M-Systems introduced first flash-based solid-state drives.

- A solid-state drive (SSD) is a data storage device that uses solid state memory to store persistent data and SSDs use same I/O interfaces developed for hard disk drives.

- SSDs do not have any moving mechanical components, which distinguishes them from traditional magnetic disks such as hard disk drives (HDDs).

- SSDs use NAND-based flash memory or DRAM to store data.

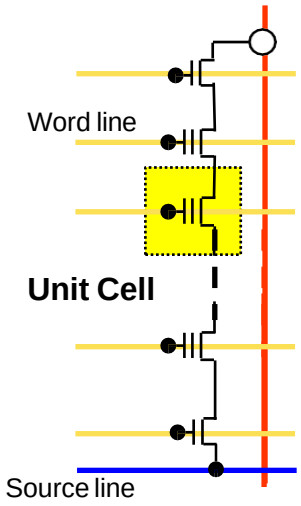
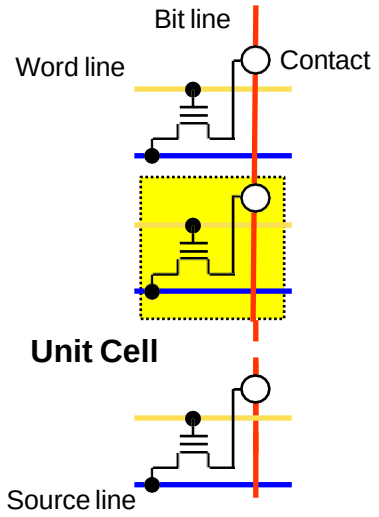
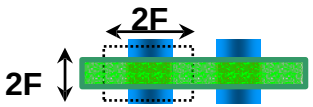
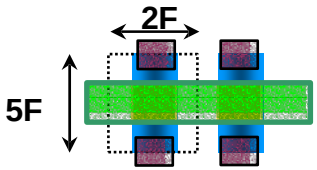
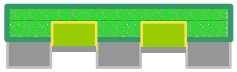
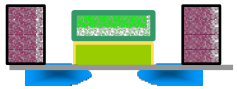
Constitució

Per tal de tenir unes bones prestacions, els requisits principals són que sigui ràpida, de gran capacitat i que es pugui llegir i escriure amb temps semblants. El primer requisit imposa que sigui una memòria basada en semiconductors.

TIPUS	Cel·la Bàsica	Característiques	Utilització
SRAM	Flip-Flop (6 transistors)	Gran Velocitat, Baixa Densitat Volàtil	Caché
DRAM	Transistor +Capacitat	Alta densitat Lenta respecte a les SRAM Volàtil Necessita Controlador	Memòria Principal (mides grans)
ROM	Fusible	Alta Densitat No Volàtil NO Reprogramable	Només per informació fixa
EEPROM	Transistor de porta flotant	S'esborra elèctricament cel·la a cel·la Baixa densitat (respecte a les Flash)	Sistemes de baixa capacitat, reprogramació y simplicitat de connexió
FLASH	Transistor de porta flotant	No Volàtil S'esborra elèctricament per blocs Alta densitat (resp. a les EEPROM)	SETUP-BIOS Sistemes reprogramables d'alta capacitat

Resum dels tipus de Memòries Semiconductores que poden formar part d'un Computador.

NAND vs. NOR - Cell Structure

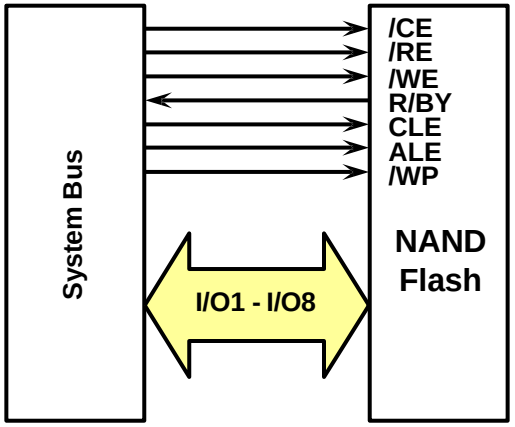
	NAND	NOR
Cell Array		
Layout		
Cross-section		
Cell size	$4F^2$	$10F^2$

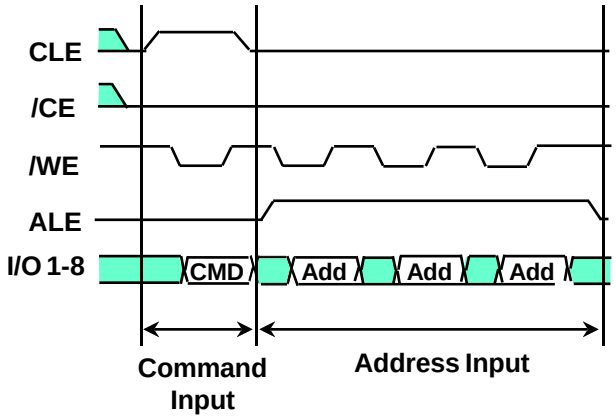
NAND / NOR Characteristics

	NAND	NOR
Capacity	~ 1Gbit (2chips/pkg)	~ 128Mbit
Power Supply	2.7-3.6V	2.3-3.6V
I/O	x8	x8/x16
Access Time	50ns(serial access cycle) 25μs(random access)	70ns(30pF, 2.3V) 65ns(30pF, 2.7V)
Program Speed (typ.)	———	8μs/Byte
	200μs/512Byte	4.1ms/512Byte
Erase Speed(typ.)	2ms/Block (16KB)	700ms/Block
Prog+Erase(typ.)	33.6ms / 64KB	1.23s/Block (main:64KB)

