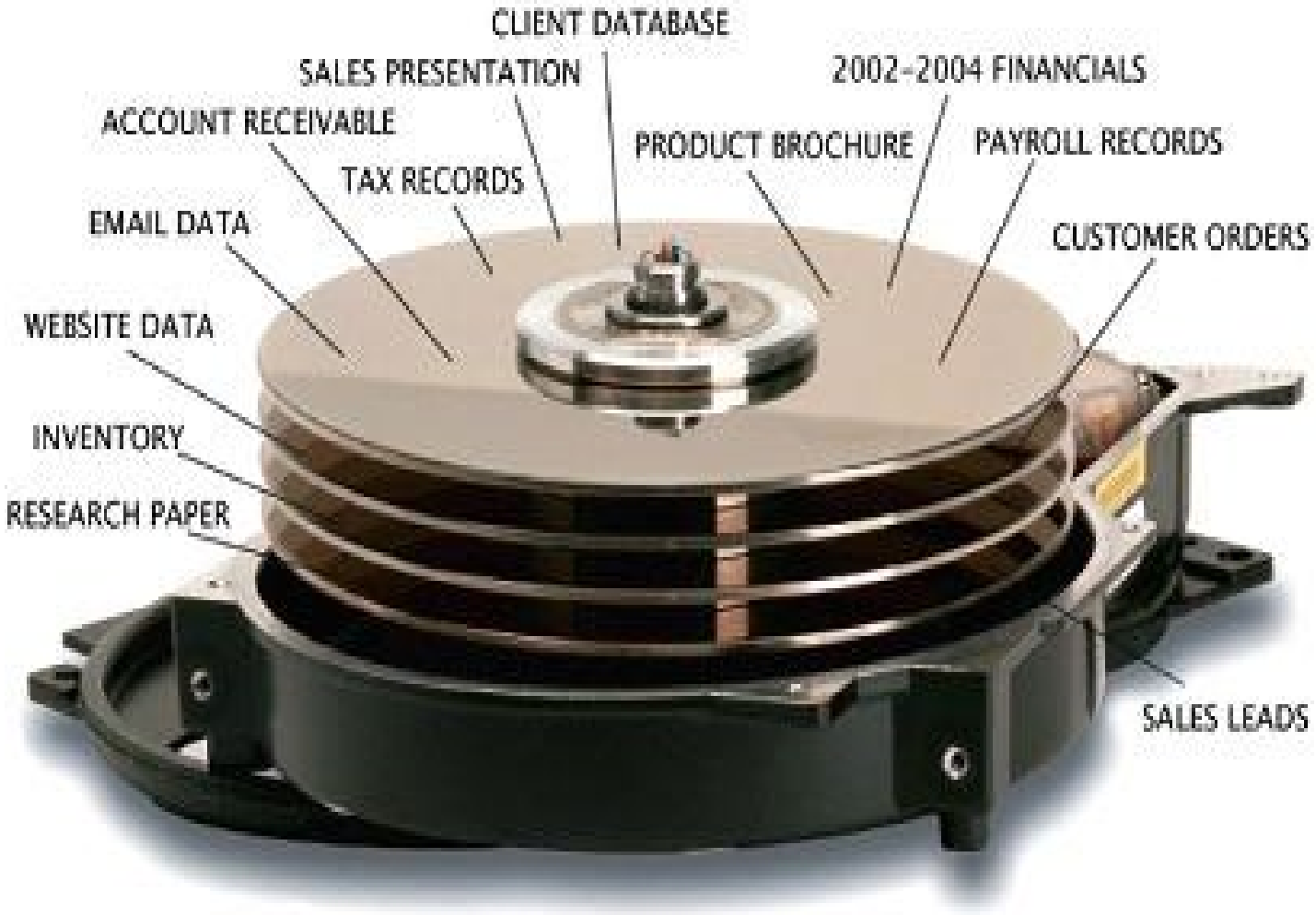
Memory and Remanence

Data Remanence

The residual representation of Data that has been in some way nominally erased or removed



What is Data Remanence?

Data that PERSISTS even when deleted by “Non-invasive” means.

