



B4-Flash Memory for SSD Applications

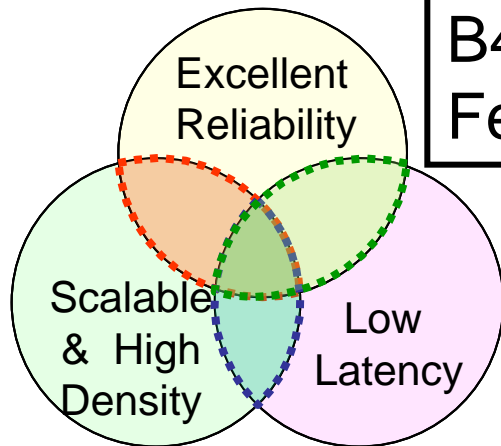
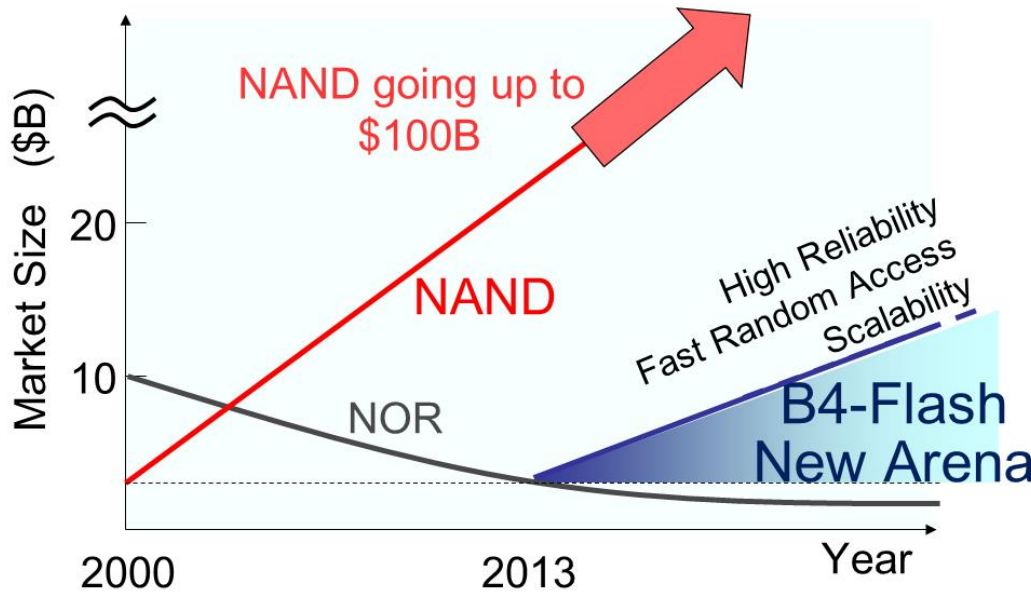
- New Storage Arena with B4-Flash -

13th, Aug., 2013
GENUSION, Inc.

URL: <http://www.genusion.co.jp>

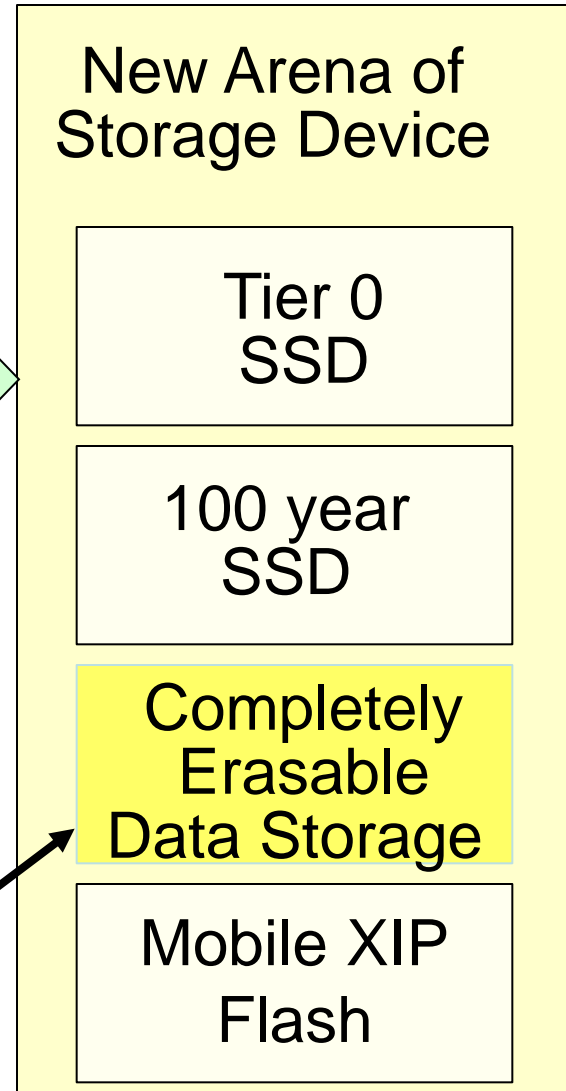


New Arena of Storage Device with B4-Flash



B4-Flash Features

In Production





**“B4-Flash” offers the Solution
for high featured Storage Devices
with High Reliability, High Performance and
High Density**



B4-Flash for Storage Solution

1. B4-Flash is the innovative NVM device as;
 - High Reliability;
100K Endurance,
20 years retention after 100K E/W
 - High Performance; Low Latency (100ns), Fast Re-writable NOR
 - Good Scalability down to less than 50nm

2. B4-Flash can create New Storage Arena for SSD
 - Completely File Erasable SSD; Production already started
 - 100 year retention SSD can be achieved
 - Tier 0 SSD for high-end server is proposed.

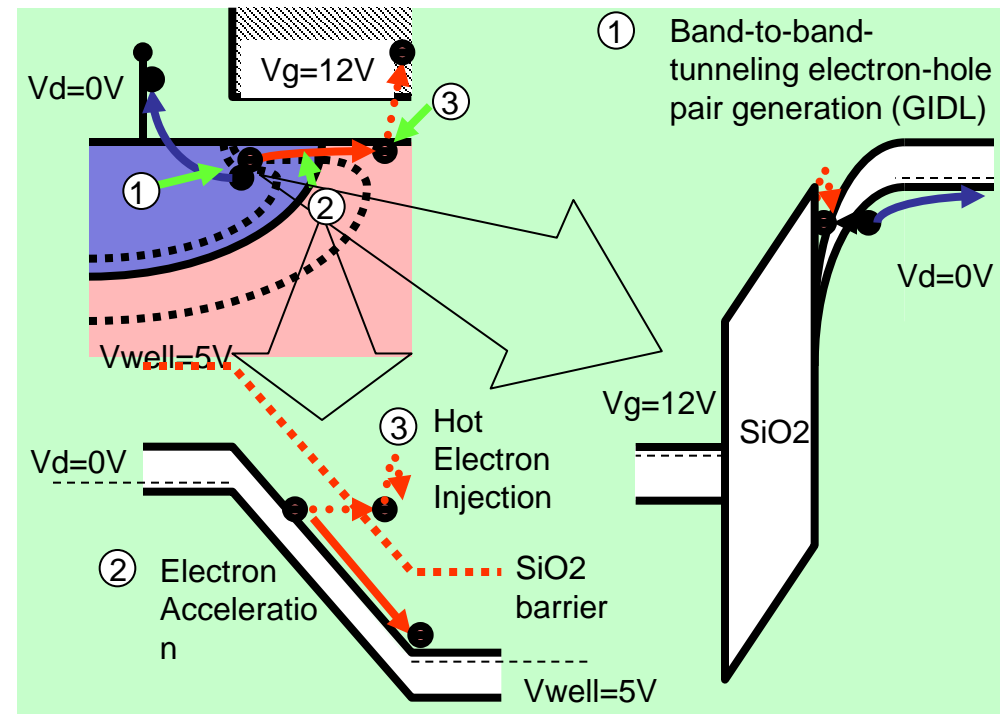
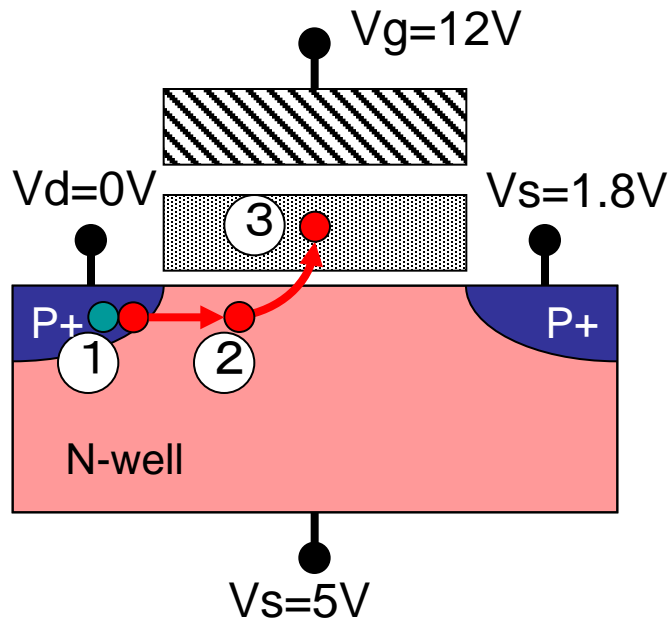
3. GENUSION is willing to cooperate with partners to create New Storage Era with B4-Flash .