NAND Flash Memory Concept

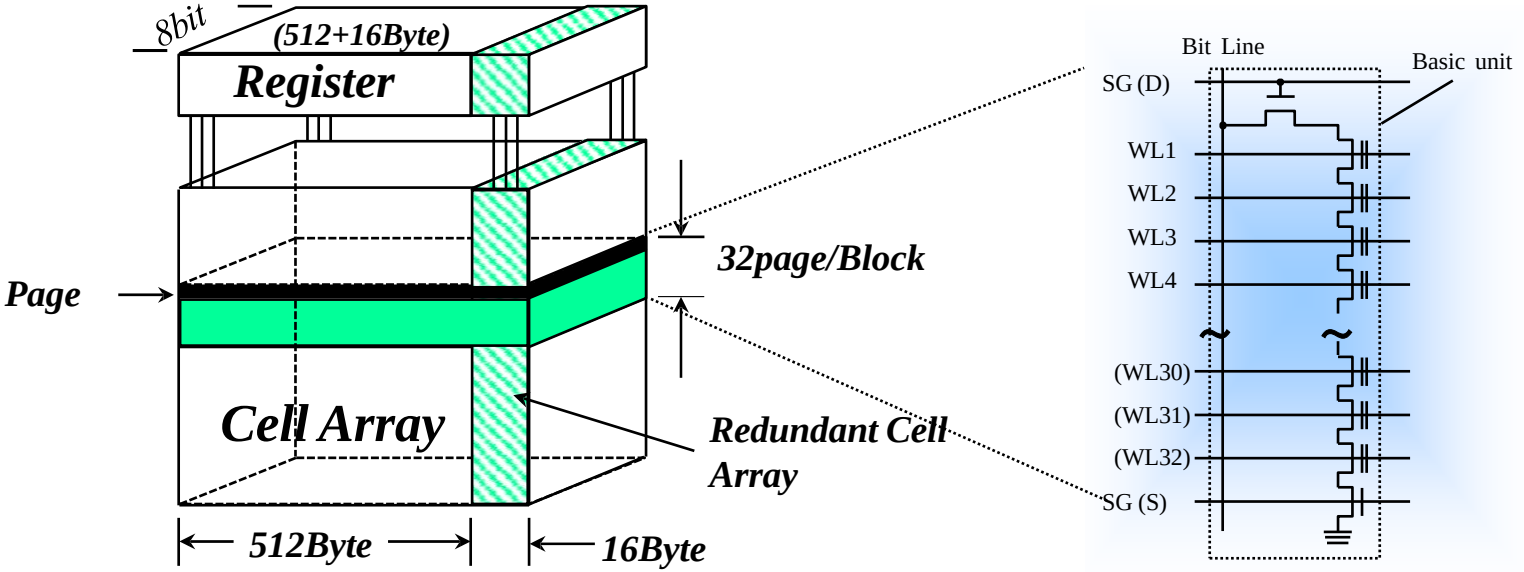
- **Suitable for file storage**
  - **File memory architecture**
  - **Page programming (512 bytes/page)**
- **High performance**
  - **High speed programming and erasing**
- **Low cost**
  - **Small chip size based on NAND Structure**
  - **Small pin count**
- **Easy memory expansion**
  - **Simple interface by command control**





