

A high-angle photograph of two technicians in a server room. One technician in a blue shirt is leaning over a server rack, while another in a light grey shirt is looking at a server unit. The room is dimly lit with blue ambient lighting. A white circuit board pattern is overlaid on the left side of the image.

QLC Flash: Meeting the Challenges of the New Data Economy

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The Micron logo, featuring a stylized white 'M' with a circular swoosh around it, followed by the word 'Micron' in a bold, sans-serif font with a registered trademark symbol.

Micron[®]



Micron
Technology, Inc.
is founded



Photo source: www.alamy.com

 **Micron**



Micron
Technology, Inc.
is founded

PC/
Internet
Era



2000-
2007

250 billion GB
created annually

Mobile
Era



2008-
2016

7,000 billion GB
created annually

Data
Economy
Era

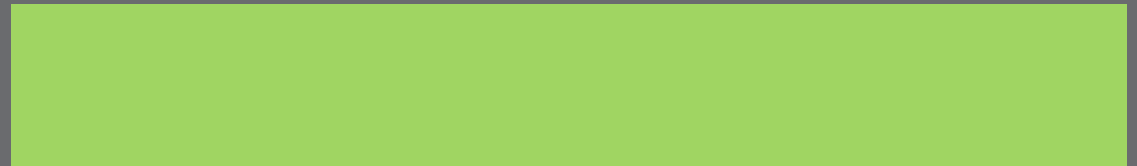


2017-
NOW

22,000 billion GB
created in 2017

The New Data Economy is accelerating data creation

2021



Data
Economy
Era



2017-
NOW



22,000 billion GB
created in 2017

62,000 billion GB
created in 2021



Client PC

- >80% PC SSD adoption anticipated
- >2X expected average capacity increase

Source: Micron, 2021 data from IDC WW 2017-2022 SSD Market Forecast Update





Micronite PC

- ~~>80% PC SSD~~ adoption anticipated
- ~~with 5G~~ expected average
- ~~capacity increase~~ DRAM and >3X NAND per phone anticipated

Source: 2021 data from Micron



Automotive

- Vehicle sensors projected to increase to 205 per car
- 27 billion sensors DRAM and eNAND per automotive vehicle

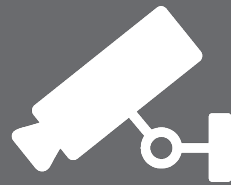
Source: 2020 data from <http://www.automotivesensors2017.com/>



Automotive Insights

- Vehicle data is growing projected business data to 200 per car
- 5 image sensors
- 22 billion sensors anticipated generating automotive data

Source: 2020 data from equalum.io: "The Future of Big Data is Here"



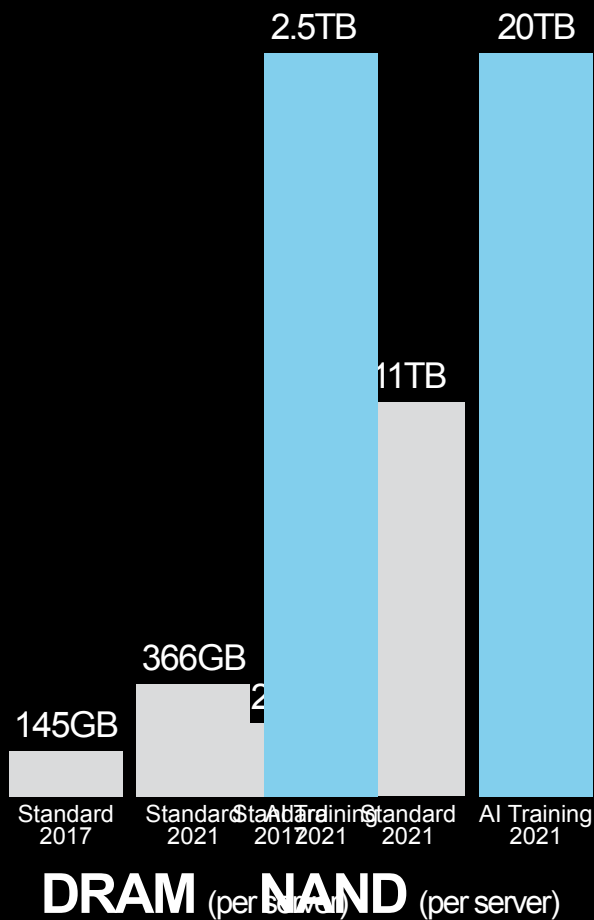
Data Centric Things

- Sensor data growing at 50X business data
- 3 image sensors for every human anticipated



AI requires memory and storage to deliver results

Harvesting Big Data to
Create Immense Value



AI Workloads Unleash the Need For More Memory & Storage

AI Training Impact in 2021 vs. Standard Server Config

6.8X
6.8X
DRAM NAND

Source: Micron





AI Workloads Unleash the Need For More Memory & Storage

Systems are already capable:

1.5TB
DRAM

30TB
NAND



AI & DL Are Changing the IO Patterns of the Data Center



Traditional Data Center IO
4:1 read-to-write ratio

VS.