B4-Flash Technology as innovative NVM

B4-HE is the Innovation of Flash technology

Back Bias assisted Band to Band tunneling (B4) - Hot Electron Injection



B4-HE injection + Pch MOS transistor memory cell

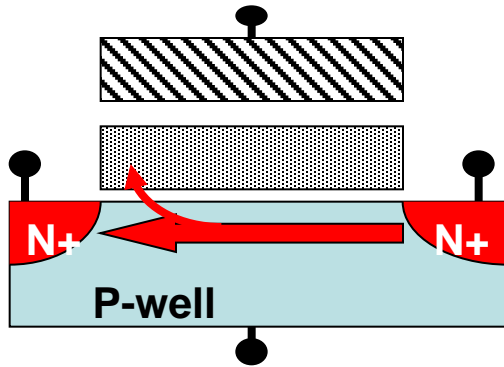
- Fastest Re-writable and Highly Scalable NOR Flash
- High Endurance to 100K E/W and Excellent Retention of 20years after 100K E/W





B4-Flash Features

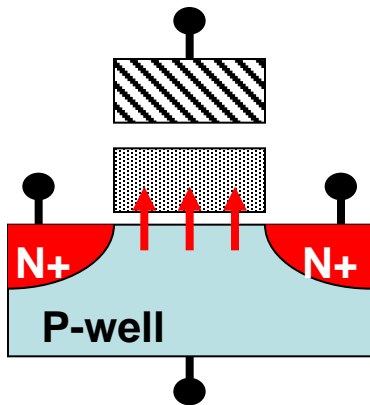
NOR



Performance : High

Cost: High
Prog: Slow
Erase: Slow

NAND

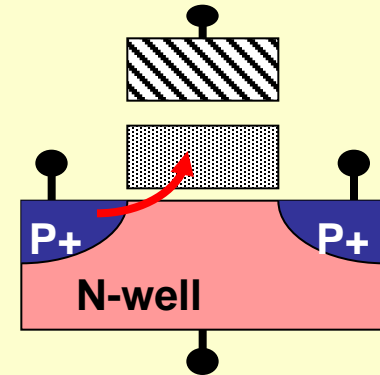


Cost: Low
Prog: Fast
Erase: Fast

Performance : Low

B4-Flash Memory

New Flash Mechanism

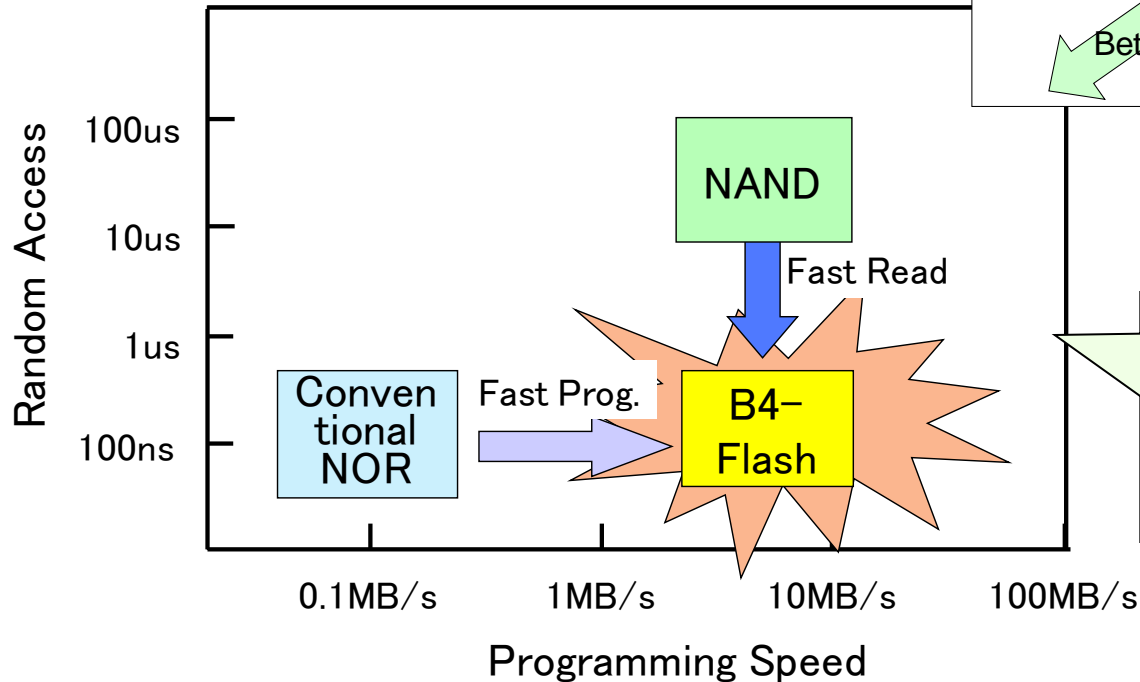
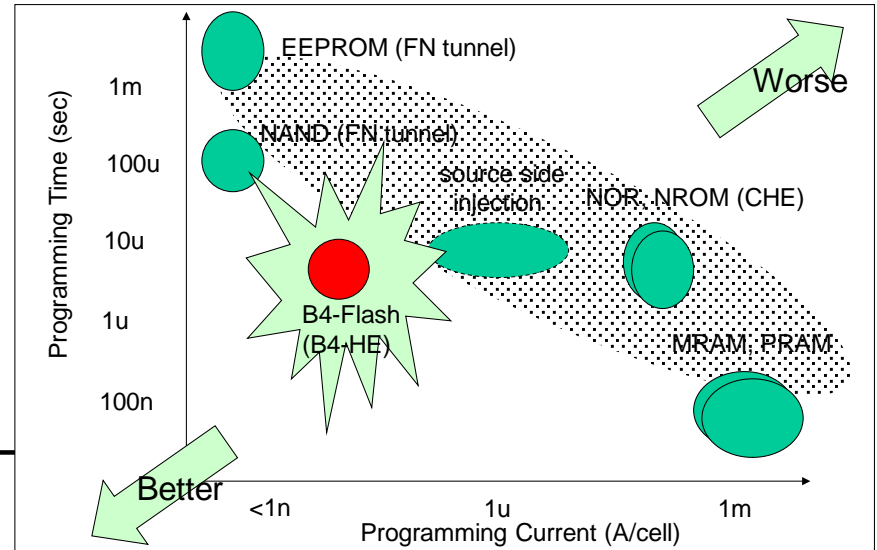


Performance: High
Cost: Low
Prog: Fast
Erase: Fast

Reliability: Excellent

B4-Flash High Speed Program Capability

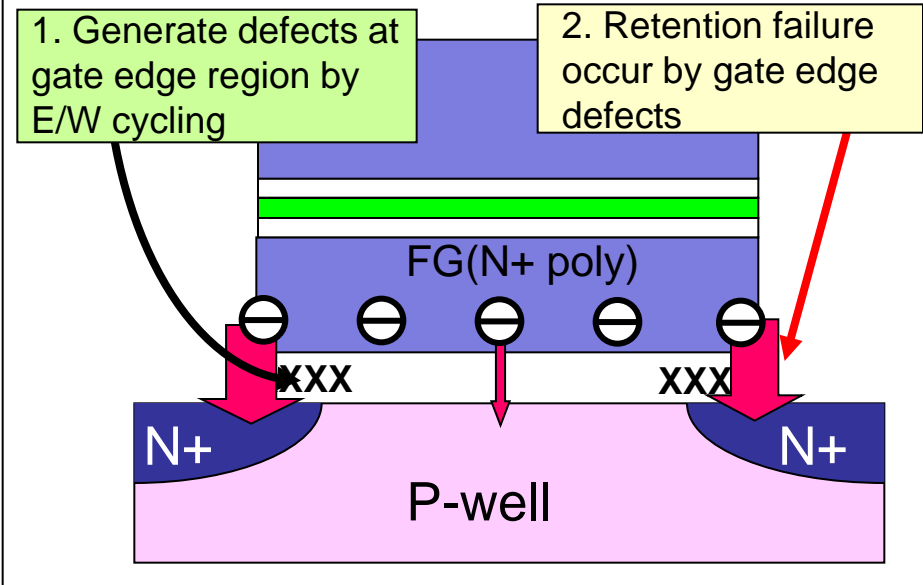
Small current and fast time of B4-Flash programming theoretically achieve 100MB/sec programming throughput.