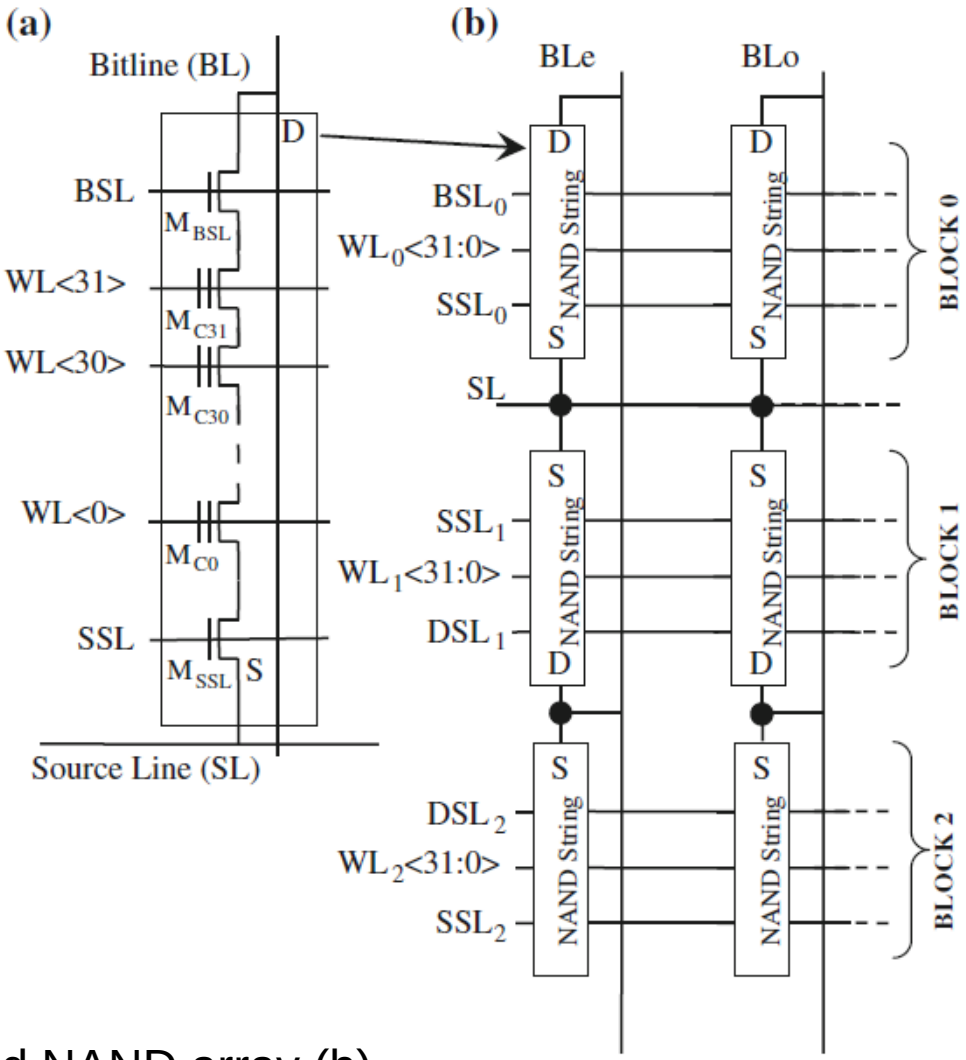
NAND Flash Memory Block Diagram

ex.256Mb NAND Flash Memory



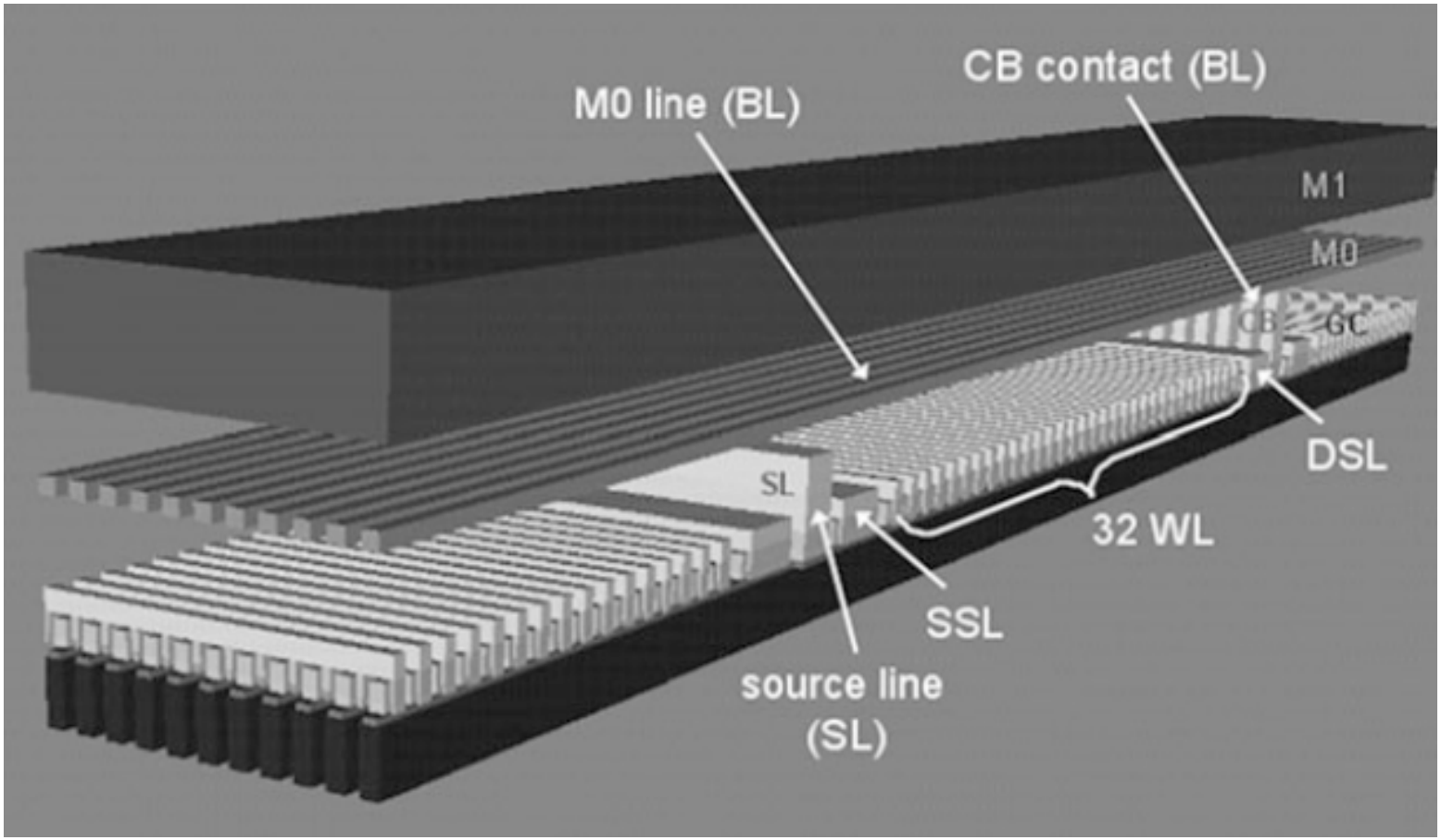
256Mb NAND Flash
Page Size : 512+16 Bytes
Block Size : 16KBytes
# of Blocks : 2048 Blocks

NAND Flash Memory Block Diagram



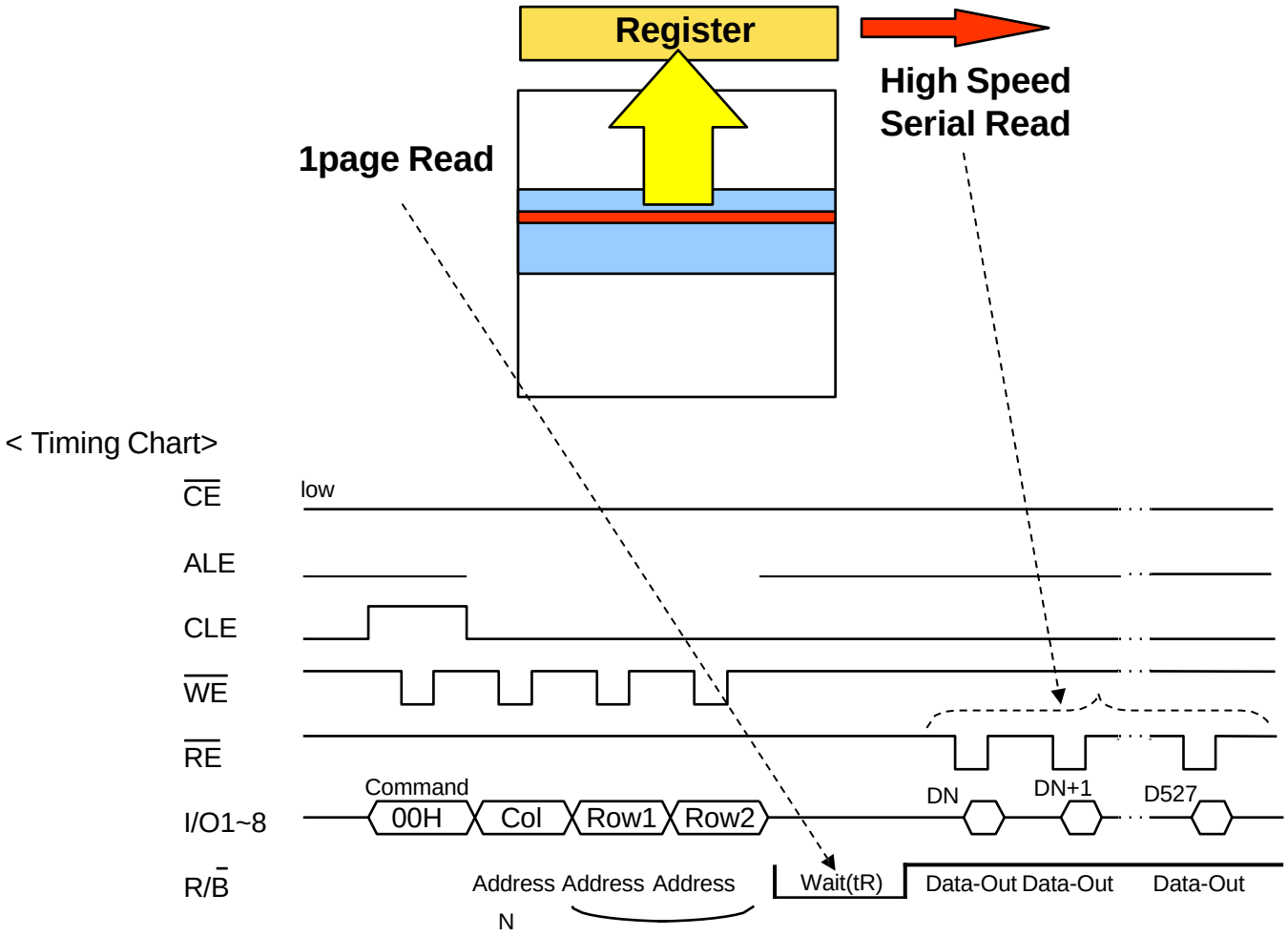
NAND string (a) and NAND array (b)