Usually referenced as residual data that stays on in Magnetic Media (but not anymore)

Discussed usually in Digital Forensics and Data Destruction

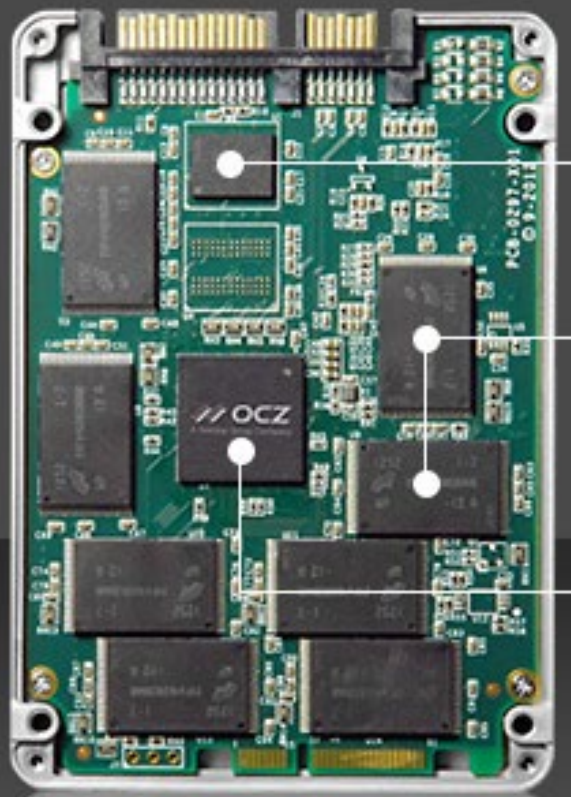
HDD

3.5”

Shock resistant up to 350g/2ms

SSD

2.5”



Shock resistant up to 1500g/0.5ms

Data Remanence in Disk Drives

HARD DISKS

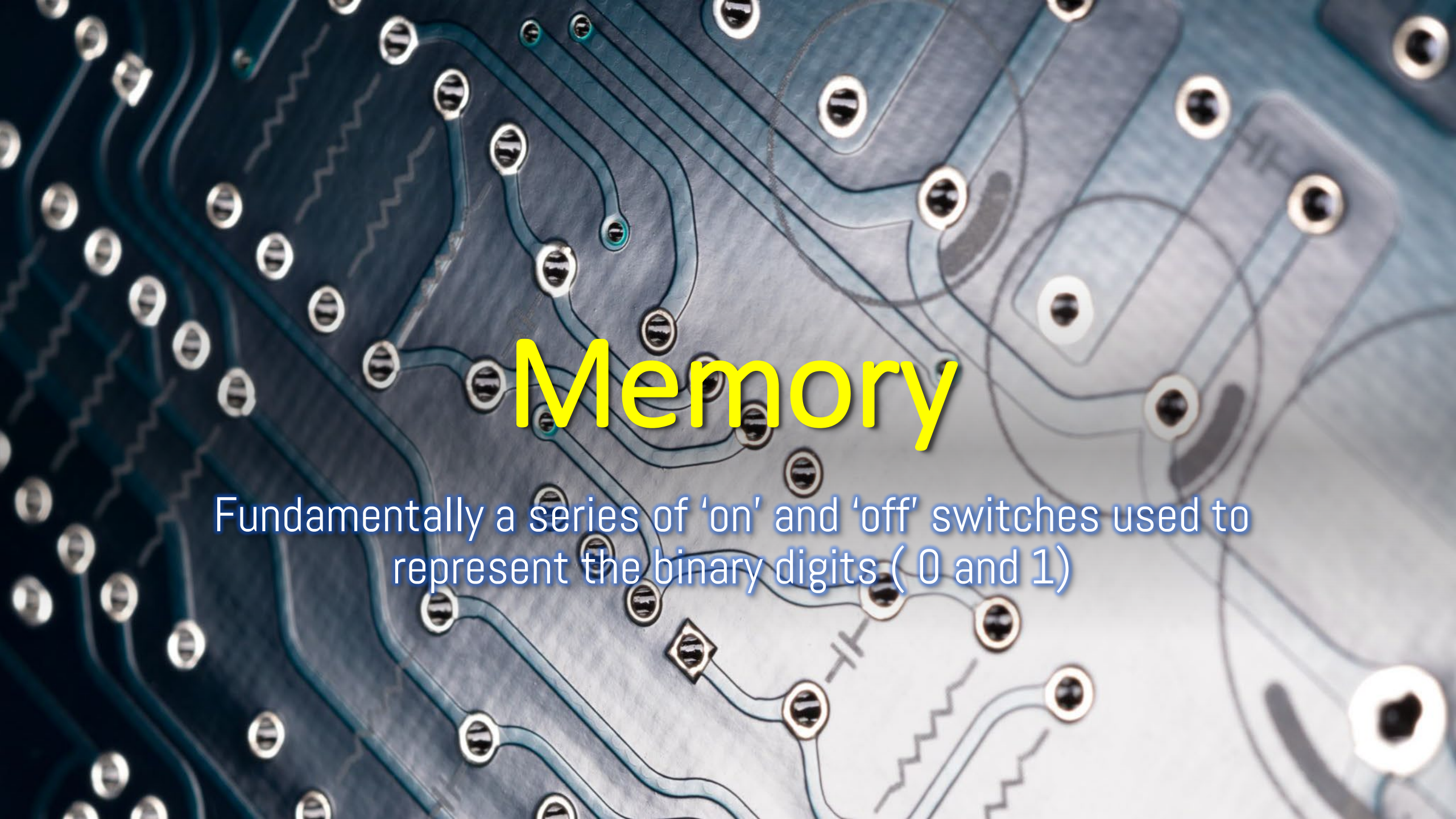
- Data is recorded magnetically on platters
- Mechanical – the read/write heads move and the platter rotates
- Magnetic data is not erased, only the indexes
- New data may be saved over deleted data