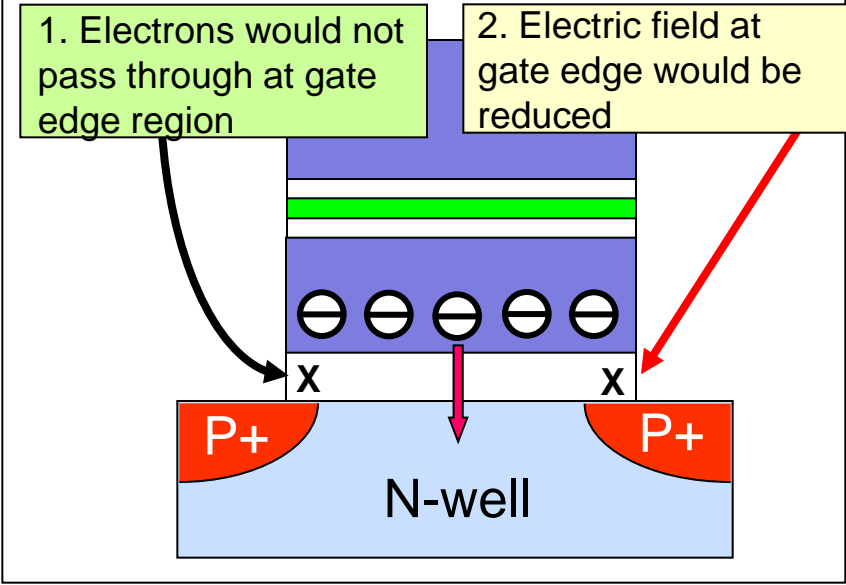
B4-Flash Performance
Create New Arena of Flash

Physical explanation of high Reliability property in B4-Flash

Current NOR/NAND flash
Retention failure initiate defects at gate edge region



GENUSION B4-Flash
No retention failure at gate edge



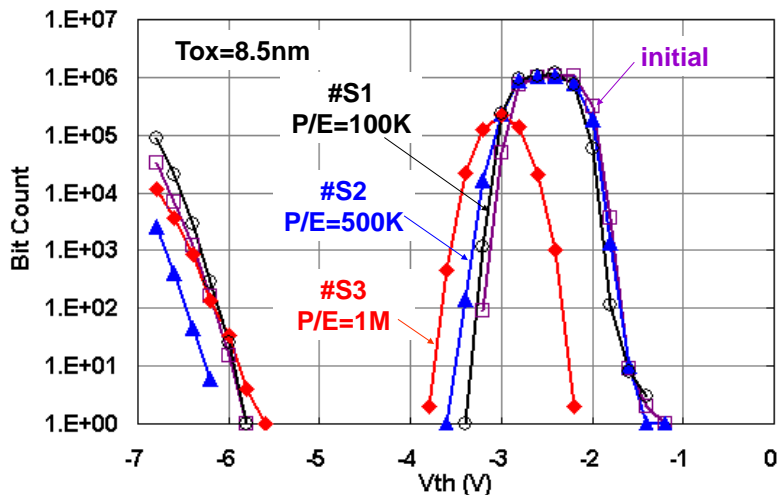
(1) It is reported that 85% of data retention failures are originated to the defects located at gate edge region.

(2) B4-Flash would not damage gate edge region during cycling and would reduce electric field at gate edge because of Pch transistor band configuration, which may improves retention characteristics drastically.

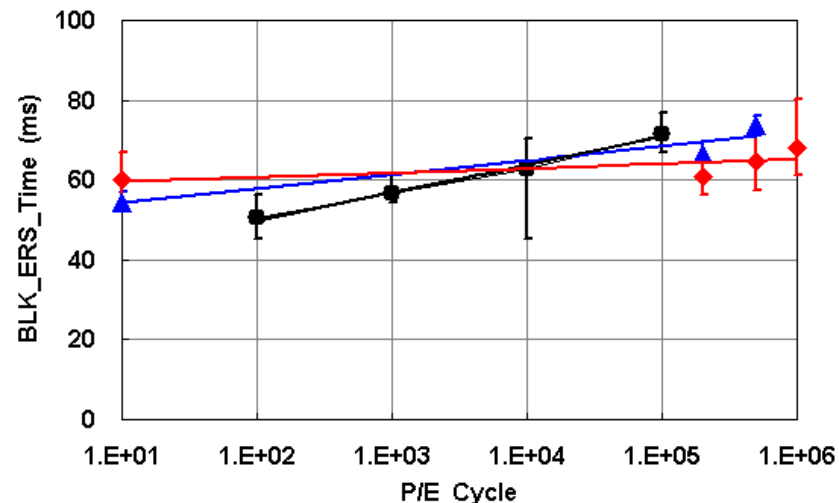
1 Million Erase/Write Endurance Characteristics of 512Mb B4-Flash



Fig.2 Vth distributions of a block (8Mbit)



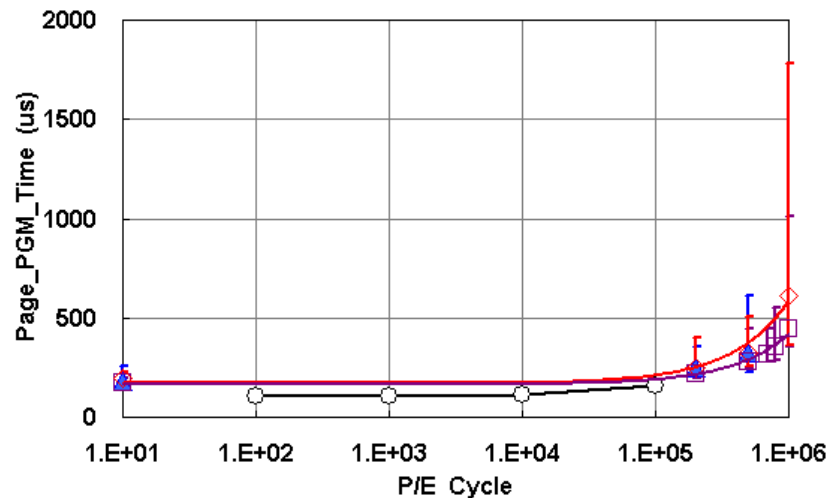
Program Time vs. E/W Cycles



Typical E/W characteristics of 512Mb B4-Flash products has been confirmed up to 1M cycling.

Ref. to “B4-Flash Memory with One Million Cycling Endurance –Suitable for Extremely High End SSD Applications”, S. Shukuri, et. al., IMW 2013, p196.