NAND Flash Memory Block Diagram



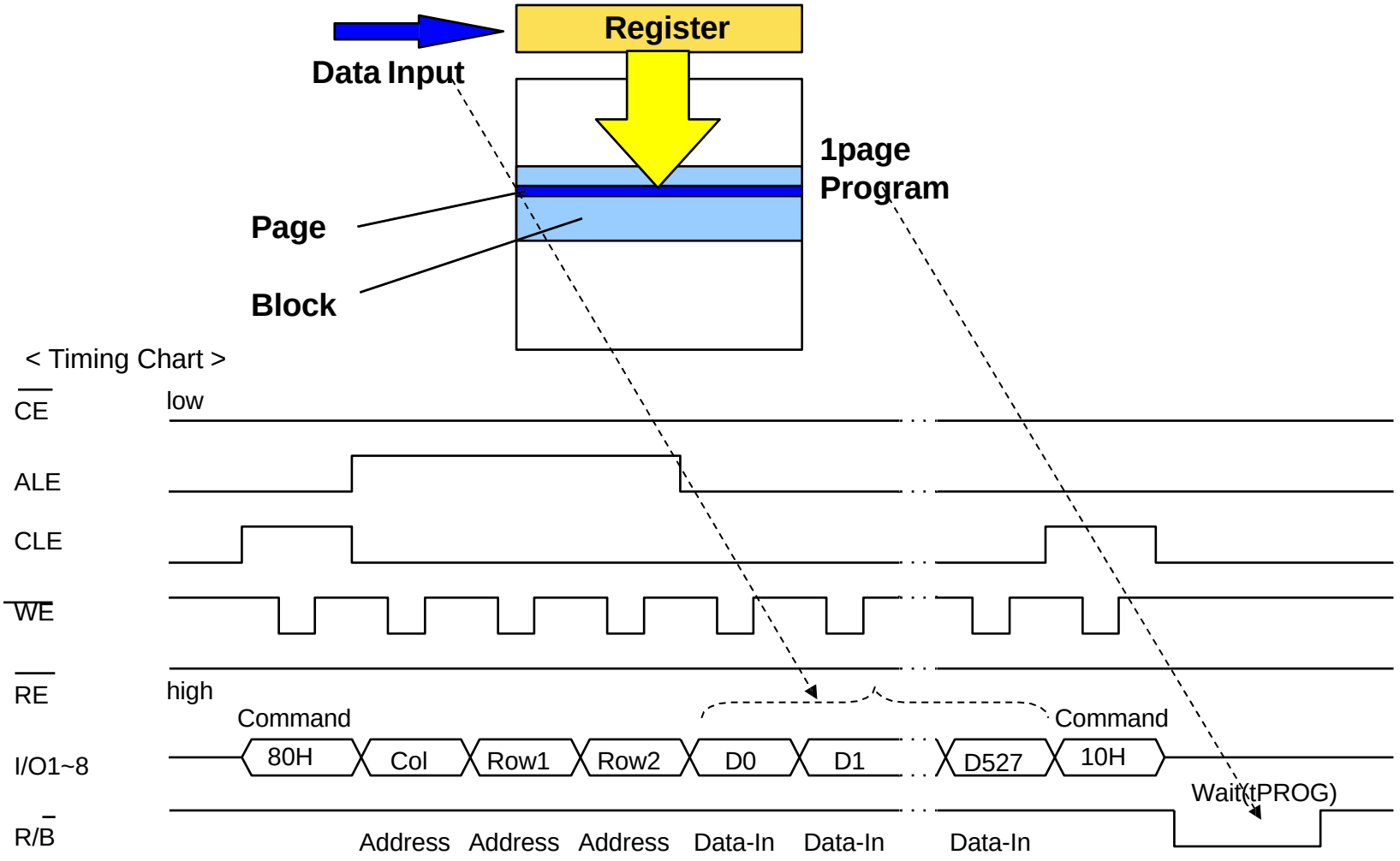
NAND array section along the bitline direction

Read



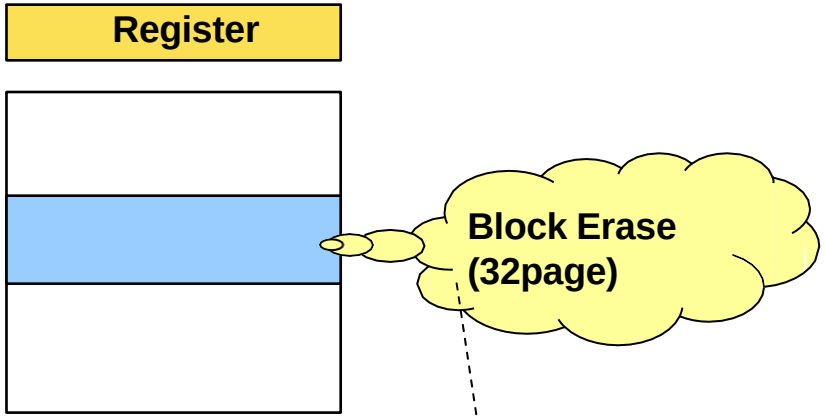
(ex. 256Mb NAND Flash Memory)

Program

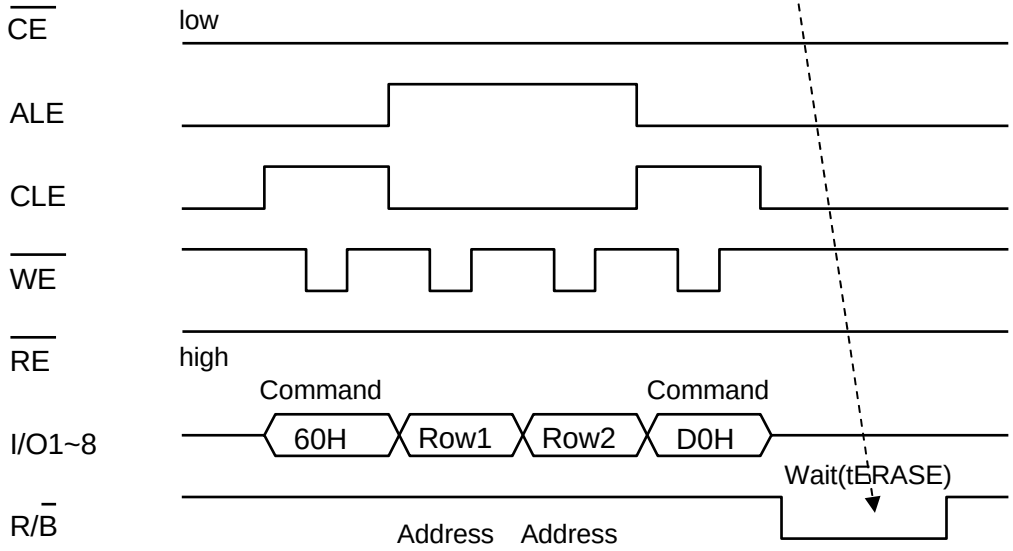


(ex. 256Mb NAND Flash Memory)

Erase



< Timing Chart >



(ex. 256Mb NAND Flash Memory)