SOLID STATE DRIVES

- Uses Flash memory (chips) to store data
- Data Accessed directly (no mechanically moving parts)
- New data is typically written to a new location
- Destruction Incineration/shredding is best for chips
- Hybrid drives are not cleared by degaussing

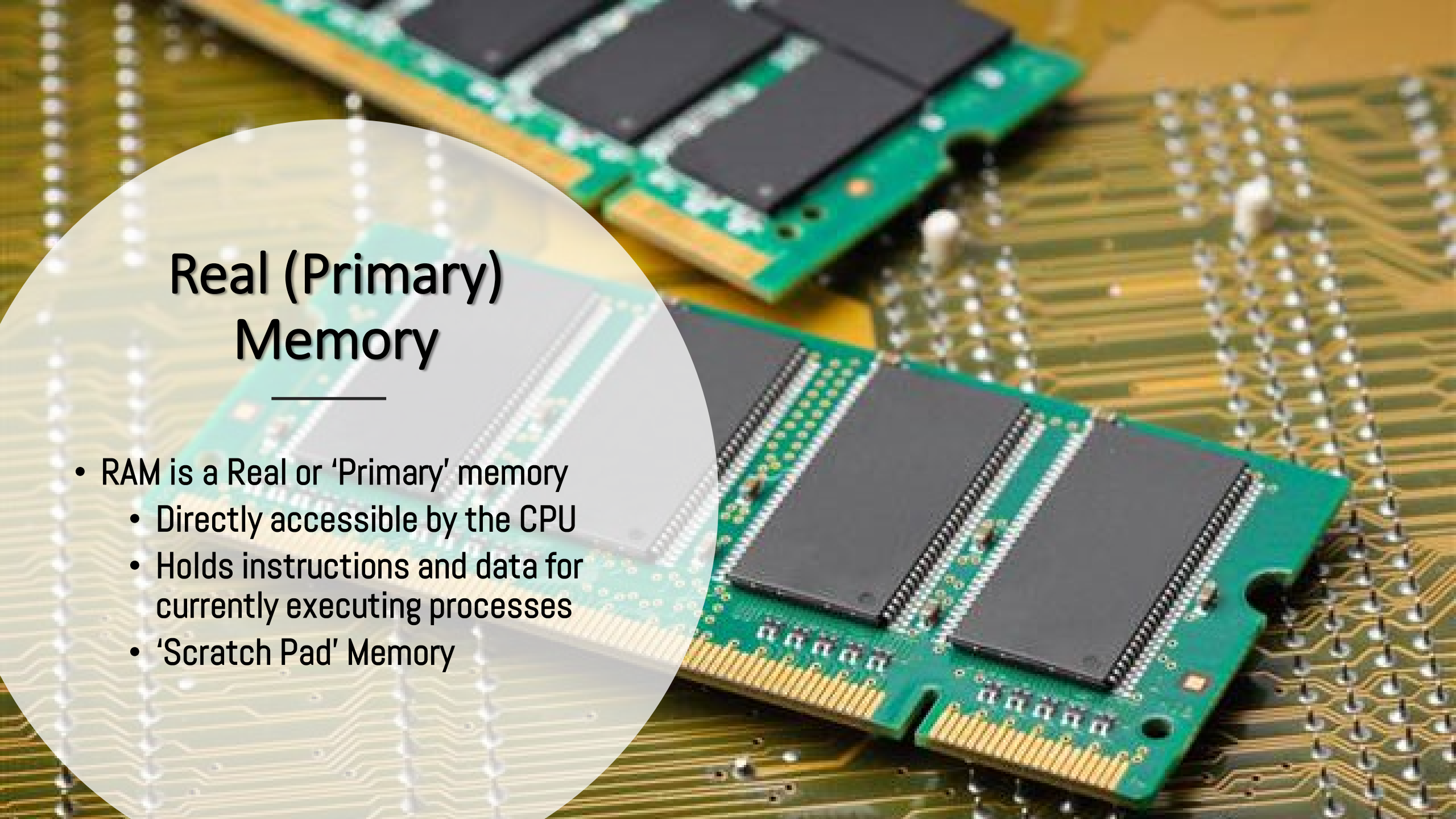
Data Remanence Countermeasures

Method	*Concept*	*Drawbacks*
Overwriting	Writing using a software solution a sequence of zeros, ones or random data on all sectors of a hard disk.	Not efficient on solid state or USB flash drives. Not tailored to virtual and dynamic environment such as cloud.
Degaussing	Using a special equipment (Degausser) to remove or reduce magnetic fields on a drive.	Limited to magnetic drives. May render the media inoperable.
Encryption	Encrypting data before storing in cloud servers. Saving keys in local or virtual private server.	Difficult key management. Encrypted Data cannot be processed in the Cloud.
Destruction	Using physical or chemical destruction techniques.	Simply not applicable in a cloud environment.


Memory
Fundamentally a series of ‘on’ and ‘off’ switches used to represent the binary digits (0 and 1)

Memory

S.No	Volatile Memory	Non Volatile Memory
1	Volatile memory is the type of memory where data is lost when power is turned off	Non Volatile Memory is a type of memory where the data is not lost when a computer is switched off.
2	Data temporarily stored in volatile memory	Data permanently stored in non volatile memory
3	It is faster than non-volatile memory.	It is slower than volatile memory.
4	It has less storage capacity	It has more storage capacity than volatile memory
5	Data can be easily transferred	Data can not be easily transferred
6	It is more costly per unit size.	It is less costly per unit size.
7	CPU has direct access to data.	CPU has no direct access to data.
8	Process can read and write	Process can only read.
9	It has a high impact on the system's performance.	It has a high impact on a system's storage capacity.
10	Data and programs that are currently fetch by CPU are stored in Volatile memory	Any kind of data and programs are stored in Non Volatile memory
11	Example: RAM and Cache Memory	Example: ROM and HDD

