Industry Innovation with Samsung’s Next Generation V-NAND

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Overview

1. Industry Trends

2. 3D V-NAND

3. NVMe SSD

4. New Solutions
Overview

1. Industry Trends
Data Explosion Era
IT Growth Drivers: PC → Mobile → IoT

Unit, M

100
1,000
10,000
50,000

1990 2000 2010 2020

50 Billion Devices by 2020

Source: KPCB, Cisco
Mobile Data Traffic Growth

2018: Billions of Devices 190EB

- More Connections
- Faster Speeds
- More Video
- More Users

5EB The total data created between the dawn of civilization and 2003

Global Mobile Data Traffic Forecast, 2013–2018
More video is uploaded to YouTube in one month than the 3 major US networks created in 60 years.

Source: Samsung
Social Networking Changing Everything

Facebook
>8.7B Pages / day

WhatsApp
>50B Messages / day

Twitter
>500M Tweets / day

SnapChat
>1.2B Messages / day

Phones Checked 100B Times / Day

※ Source: Google
Social Networking: Then and Now...

First Selfie (1839)  

Pope Francis (2013)

100M+ “Selfies” Taken / Day

※ Source: Google
Space: Then and Now

1969

2012
March 2, 2014

During the 86th Academy Awards
Ellen DeGeneres’ Selfie shuts down Twitter

The Selfie that shut down Twitter with a record
1.2 million retweets in 15 minutes…
What Selfie Will Break the Record?

Jim Elliott @Jimelliott70 - Aug 1
Great view of the new 49er stadium from the roof of our new building. Can’t wait for the ribbon cutting in mid-2015!
The New World Record

“Winning” Selfie Creates New Record: >32M Re-Tweets
Exponential Growth: 3.6B Photos / Day in 2014

Daily Photo Uploads

- WhatsApp
- Facebook
- Instagram
- Snapchat

※ 2014 YTD as of May. FCST is extrapolation of public data.

91% of Mobile Internet Access is for Social Media
New Era for Flash
NAND Flash Ubiquity

NAND at the core of the data center and every consumer device
NAND Growth Outlook

NAND Demand Growth (Bit)

1GB Eq. B Unit

Exponential Growth Continues

Portion Change by Application

*Source: Samsung
SSD Growth Outlook

PC Market

Data Center / Enterprise Market

Million TB

2014 2015 2016 2017 2018

Desktop Notebook

Million TB

2014 2015 2016 2017 2018

Enterprise Data Center

4.7X

8.4X

Exponential Growth Continues

iSuppli, ’Q1 2014 + Samsung MKT, ’Q1 2014
Samsung NAND
Leadership
Samsung Memory Market Share Leadership

*Source: Samsung 2013

- NAND: 34.7% Samsung, 65.3%
- SSD: 46.6% Samsung, 53.4%
2006: Launched our First SSD

Brought SSD’s to the mainstream market
2008: World’s 1st MLC SSD

Reduced Cost and Higher Density for wide spread adoption

Lowered cost by 40%!

SSD $ / GB
2012: World’s 1st 3bit SSD

Higher capacity to compete with HDD
2013: World’s 1st PCIe SSD for PC

- 2006: 1st Samsung SSD
- 2008: 1st 2bit MLC SSD
- 2012: 1st 3bit SSD
- 2013: 1st PCIe PC SSD

Bandwidth:
- SATA: 600MB/s
- PCIe: 4GB/s

Latency:
- SATA: 10μs
- PCIe: 3μs

7X improvement in Bandwidth and 1/3X improvement in Latency.
2013: World’s 1st 3D V-NAND SSD

More Capacity
More Speed
More Power Efficiency
How Can We Satisfy Insatiable NAND Demand?

- 2006: 1st Samsung SSD
- 2008: 1st 2bit MLC SSD
- 2012: 1st 3bit SSD
- 2013: 1st PCIe PC SSD
- 2013: 1st 3D V-NAND SSD

New Technology
New Products
Industry Collaboration
NAND Flash Challenges

We Need a Breakthrough...

- Density
- CAPEX
- Technology

- 120nm 1Gb
- 90nm 2Gb
- 70nm 2Gb
- 60nm 8Gb
- 50nm 16Gb
- 40nm 16Gb
- 1x 128Gb
Breakthrough Technology
Bob Brennan
(SVP, Memory Solutions Lab)
Overview

1. Industry Trends

2. 3D V-NAND
2013: World’s 1st 3D V-NAND

128Gb : 24 Stack 2bit

Flash Memory
SUMMIT
Aug, 2013

Samsung 3D V-NAND SSD Announced

Samsung mass produces industry’s first 3D NAND flash chips

The 3D flash technology lays a foundation for next generation 1Tbit chips

Broke Through 10nm Process Barrier
2014: 2nd Generation
2nd Generation 3D V-NAND

128Gb 32 Stack 2bit cell

24 Stack 2bit

32 Stack 2bit

1.4X Density
Cell to Cell Interference-Free Structure

24 → 32 Stack V-NAND Maintains Low Interference

32 Stack = 24 Stack
2014: 850 PRO: World’s 1st 32 Stack V-NAND SSD

- ‘3D V-NAND created the fastest ATA 600 SSD’
- ‘Vertical NAND opens up a whole new world when we look at SSD endurance, density, battery life for portables, and last but not least, SSD performance.’
- ‘3D V-NAND ensures better performance and durability’