< Required Items >

1. NAND Flash File Management

- Bad Block Management
- Wear Leveling Treatment

2. ECC Support

- 1 bit/page error correction
  and 2bit/page error detection**

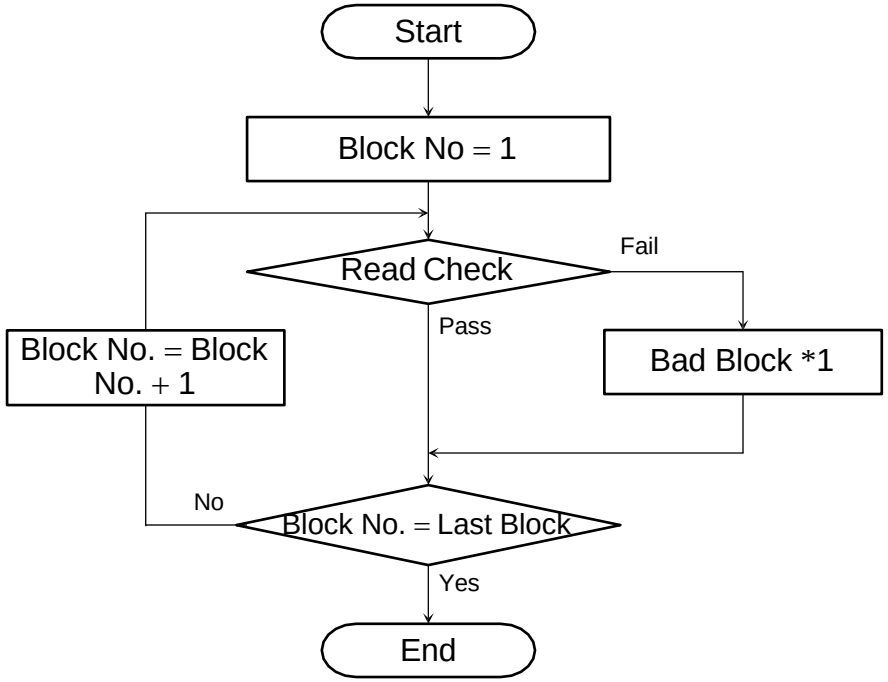
* ECC : Error Correction Code

* * : 2LC NAND Flash 1bit/page ECC

Invalid block detection at Incoming

Number of valid blocks at shipping

Type.	Min.	Max.
TC58V64	1014	1024
TC58128	1004	1024
TC58256	2008	2048
TC58512	4016	4096
TH58100	8032	8192



Invalid blocks have to be detected by bad block test flow before erasing.

- Invalid block : include “0” data. This “0” data may be lost by erasing.
- Valid block : has only “1” data.

< Read Check >
Read the 1st page of each block. If byte 517 of the 1st page is not FF (Hex), define the block as a bad block. The 1st block in the device is guaranteed to be good at time of shipment.

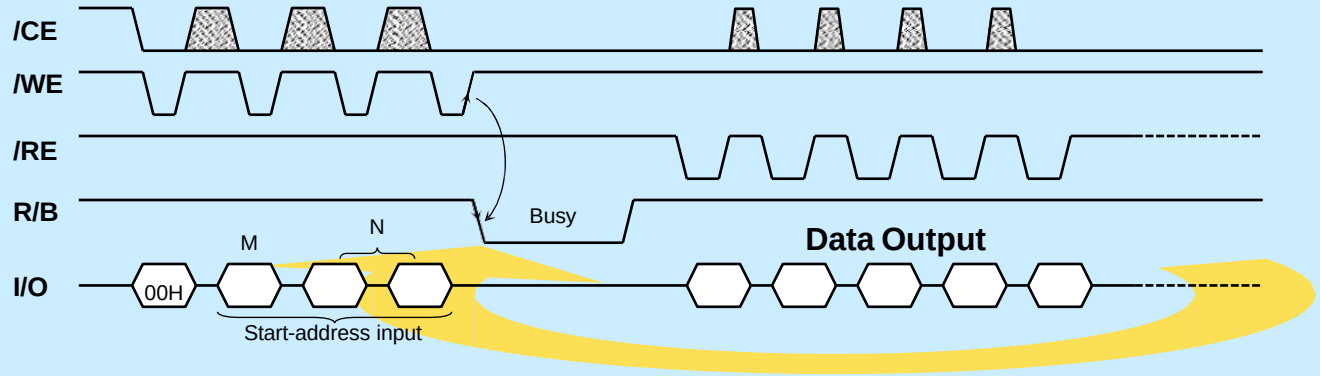
*1 : No erase operation is allowed to bad blocks

NAND Flash Memory Basic Specification

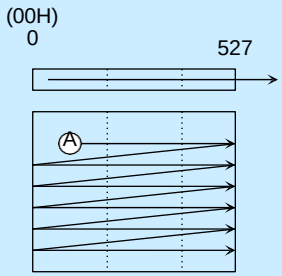
	0.16um				
	TC58V64BFT	TC58128AFT	TC58256AFT	TC58512FT	TH58100FT
	64Mb	128Mb	256Mb	512Mb	1Gb
Density	(8M+256K)x8	(16M+512K)x8	(32M+1M)x8	(64M+2M)x8	(128M+4M)x8
Operation voltage	2.7V-3.6V	←	←	←	←
Page size (program unit)	512B+16B	←	←	←	←
Block size (erase unit)	8KB+256B	16KB+512B	←	←	←
Number of Pages per Block	16	32	←	←	←
Number of Blocks	1024	1024	2048	4096	8192
Number of Address cycle	3	←	←	4	←
Random access time (us)	25us (max.)				
Serial access time (ns)	50ns (min.)				
Package	400mil / 0.8mm TSOP type II	TSOP I 48-P-1220-0.50			

2 Type Read Function

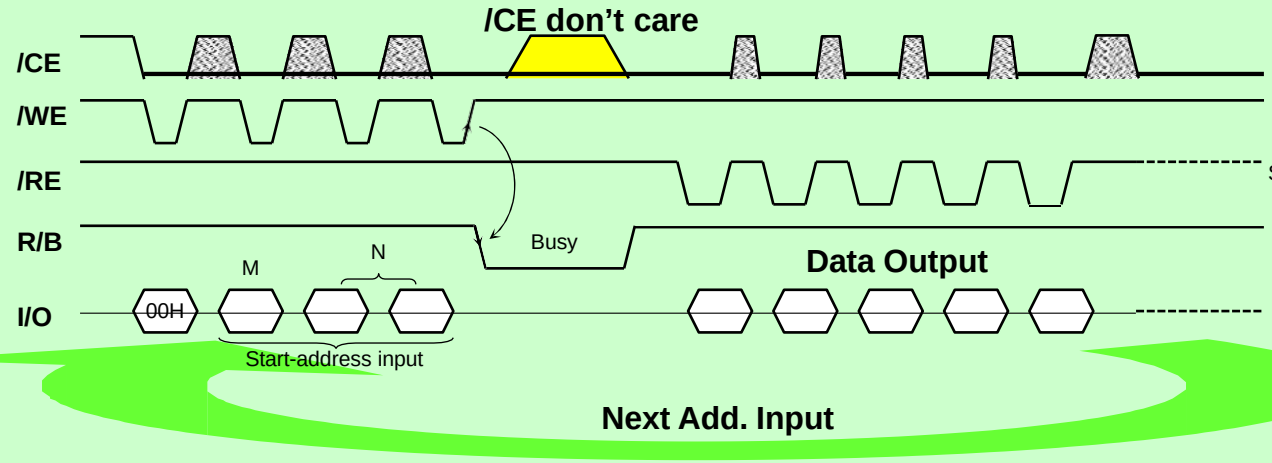
Type 1 (TSOP Package)