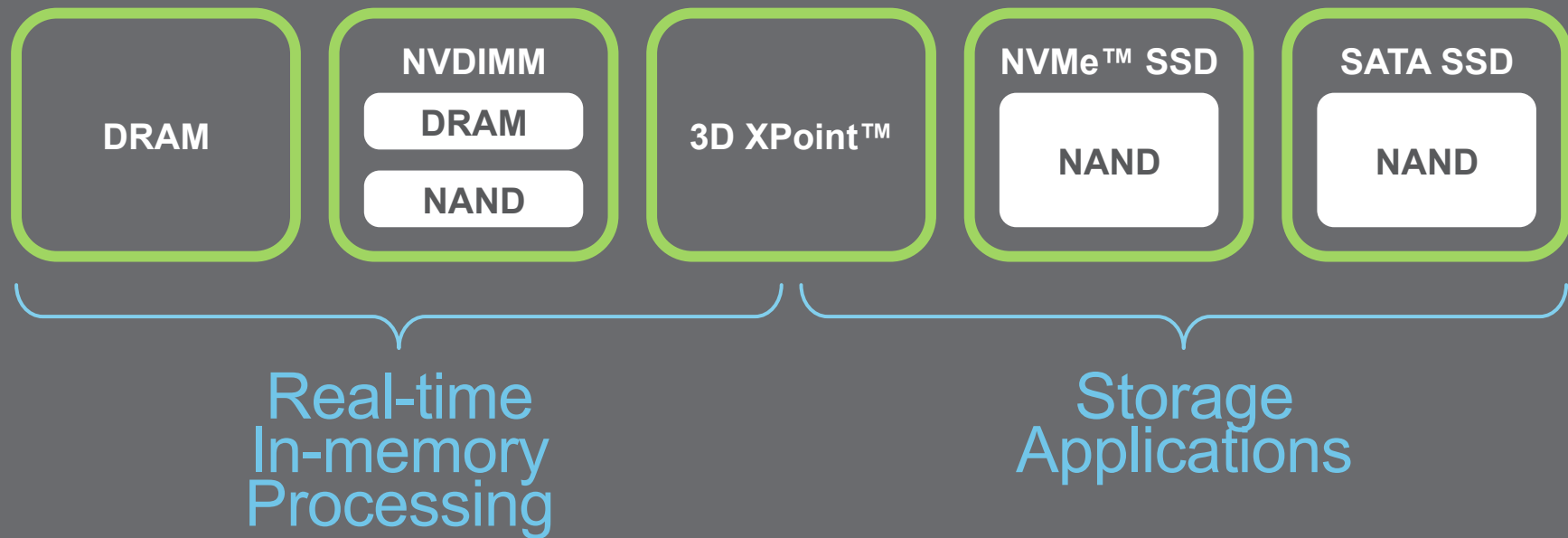
IO pattern, Deep Learning for AI
5000:1 read-to-write ratio

Source: EnterpriseStorageforum.com: "Data Storage, AI, and IO Patterns"



Accelerating Intelligence

Spanning the Memory & Storage Continuum

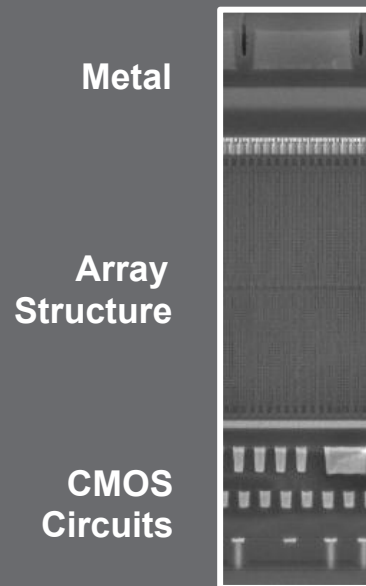


Micron
Innovation
in NAND

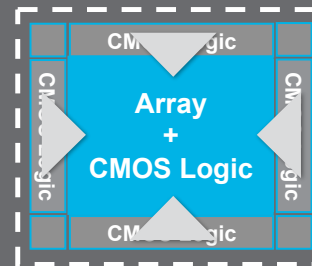


CMOS under the Array (CuA)

NAND with CUA



Top Down View CMOS under Array

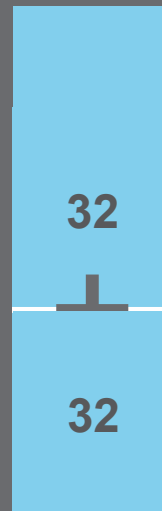


Enabled
Cost Reduction
& Performance
Improvements

Micron
Innovation
in NAND



Array Stacking



32 Layer
Gen. 2

- 50% increase in layers
- Sets write bandwidth benchmarks
- Array stacking for the 2nd time
- Uses CMOS under array for the 3rd time

A decorative graphic on the left side of the slide, consisting of a complex network of white lines and dots on a dark gray background, resembling a circuit board or a data network.