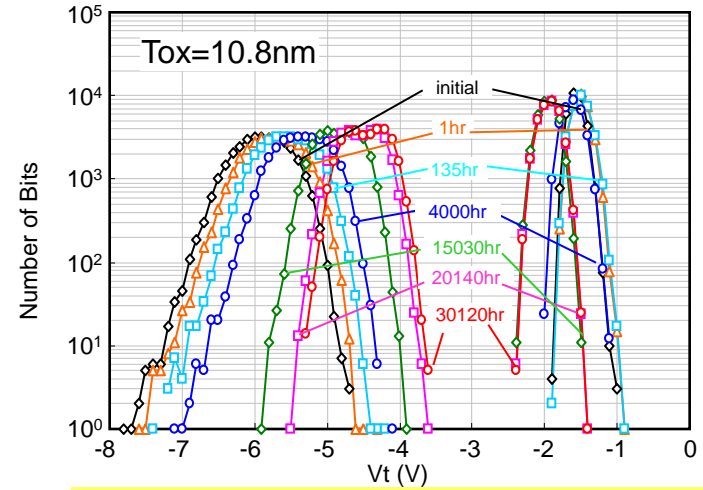
Erase Time vs. E/W Cycles



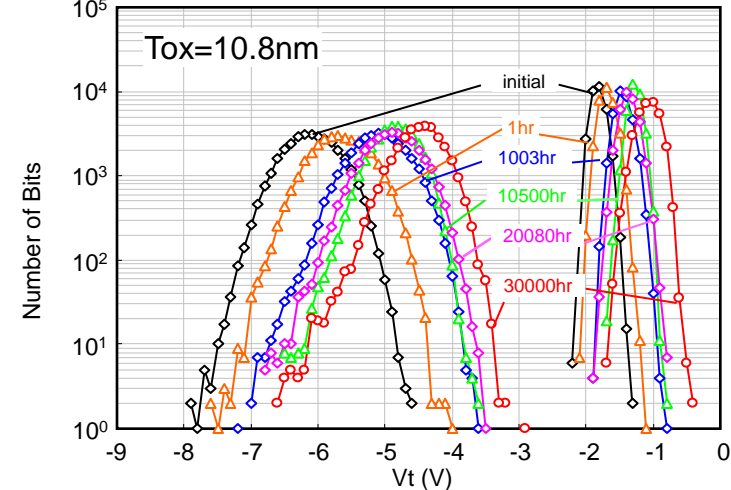


Excellent Reliability Proven in very long term exam.

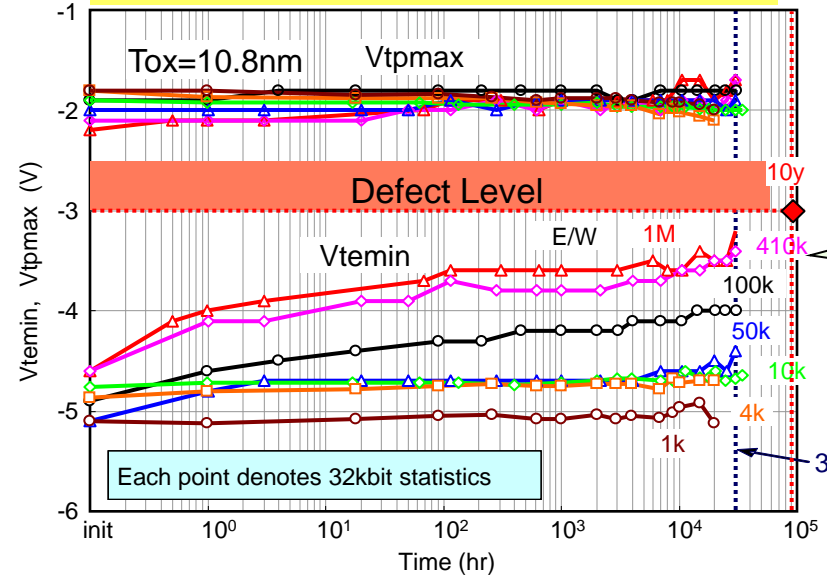
E/W=10k 250C Retention up to 3.4 years



E/W=1M 150C Retention up to 3.4 years



150C Retention after E/W stress



130nm Process Examination

one million E/W stress and 150C retention results show B4-Flash excellence in reliability.



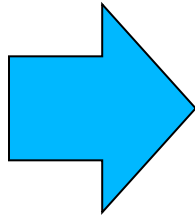
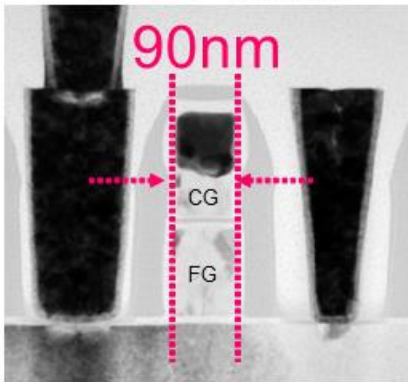
B4-Flash achieves the smallest NOR Cell for chips

B4-Flash succeeds to brakes through the limit of NOR Flash gate length

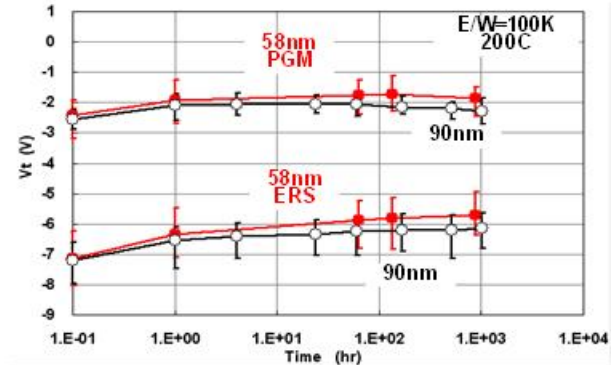
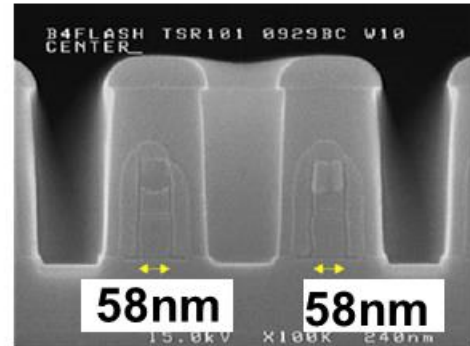


90nm B4-Flash product

90nm
B4-Flash

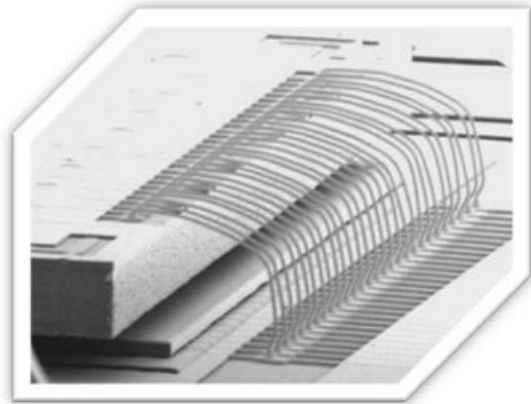


B4-Flash has achieved 512Mb Real Chip with 58nm gate length NOR





GENUSION Package Solution for High Featured Storage Devices



**Real KGD
Solution**

Si-Capsule

B4-Flash

NAND

DRAM

sub-
controller

Si-Capsule
Controller LSI

- "real KGD" process using Burn-in and Full Function Test as Memory module
- very wide bus I/Os with common dies
- Si-Capsule can offer innovative devices for Storage Solution

Patented in US and Japan by GENUSION





B4-Flash embedded Storage for XIP operation in Hand-sets

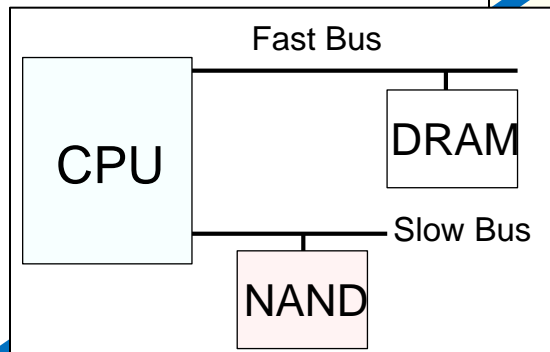


Proposal of Mobile XIP Storage with B4-Flash

- Mobile Storage has been changed in each generation
- B4-Flash can offer the next generation Mobile Storage