Sequential Read



Type 2 (BGA/MCP Package)



No Sequential Read

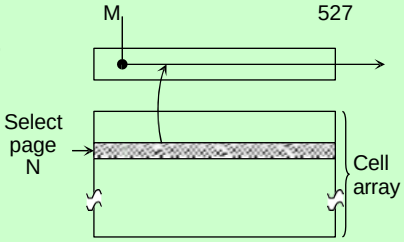
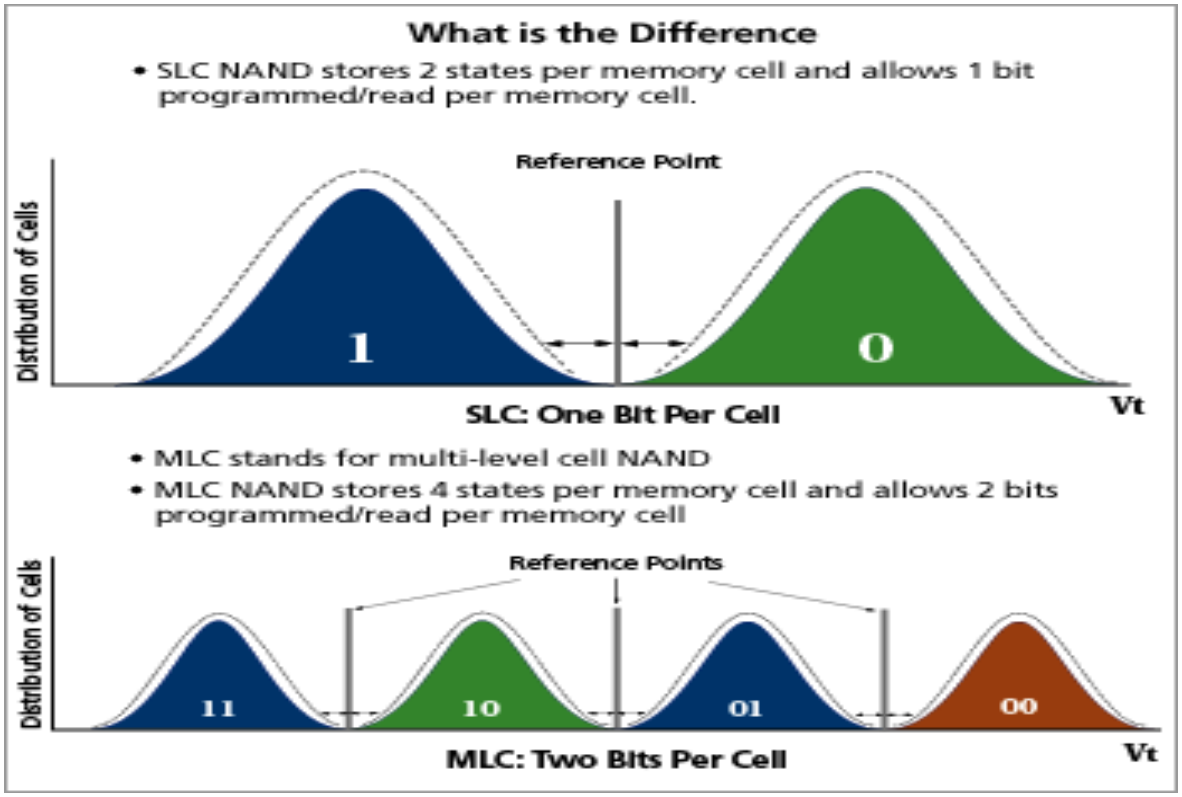
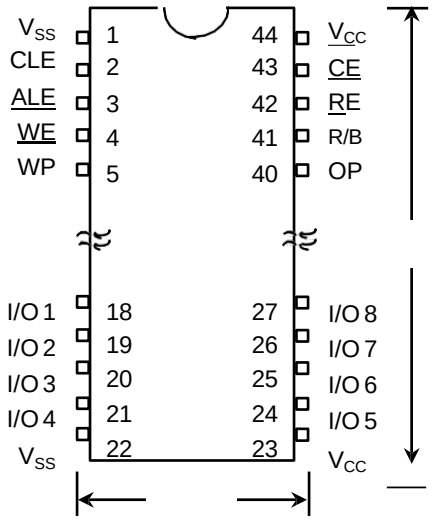
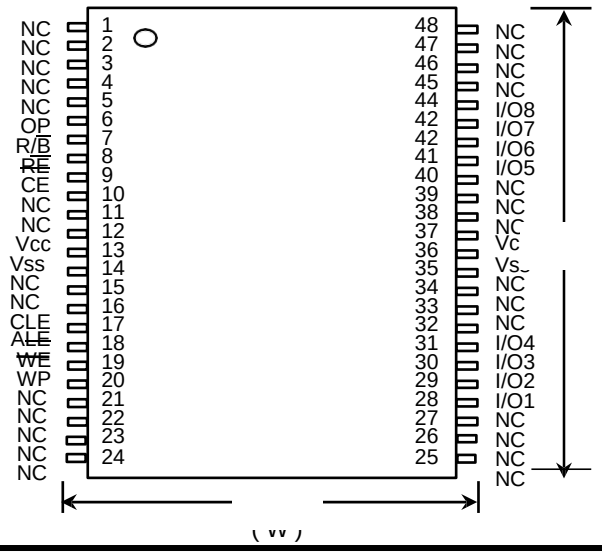