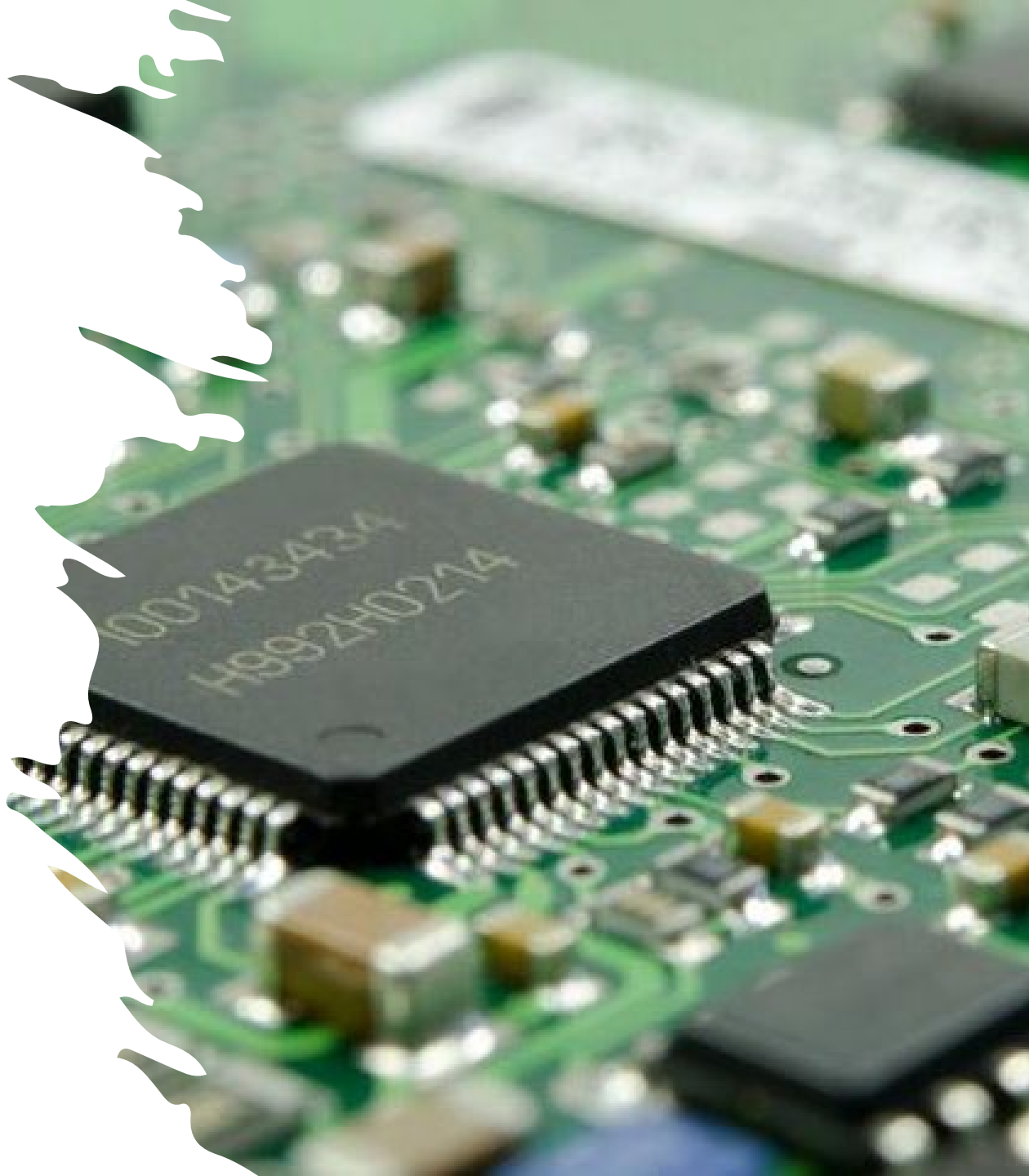


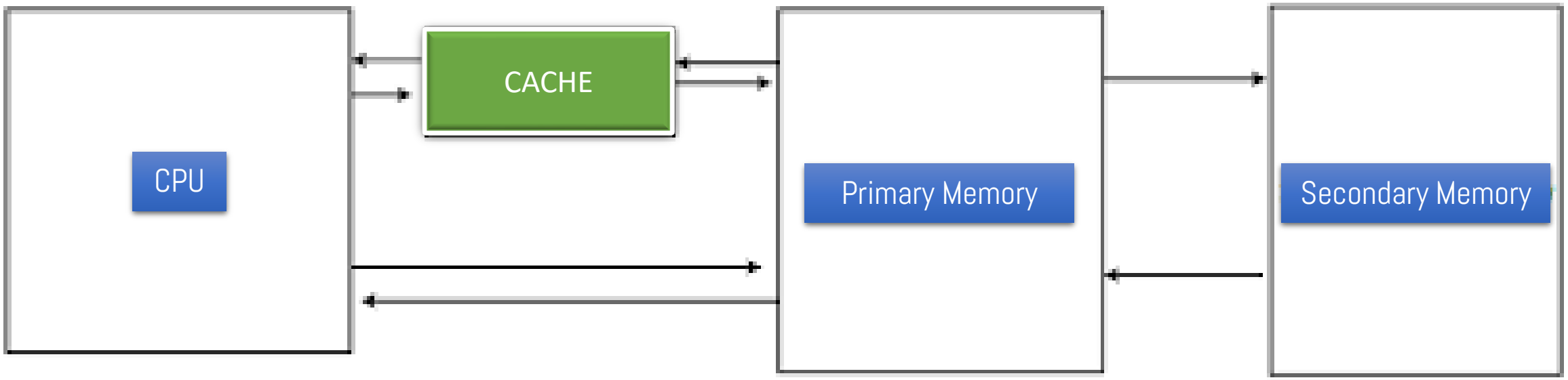
Real (Primary) Memory

- RAM is a Real or ‘Primary’ memory
  - Directly accessible by the CPU
  - Holds instructions and data for currently executing processes
  - ‘Scratch Pad’ Memory

Cache Memory

- Fastest system memory
- Keeps up with the CPU as it fetches and executes instructions
- Data most frequently used by CPU is stored here
- fastest portion of the CPU cache is the register file, which contains multiple registers. Registers are small storage locations used by the CPU to store instructions and data
- The next fastest form of cache memory is **Level 1 cache**, located on the CPU itself. Finally, **Level 2 cache** is connected to (but outside of) the CPU.
- Static random-access memory (SRAM) is used for cache memory.