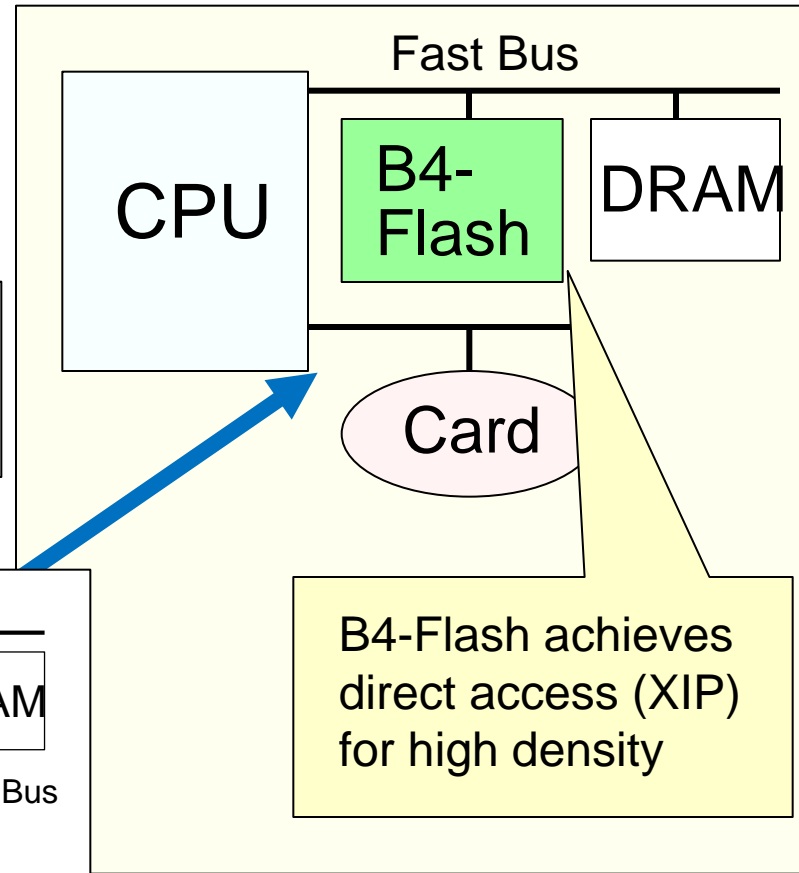
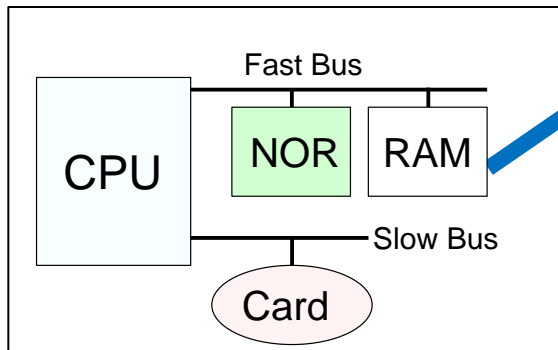
NAND-DRAM latency Gap makes "freeze".

3G/Early4G



NOR couldn't correspond to high density data

2G/Early3G



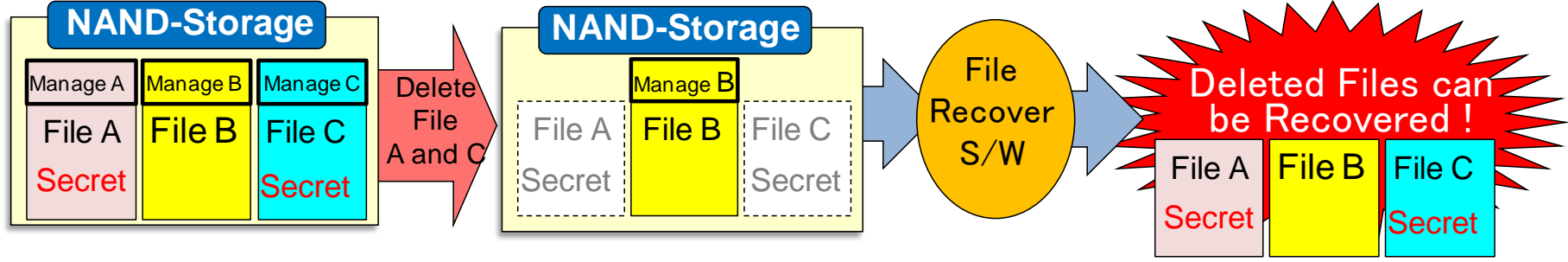
Next Generation



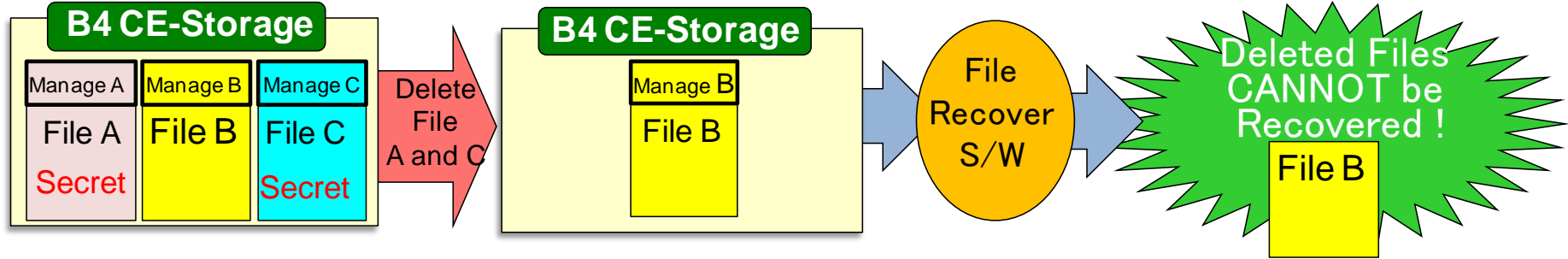
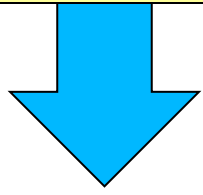
Completely File Erasable SSD with B4-Flash



Completely File Erasable Data Storage



B4-Flash achieves Completely Erasable Data Storage thanks to its High Reliability.



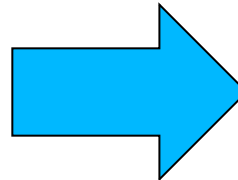


Completely File Erase can be done by B4-Flash

Conventional
Storage Memory

Using NAND Flash

- No erase of the physical data due to less reliability of the device
- Only File Tag is changed
- "Virtual Erase Method"



CE-File Memory
(Completely Erasable)

Already
in Production

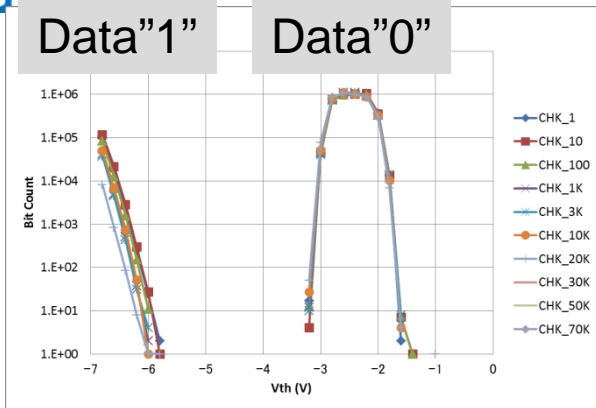


Using B4-Flash
instead

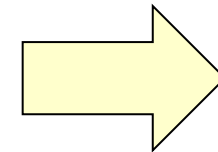
- B4-Flash achieves High Reliability
- Completely Erase of each File
- Physical Erase Method

B4-Flash with high cycling endurance capability can execute file by file complete and physical data erase instead of "Virtual Erase".