Figure 3. Read mode (1) operation



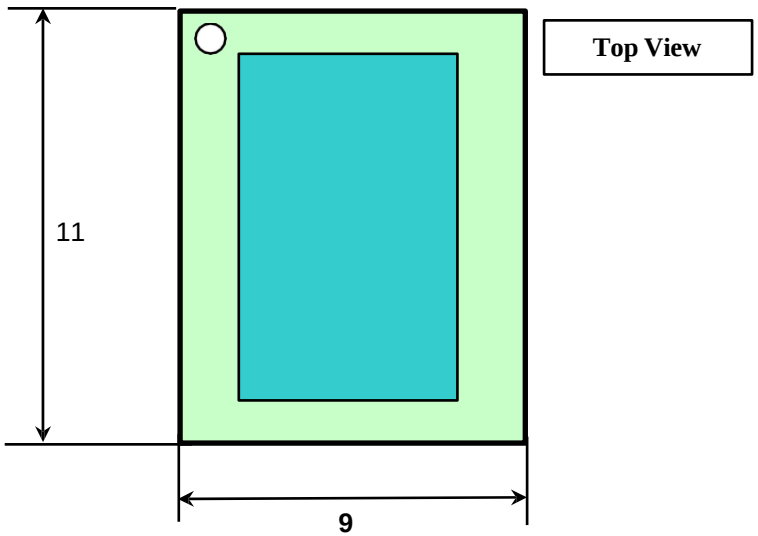
- MLC offers higher storage density.
- But MLC is slower and less robust.
- MLC → 10,000 erase/program cycle.
- SLC → 100,000 erase/program cycle.

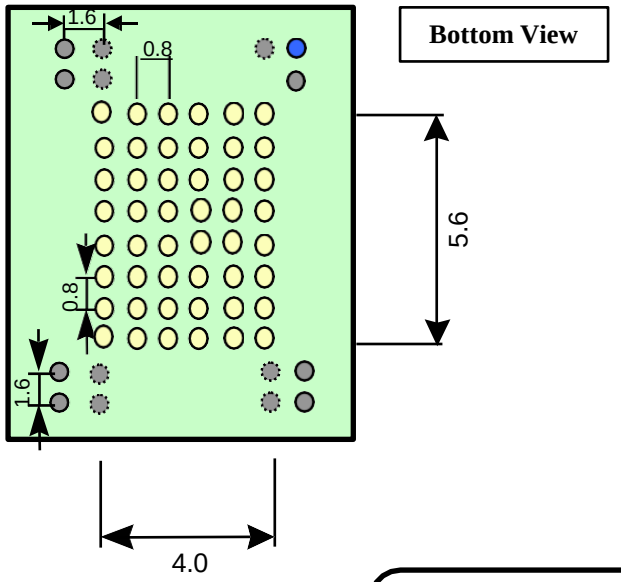
Package Type		**TSOP-II** 44-P-400-0.8	**TSOP-I** 48-P-1220-0.50
Top View			
Package dimensions & Close section View & Memory P/N	Single	**18.41(L) x 11.76(W) x 1.2 (max) mm**  **64Mbit : TC58V64BFT**	**12.0(L) x 20.0(W) x 1.2 (max) mm**  **128Mbit : TC58128AFT** **256Mbit : TC58256AFT** **512Mbit : TC58512FT**
	Stacked		**12.0(L) x 20.0(W) x 1.2 (max) mm**  **1Gbit : TH58100FT**

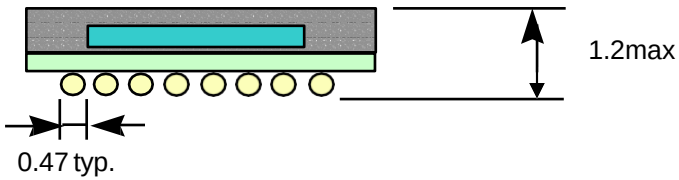
256M/128M NAND Flash CSP

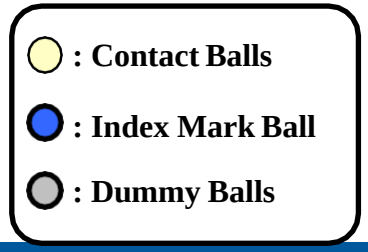
Package Size	Design rule	
	0.16um	0.13um
256M :	9mm X 11mm	7mm X 10mm
128M :	7mm X 10mm	7mm X 10mm

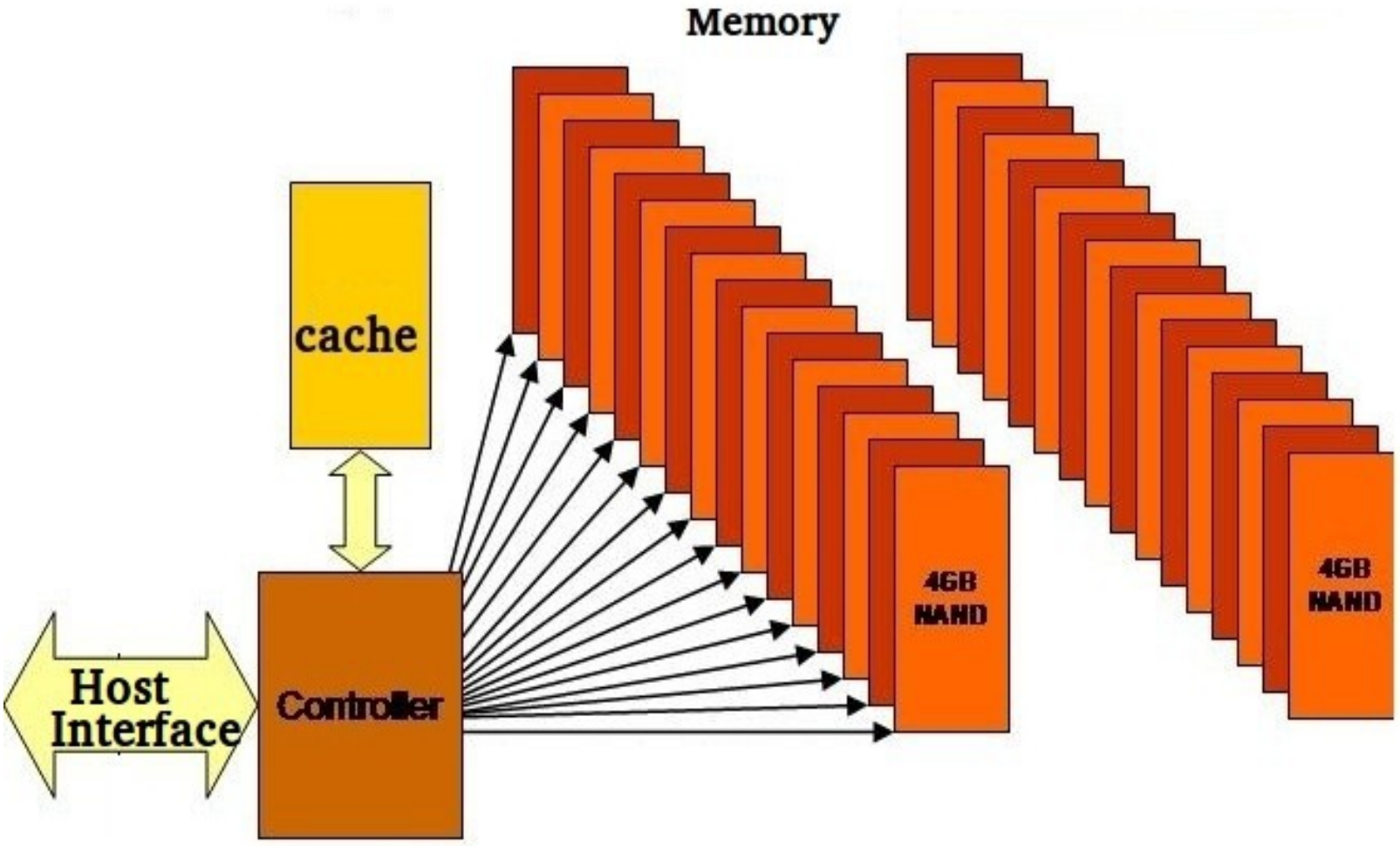
(7x10 : ● no dummy ball)