Russ Meyer

Micron Corporate VP of Non-Volatile Memory Integration



4th Gen 3D NAND:
**Optimized for
performance
and scaling.**



Micron Developed

Micron's solely developing Replacement Gate (RG) technology



Uniquely Designed

Incorporates unique combination of CMOS under array with novel charge trap cell technology



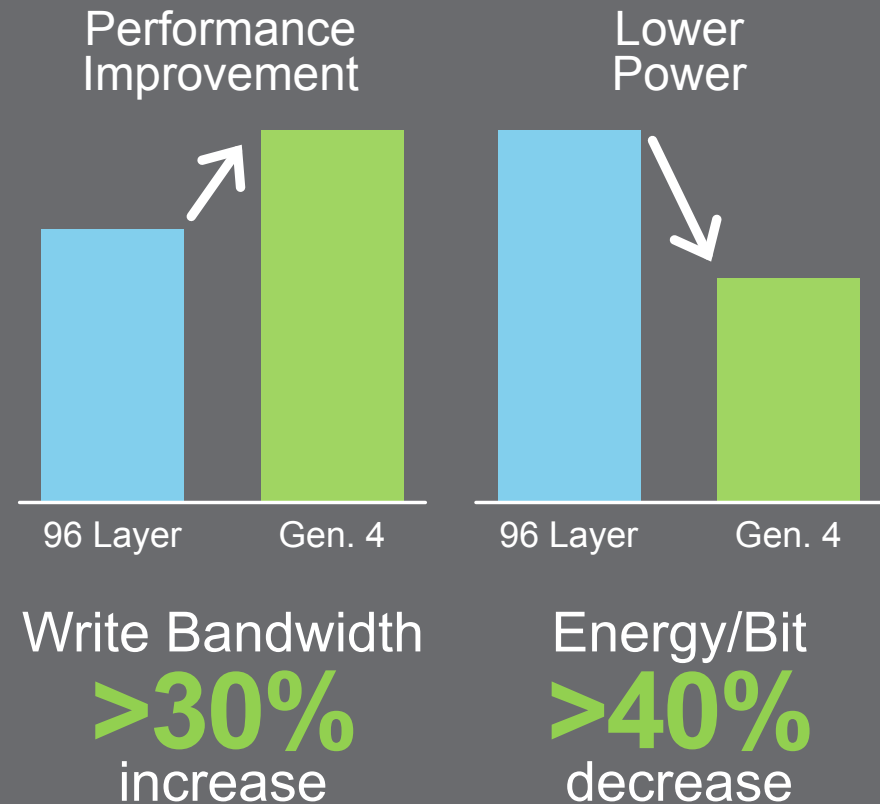
Performance Driven

Targets industry-leading die size & performance



4th Gen 3D NAND: Optimized for performance and scaling.

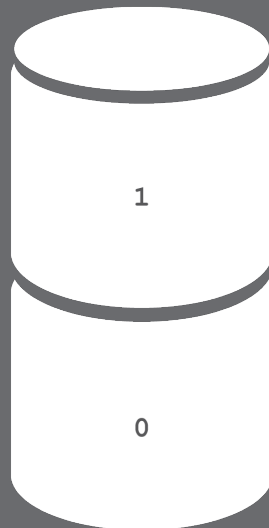
Significant Improvements
Optimized To Meet
Future Needs Of
Multiple End Markets