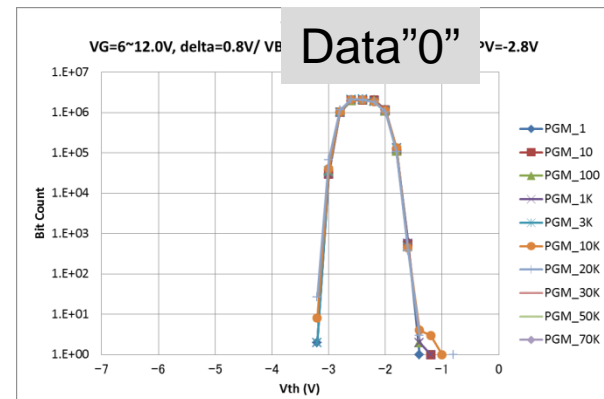
Physics of Completely File Erase



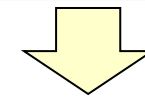
Data programmed file state



File by file
data erase

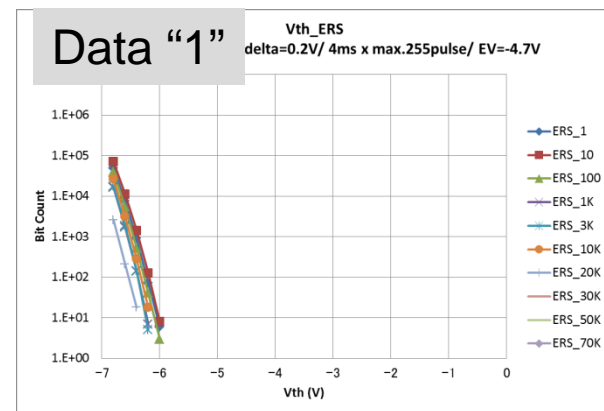


(1) All "0" over-write to black out the data



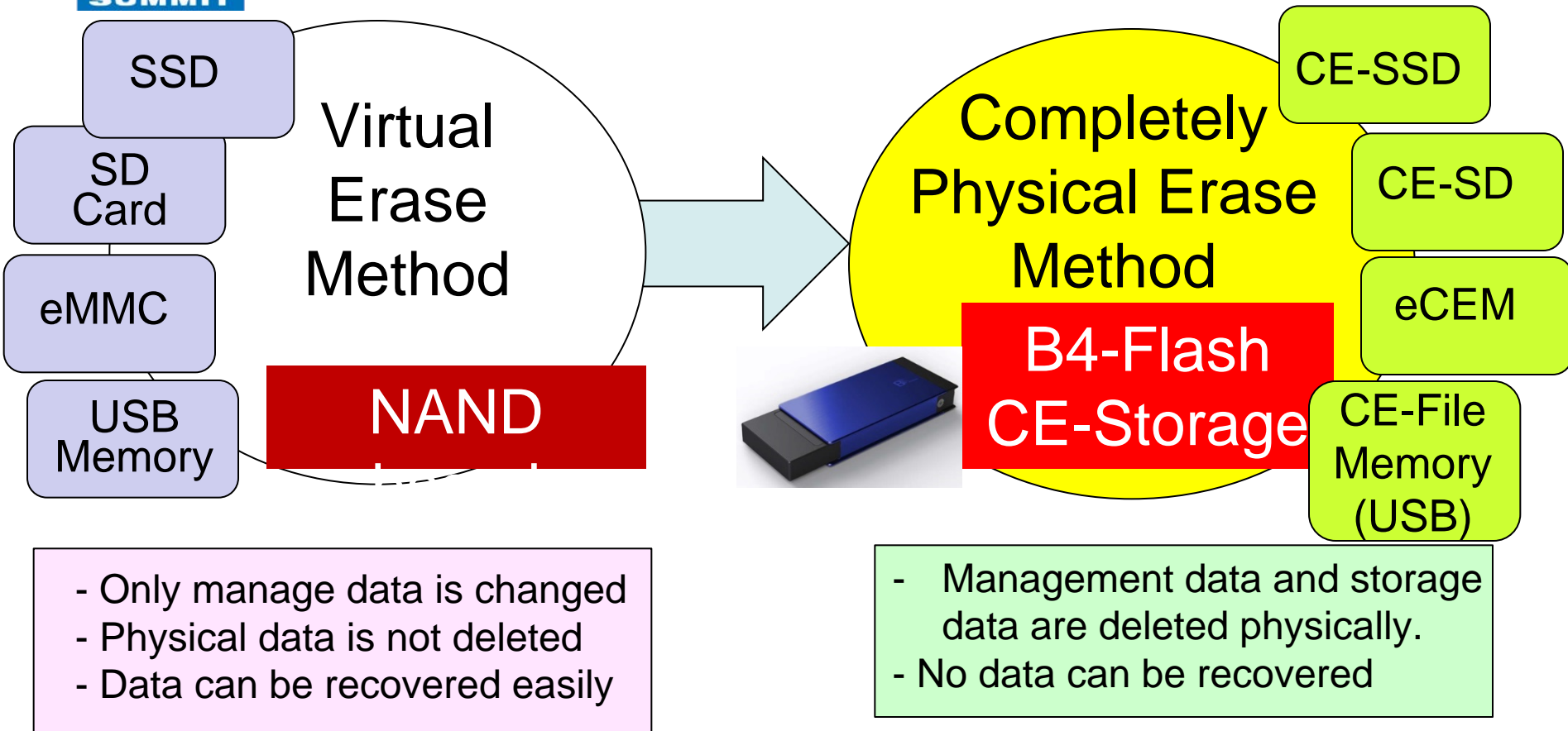
Internal operation

- B4-Flash, component of CE-File Memory, stores the data by electrical status of the memory cells, just the same as NAND.
- B4-Flash can execute file by file data alternation, which NAND flash cannot.
- B4-Flash can realize file by file complete erase.



(2) B4-Flash memory erase operation

Completely Erasable Data Storage Family



Conventional Storage from SD card to SSD cannot delete the data completely due to the feature of NAND.
B4-Flash makes the completely physical erase on storage devices.

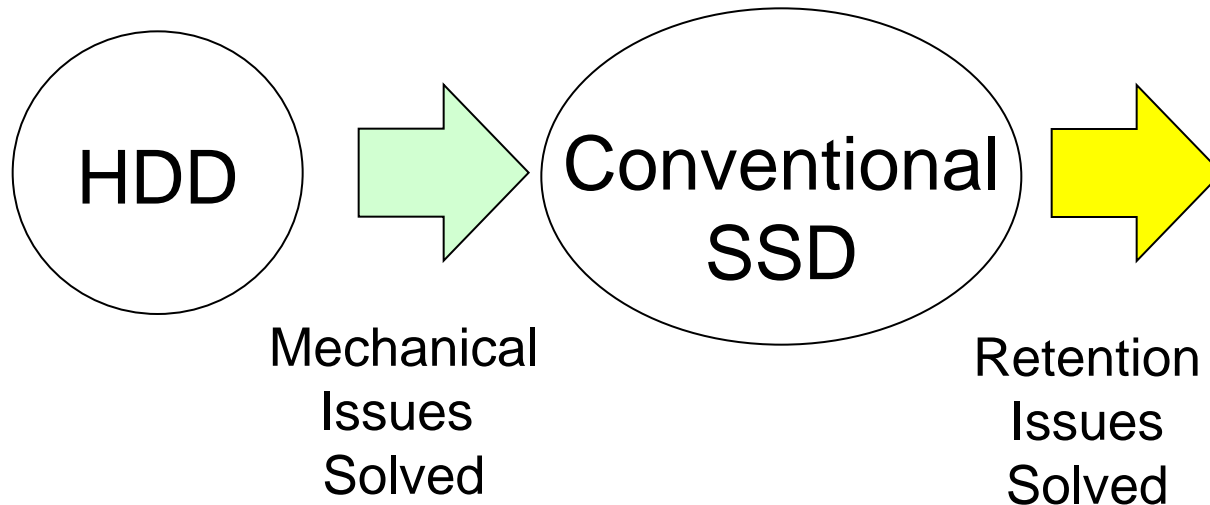


100 years Data Retention SSD
- 100yrs SSD -

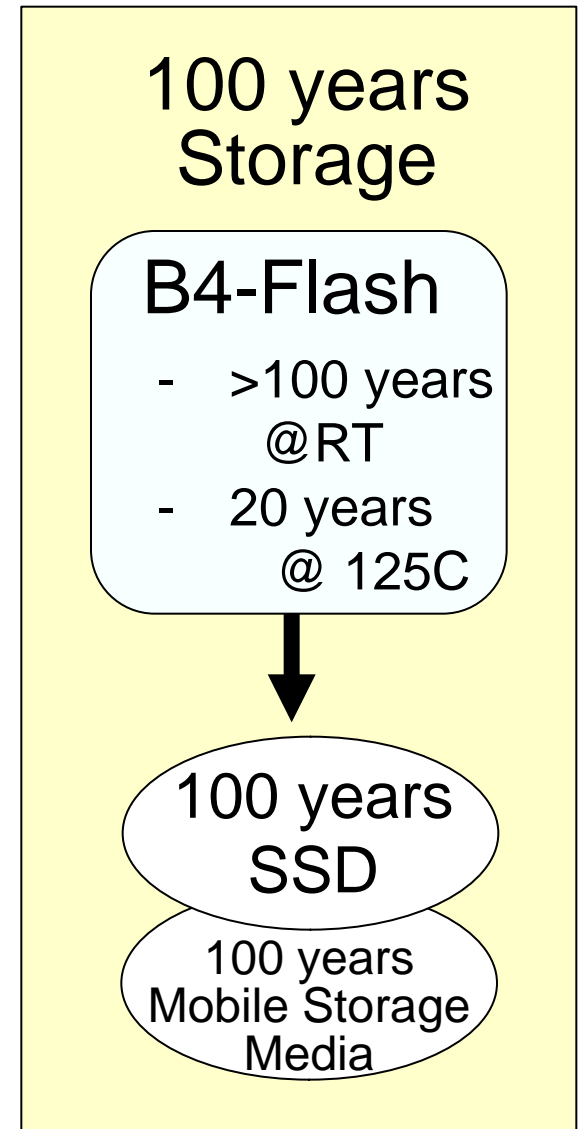
100 year Data Retentive Storage with B4-Flash



B4-Flash can achieve 100 years retention storage device thanks to B4-Flash special feature.