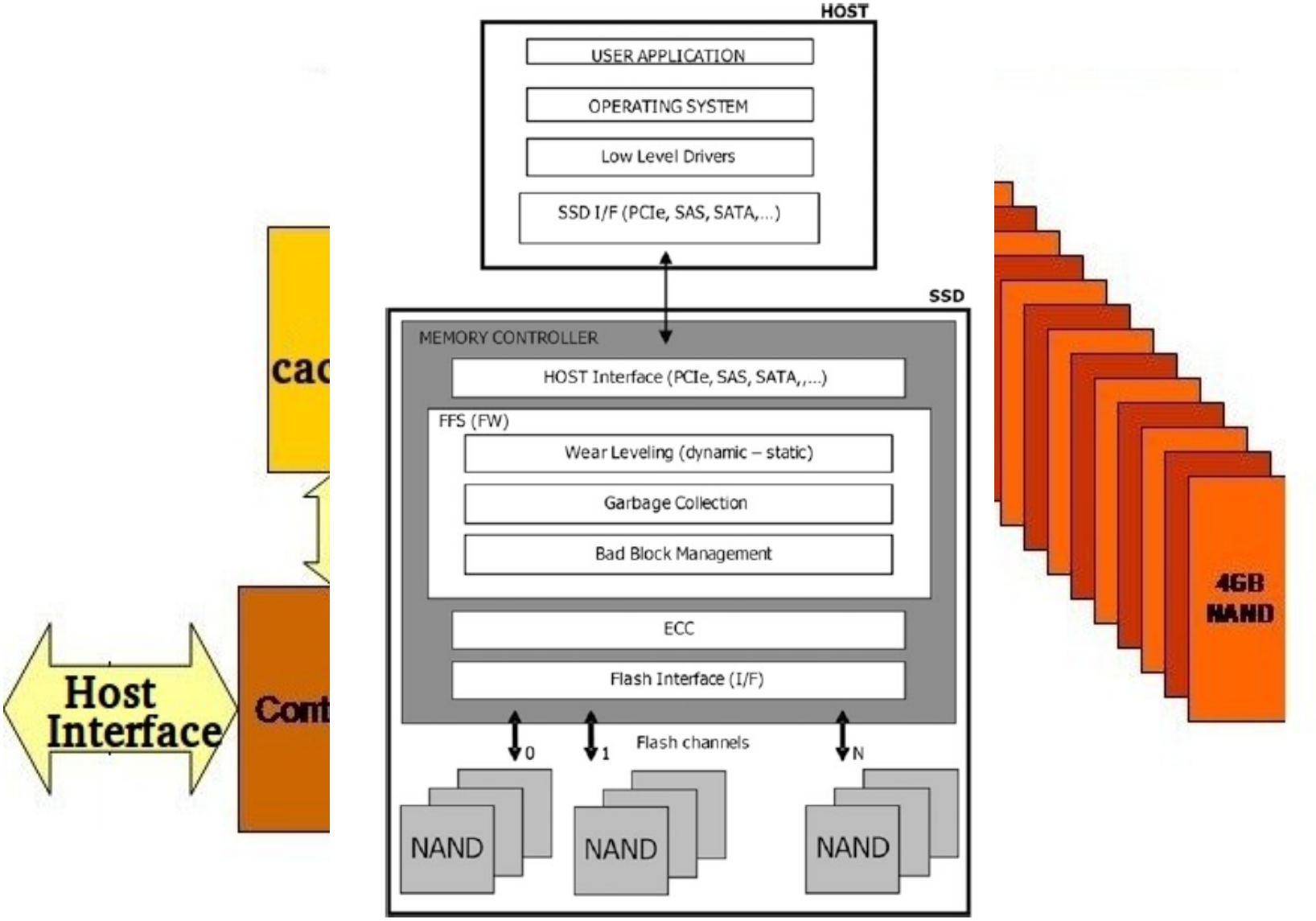







Memory
cache
Host Interface
Controller
4GB NAND
4GB NAND

SSD Architecture



- The controller is an embedded processor and executes firmware- level code.

Functions:

- Error correction (ECC)
- Wear leveling
- Bad block mapping
- Read scrubbing and read disturb management
- Read and write caching
- Garbage collection
- Encryption

- A flash-based SSD typically uses a small amount of DRAM as a cache, similar to the cache in hard disk drives.

Attribute	SSD (Solid State Drive)	HDD (Hard Disk Drive)
Power Draw / Battery Life	It uses less power if you talk about an average of about 2 to 3 watts, which gives 30+ minute battery boost.	It uses much more power than SSD. If you talk about the average, about 6 to 7 watts, so it uses a lot of batteries
Cost	This is very expensive	It is much cheaper than SSD.
Capacity	Most of this storage is not made because of its cost.	They are made of very high capacity and also come in use.
Operating System Boot Time	Its average bootup time is 10-13 seconds	Its average bootup time is 30-40 seconds
Noise	Sound is not produced due to not being a moving part in it	There are moving parts in it and there are also sounds of clicks and spinning.
Vibration	Because there is no moving part in it, it does not cause much vibration	There is a spinning of platters in which it is common to have a vibration in it.
Heat Produced	It does not demand much power, there are no moving parts too, due to which it generates very little heat.	It produces more heat than SSD because it has moving parts which are constantly moving around.
Failure Rate	In the mean time between failure rate of 2.0 million hours	In the mean time between failure rate of 1.5 million hours
File Copy / Write Speed	The speed of copying is generally from 200 MB / s to 550 MB / s	In this, the speed of copying is usually 50 MB / s to 120 MB / s
Encryption	In Drive there is Full Disk Encryption (FDE)	In Drive there is Full Disk Encryption (FDE)
File Opening Speed	It opens 30% faster than HDD	It is significantly slower than SSD
Magnetism Affected	SSD is safe from any type of magnetism effect	At the same time, Magnets have a lot of influence on HDD so that data can be completely erase.