Micron
Innovation
in NAND



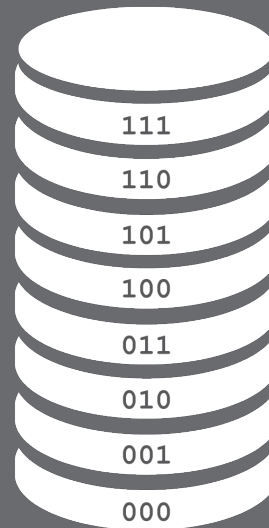
4 bits per cell



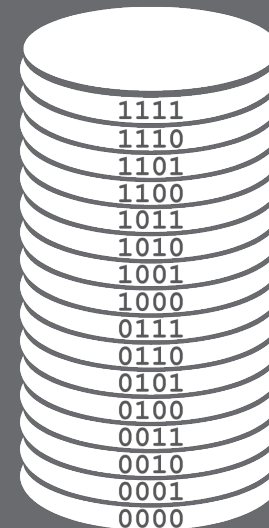
SLC
1 bit/cell



MLC
2 bits/cell



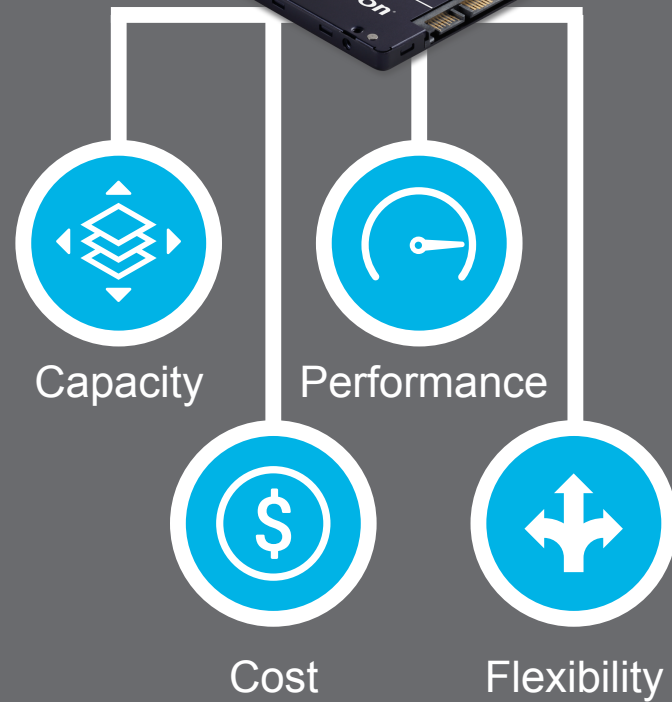
TLC
3 bits/cell



QLC
4 bits/cell

Now Shipping the
Industry's First
QLC SSD

Read-Intensive
Enterprise Workloads
at 7X lower TCO



QLC refers to 4 bits per cell. TCO vs. 7200 RPM HDD for same performance



The QLC
Workload
Advantage



**Right-sized,
cost-effective
performance
for the top
workloads of
today &
tomorrow**



**Real-time analytics
& read-centric
data stores**



**Content delivery
& distribution**

The QLC
Workload
Advantage



BI/DSS with MS SQL: Get more out of less



25% fewer drives
to achieve 4.6x
better query results

5210 QLC



TLC (x4)



vs.

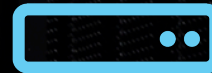
2.4TB 10K



HDD (x8)



x86 (x1)



Source: Micron
TPC-H testing performed by Micron.

Micron

The QLC
Workload
Advantage



No SQL Cassandra

Get nearly 4x the IO
performance with
a fourth of the drives



4X 2.4TB 10K HDD

1,776
operations
per second



1X 7.68TB 5210

6,900
operations
per second

3.9X more operations
per second

10% power savings
with 5210

Source: Micron
YCSB testing performed by Micron.

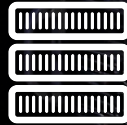


The QLC
Workload
Advantage



Ceph Object Store:

Ceph with QLC is a
cost-effective media
streaming solution



3 Node Ceph Cluster



24X 8TB 5210 ION SSDs
can produce:

70Gbps
object read output

Source: Micron
RADOS Bench object storage benchmark performed by Micron.



Unleashing
NAND with
Software



Increasing
QLC NAND
throughput &
endurance



2X better
throughput



4.5X reduction in
write amp

Source: Micron



Unleashing
NAND with
Software



Increased Operations per Second
More than **8X** improvement



Reduced Latency
95%+ latency reduction



Lower System Write Amplification
More than **8X** improvement



Reduced Power Consumption
7X improvement

Micron storage stack:
**Designed to
optimize
database
application**

Unleashing
NAND with
Software



Engaging with
customers at
a different
level

“

*Researchers
accelerated speeds
on our weather
sampling database
by more than 2X ...
which will enable
more comprehensive
and fine-grained
understanding of
climate conditions
and natural hazards.*

”

TACC

Micron



Transforming how the
world uses information
to enrich life.



Join Micron at FMS 2018:

Booth 407

Breakout sessions:

QLC Is the Best Way to Replace Enterprise HDDs

Today | 3:40-4:45 p.m. | Great America Ballroom J

Meeting the Storage Needs of 5G Networks

Today | 4:55-6:00 p.m. | Great America Ballroom J

QLC and Mixed Mode SSDs Require Deep FTL-Tuning

Today | 3:40-6:05 p.m. | Great America Meeting Room 1

New Flexible Form Factors for Enterprise and Data Center SSDs

Tomorrow | 8:30-10:50 a.m. | Great America Ballroom K

Reception: 7 p.m. tonight in the Terra Courtyard



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