Retention Issues Solved

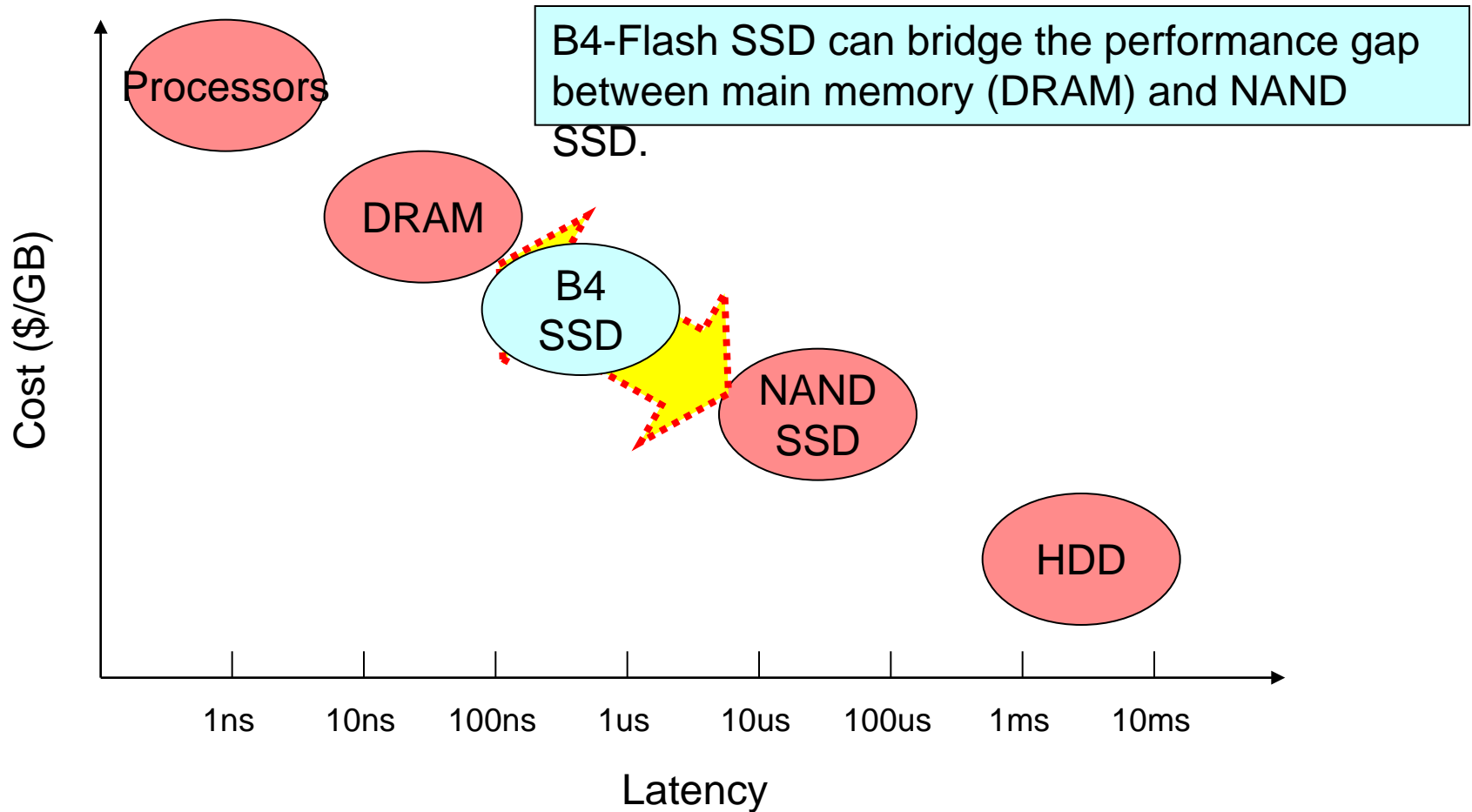




Tier 0 SSD
for high-end featured Storage
With B4-Flash



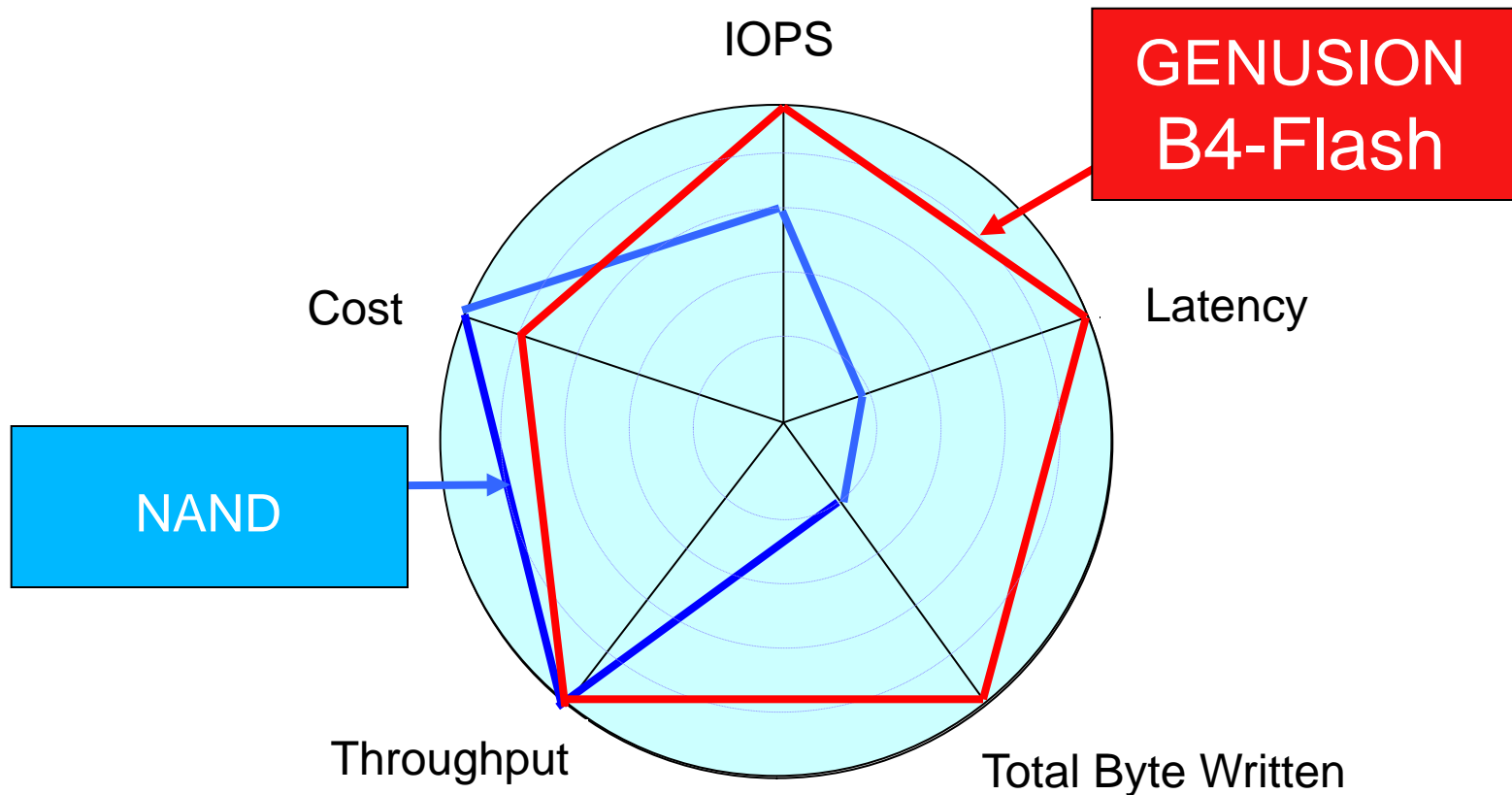
B4-Flash can bridge the performance gap between DRAM and NAND





B4-Flash vs NAND for SSD application

B4-Flash achieves superior performance to NAND for SSD application





Chip Spec. Comparison of B4-Flash to NAND

		NAND		B4-Flash		
				NOR		for SSD
		SLC	MLC	SLC	MLC	MLC
technology node		34nm		90nm		58nm
density		16Gb	32Gb	512Mb	1Gb	4Gb
Read	page size (Byte)	2048	4096	32	32	4096
	1st access	25usec	50usec	115nsec	200nsec	1usec
	Sequential access (nsec)	25	25	30	30	25
Write	page size	2048	4096	1024	1024	4096
	write cycle (nsec)	22.5	25	75	150	25
	write time (usec)	300	900	150	800	900
E/W cycling endurance		10K	3K	100K	100K	100K

B4-Flash achieves superior 1st access and cycling endurance performance to those of NAND, which realizes higher performance SSD than those consist of NAND.