Timeline:
- 2006: 1st Samsung SSD
- 2008: 1st 2bit MLC SSD
- 2012: 1st 3bit SSD
- 2013: 1st PCIe PC SSD
- 2013: 1st 3D V-NAND SSD
- 2014: 1st 32 Stack V-NAND SSD
V-NAND 850 Pro

Performance

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Planar</th>
<th>3D V-NAND</th>
</tr>
</thead>
<tbody>
<tr>
<td>128GB</td>
<td>7.6K</td>
<td>8.2K</td>
</tr>
<tr>
<td>256GB</td>
<td>7.6K</td>
<td>8.2K</td>
</tr>
<tr>
<td>512GB</td>
<td>7.6K</td>
<td>8.2K</td>
</tr>
<tr>
<td>1TB</td>
<td>7.6K</td>
<td>8.2K</td>
</tr>
</tbody>
</table>

V-NAND Performance Leadership
V-NAND 850 Pro

Active Power [W]

Planar 3D V-NAND

- 840 PRO
- 850 PRO

- 128GB: 10%
- 256GB: 31%
- 512GB: 38%

Up to 38% Lower Power
V-NAND 850 Pro

Twice the Lifetime
V-NAND
But Wait, There’s More...
Announcing World’s 1st: 32 Stack, 3bit V-NAND

32 Stack 3bit cell

1xnm Planar 3bit

32 Stack 3bit

1X

0.5X

2X Density
Disruptive Density

Three Sixty Residences (24 Floors)

One California (32 Floors)

101 California Street (~48 Floors) Effectively

1st 3D V-NAND Mass Product

2nd 3D V-NAND Innovation

New Innovation (3bit)

New Era of 3D V-NAND
V-NAND Density

One Terabit Density

Design Rule (Layer)

Year

2003 2011 2012 2013

128Gb 256Gb 1Tb

24 Layers 32 Layers 100 Layers

3bit 3D V-NAND Enables Capacity to Scale…
V-NAND Reliability

Voltage Distribution Comparison

Planar 3bit
V32 3bit

10X Reduction

Lower Overlaps = Fewer Errors

3bit V-NAND Improves Bit Error Rate
V-NAND Speed

Planar (1xnm/3bit) vs 3D V-NAND (32 stack/3bit)

*Lower is better

2X Faster
V-NAND Power

Consumption @ Read

- 40%

Planar (1xnm/3bit) vs 3D V-NAND (32 stack/3bit)

*Lower is better

~40% Lower Power
The World's First 3bit-based 3D Vertical NAND Flash Memory

Breaking Through the 10nm Process Barrier with Innovative 3D V-NAND Technology
Overview

1. Industry Trends
2. 3D V-NAND
3. NVMe SSD
2014: World’s 1st NVMe SSD in Production
NVMe SSD: High Performance, Low Latency

SATA SSD

600MB/s

10 μs

NVMe SSD

7X Bandwidth

4GB/s

1/3 X Latency

3 μs

NVMe Unleashes V-NAND
Better Together

High Capacity
- 2TB
- 4TB
- 8TB
- 16TB
- 32TB

High Performance
- 3D V-NAND

Best TCO
- World’s 1st NVMe V-NAND SSDs in Production
NVMe Performance

Server Application Performance

- Decision Support System: 3.2 X
- Media Streaming: 2.8 X
- OS Paging: 2.4 X

* High is better

SSD IOPS → Application Speedup
NVMe Enterprise Leadership

SM1715 / XS1715

HHHL 2.5”

Performance
3000/1400 MB/s
750K/115K

Power
10-25W

World’s 1st, Available Now: Dell PowerEdge Series
Video: What can XS1715 do?

2.57 Million IOPS
NVMe Datacenter Leadership

SM953

M.2  2.5"

Performance  Power
2200/850 MB/s  <6W
300K/14K

Datacenter TCO Optimized, Available Soon
Leadership V-NAND, Leadership Solutions

- 2006: 1st Samsung SSD
- 2008: 1st 2bit MLC SSD
- 2012: 1st 3bit SSD
- 2013: 1st PCIe PC SSD
- 2013: 1st 3D V-NAND SSD
- 2014: 1st V-NAND NVMe SSDs
- 2014: 1st 32 Stack 3bit V-NAND SSDs
Overview

1. Industry Trends
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3. NVMe SSD
4. New Solutions
Announcing Storage Intelligence
Storage Intelligence: What if?

Harness SSD Compute Capacity?
Storage Intelligence: Garbage Collection

Deterministic, Low Latency

1000X

Latency (ms)

Number of I/Os

Legacy SSD

Intelligent SSD
Legacy SSD

Storage Intelligence : Multi-Stream

Multi-Stream
Multi-Stream Results

Legacy SSD

![Legacy SSD graph](image1)

Multi-stream SSD

![Multi-stream SSD graph](image2)

Deterministic Latency
Multi-Stream Advantages

Read IOPs

Average

Worst

1.3x

7.3x

Legacy

Multi-stream

WAF

0.66x

Legacy

Multi-stream

Deterministic Performance

1/3 Less Write Amplification

Performance and Endurance
Opportunity for Industry-wide Collaboration

Redefine Computational Intelligence Together…
Final Thoughts

1. Insatiable NAND Demand
2. 32 Stack 3bit V-NAND
3. 1st NVMe SSD in Production
4. Open Storage Intelligence
Thank you!