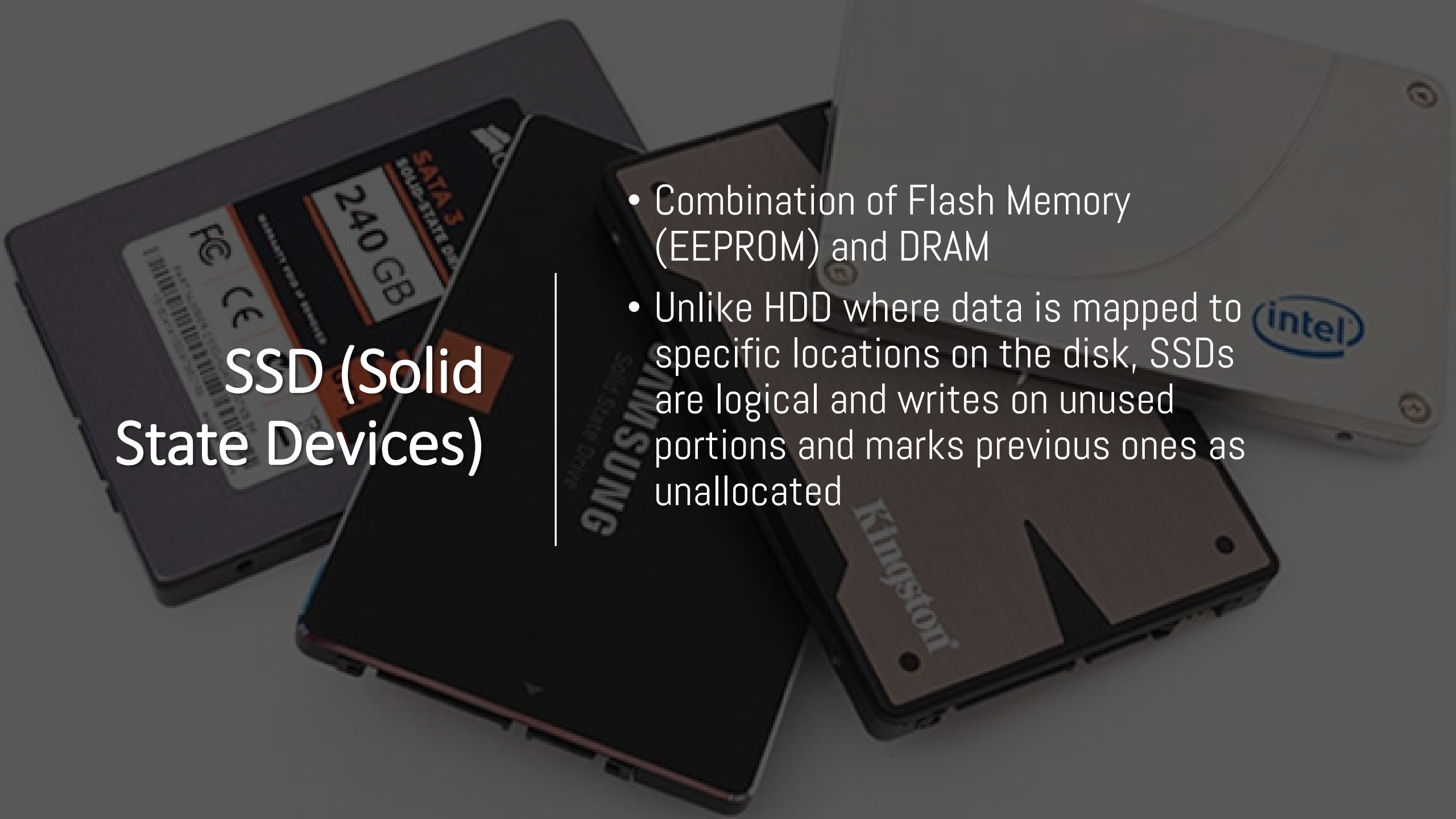
Cache Memory

RAM vs ROM

PARAMETER	RAM	ROM
VOLATILITY	Volatile: data is lost when computer is powered done	Non-Volatile: data is retained even when power is turned-off
ACCESSIBILITY	Can be directly accessed by the CPU	Cannot be directly accessed by the CPU, has to transfer to RAM
STORAGE	Used to store temporary information in a finite time	Stores permanent information (e.g., BIOS)
HARDWARE STRUCTURE	A form of chip (Integrated Circuit)	Can be a chip, magnetic media, optical disks
COST	Expensive than ROM	Less expensive than RAM
SIZE	Larger than ROM	Lesser than RAM
WRITING SPEED	Fast data write speeds	Slow write process (Burn-In)
STORAGE LIMIT	16, 32, 64GB or more	MB
EXAMPLES	Static and Dynamic RAM	PROM, EPROM, EEPROM (Flash Memory - USB)

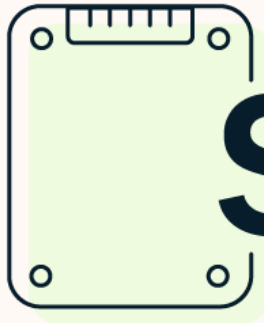
DRAM vs SRAM

SRAM	DRAM
1. SRAM has lower access time, so it is faster compared to DRAM.	1. DRAM has higher access time, so it is slower than SRAM.
2. SRAM is costlier than DRAM.	2. DRAM costs less compared to SRAM.
3. SRAM requires constant power supply, which means this type of memory consumes more power.	3. DRAM offers reduced power consumption, due to the fact that the information is stored in the capacitor.
4. Due to complex internal circuitry, less storage capacity is available compared to the same physical size of DRAM memory chip.	4. Due to the small internal circuitry in the one-bit memory cell of DRAM, the large storage capacity is available.
5. SRAM has low packaging density.	5. DRAM has high packaging density.



SSD (Solid State Devices)

- Combination of Flash Memory (EEPROM) and DRAM
- Unlike HDD where data is mapped to specific locations on the disk, SSDs are logical and writes on unused portions and marks previous ones as unallocated



SSD vs HDD

SSD			HDD
faster	✓	✗	slower
shorter lifespan	✗	✓	longer lifespan
more expensive	✗	✓	cheaper
non-mechanical (flash)	✓	✗	mechanical (moving parts)
shock-resistant	✓	✗	fragile
best for storing operating systems, gaming apps, and frequently used files			best for storing extra data, such as movies, photos, and documents

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