Chip Spec. Comparison of B4-Flash to NAND for SSD application

		NAND		B4-Flash		
				NOR		for SSD
		SLC	MLC	SLC	MLC	MLC
technology node		34nm		90nm		58nm
density		16Gb	32Gb	512Mb	1Gb	4Gb
IOPS (4096B)	Read	7849	6562	13355	11660	9671
	Write	2550	998	1566	305	998
	Read/Write	5200	3780	7461	5983	5334
IOPS (512B)	Read	26455	15924	106838	93284	72464
	Write	3210	1096	6460	1235	1096
	Read/Write	14503	8461	56649	47259	36730
Through put (MB/s)	Read	40	40	66.7	66.7	40
	Write	44.4	40	26.7	13.3	40
	Read/Write	42.2	40	46.7	40	40
Latency		25usec	50usec	115nsec	200nsec	1usec
Total Bytes Written (TB)		20	12	6.4	12.8	50

B4-Flash achieves higher IOPS, faster latency and higher Total Bytes Written compared to those of NAND.



Comparison of IOPs between B4-Flash and NAND (4096B, Read:Write=50:50)

$$\diamond \text{ IOPs} = \frac{0.5}{\text{Data transfer time (Read)}} + \frac{0.5}{\text{Data transfer time (Write)}}$$

○ NAND (MLC, 32Gb)

<Data transfer time (Read)> 50us (1st acc.) + 25ns (seq. acc.) x 4096 (page size) = 152.4us

< Data transfer time (Write)> 25ns (write cyc.) x 4096 (page size) + 900us (write time) = 1002.4us

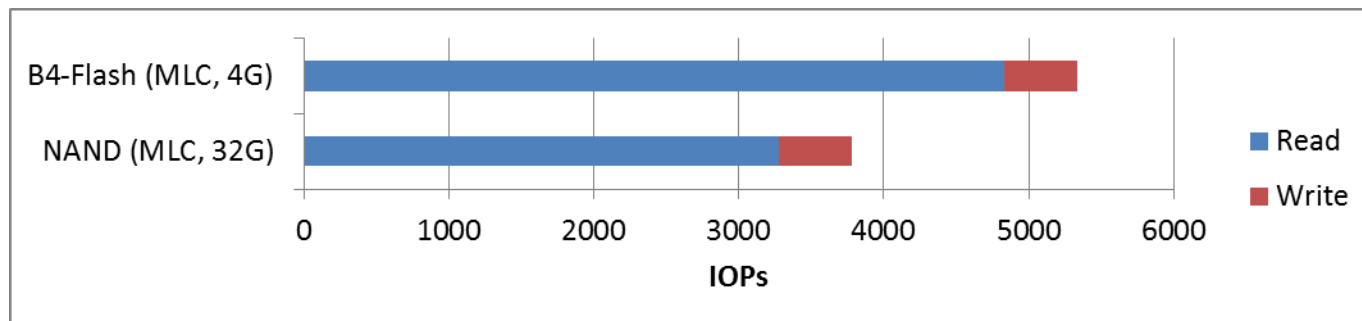
< IOPs > 3281 (Read) + 499 (Write) = 3780

○ B4-Flash (MLC, 4Gb)

<Data transfer time (Read)> 1us (1st acc.) + 25ns (seq. acc.) x 4096 (page size) = 103.4us

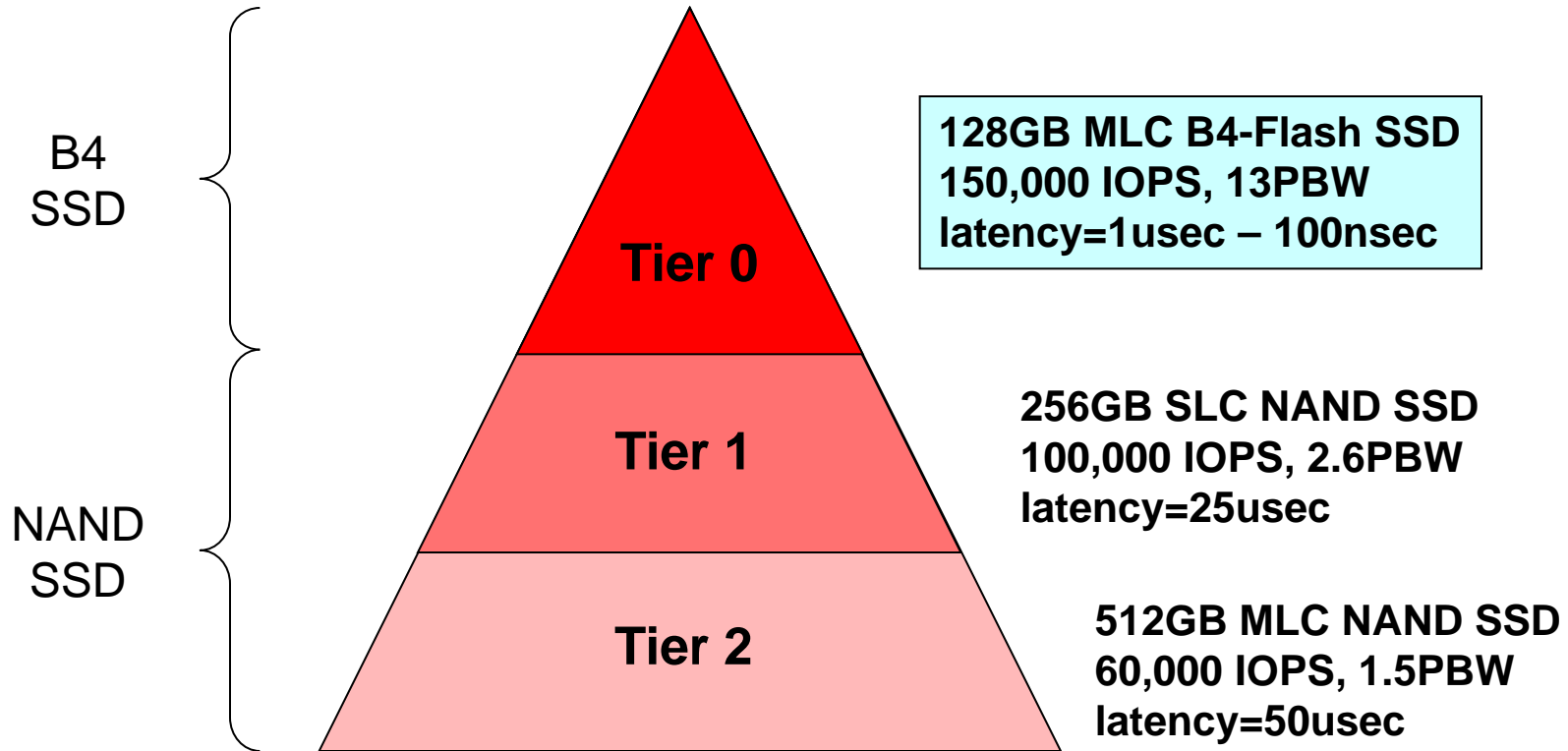
< Data transfer time (Write)> 25ns (write cyc.) x 4096 (page size) + 900us (write time) = 1002.4us

< IOPs > 4835 (Read) + 499 (Write) = 5334





Tiered SSD example proposal by B4-Flash SSD and NAND SSD



Performance Comparison for 160GB High End HDD, NAND-SSD and B4-SSD

	IOPS	TBW	\$/TBW ratio	Latency	Latency ratio
High End HDD	400	infinity	-	msec	1
NAND-SSD	100k - 1million	1.6PB - 16PB	1	several 10s usec	1/20
B4-SSD	150k - 1.5million	160PB	0.1 - 0.02	down to 100nsec	1/10000



Summary

1. New Data Storage Arena for the high-end solution can be created by B4-Flash with;
 - High Reliability
 - High Performance
 - High Density

2. New Data Storage features are ;
 - Completely File Erasable SSD
 - 100yrs Data Retention SSD
 - High performance SSD for high-end server Tier 0