Automotive Update
Q2 2019
Forward-Looking Statements

Safe Harbor | Disclaimers

This presentation contains forward-looking statements that involve risks and uncertainties, including, but not limited to, statements regarding our products and technology, market positioning, the integration of SanDisk and HGST into our company, market trends, business strategy and growth opportunities. Forward-looking statements should not be read as a guarantee of future performance or results, and will not necessarily be accurate indications of the times at, or by, which such performance or results will be achieved, if at all. Forward-looking statements are subject to risks and uncertainties that could cause actual performance or results to differ materially from those expressed in or suggested by the forward-looking statements.

Additional key risks and uncertainties include the impact of continued uncertainty and volatility in global economic conditions; actions by competitors; difficulties associated with the integration of SanDisk and HGST into our company; business conditions; growth in our markets; and pricing trends and fluctuations in average selling prices. More information about the other risks and uncertainties that could affect our business are listed in our filings with the Securities and Exchange Commission (the “SEC”) and available on the SEC’s website at www.sec.gov, including our most recently filed periodic report, to which your attention is directed. We do not undertake any obligation to publicly update or revise any forward-looking statement, whether as a result of new information, future developments or otherwise, except as otherwise required by law.

[This presentation contains financial measures defined as non-GAAP. The non-GAAP measures are used by the company’s management to forecast, evaluate and review the financial results of the company. Management believes these non-GAAP financial measures are useful because they provide meaningful comparisons to prior periods and exclude certain items that may not be indicative of the underlying performance of the company’s business. These non-GAAP financial measures should be used in addition to, and in conjunction with, results presented in accordance with GAAP to better understand the company’s financial performance. Non-GAAP measures are not in accordance with, or an alternative for, measures prepared in accordance with GAAP and may be different from non-GAAP measures used by other companies.] ¹

¹ The last paragraph of this disclaimer and the corresponding Appendix on pages 34 and 35 of this presentation are required to be included in a presentation that includes any of the following slides: 29-32.
Complete Storage Solutions from Edge to Core

- NAND Components
- Embedded NAND
- Cards
- USB
- Portable Storage

- Client SSD
- Client HDD
- Network-Attached Storage
- Direct-Attached Storage
- Personal Cloud

- Enterprise HDD
- Enterprise SSD
- JBOD & JBOF
- Storage Servers
- Tegile All-Flash & Hybrid Arrays
- Object Storage Systems

SanDisk
Western Digital
HGST
G-Technology
Upthere
Tegile

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A Powerful Platform

CUSTOMER VALUE

PORTFOLIO BREADTH

TECHNOLOGY ENGINE

~14,000 active patents

GLOBAL SCALE

70,000+ employees worldwide
Captive NAND Supply
Critical to Serving a Robust Platform

- **Japan**: Semiconductor Fabs
- **China**: Die Packaging & Test
- **Malaysia**: Integrated SSD / China backup facility

- Market leading NAND technology, assembly & test
- Complex, multi-die package assembly
- NAND focus & full vertical integration, critical to quality control, supply chain efficiency
- Dedicated production line for Automotive in SDSS
Diversified Storage Solutions

Mobile
- Designed for OEM applications
- Enables applications with wide range of performance needs

Industrial & IoT
- Extended roadmap support
- High Endurance
- Both -40°C to +85°C and -25°C to 85°C support

Automotive
- Extended temp range: -40°C to +105°C
- Special production flow for auto quality
- AEC-Q100/IATF 16949v

Home & Edge Compute
- Optimized for write endurance – up to 7K/50K (SLC/MLC) P/E cycles
- High temp support: -25°C to 95°C Ta
- Smart Partitioning for embedded flash

Surveillance
- High Endurance
- Health Monitor
- Wide temperature range for indoor / outdoor installations
Growth of NAND Requirements in the Car

<table>
<thead>
<tr>
<th>System</th>
<th>Today’s Capacity</th>
<th>Future Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infotainment/Navigation</td>
<td>8GB-128GB</td>
<td>32GB-384GB</td>
</tr>
<tr>
<td>Digital Cluster</td>
<td>4GB-8GB</td>
<td>8GB-16GB</td>
</tr>
<tr>
<td>Dash Cameras/Drive Recorders</td>
<td>8GB-128GB</td>
<td>16GB-256GB</td>
</tr>
<tr>
<td>Body Controls</td>
<td>8GB</td>
<td>32GB</td>
</tr>
<tr>
<td>Telematics/Gateway/V2X/OTA</td>
<td>8GB-16GB</td>
<td>32GB-64GB</td>
</tr>
<tr>
<td>Autonomous Drive</td>
<td>128GB-512GB+</td>
<td></td>
</tr>
</tbody>
</table>
### Main Applications for Auto-grade eMMC/UFS/SSD

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cockpit Functions</strong></td>
<td><strong>Mainstream &amp; High-End IVI</strong> Single storage for infotainment system Read-intensive 128GB – 512GB (TLC)</td>
</tr>
<tr>
<td></td>
<td><strong>Autonomous Driving L4-L5</strong> DL Networks storage facilitating real-time decision making engine Read/mix-intensive 128GB – 512GB (TLC)</td>
</tr>
</tbody>
</table>
Interface Evolution

- **SD 90MB/s**: Removable Dealer Installable Serviceable
- **e.MMC 400MB/s**: Industry Standard Multi-SOC Support Reliability
- **UFS 2.0 800MB/s**: High Performance Differential Bus Limited SOC support Cost Adder
- **PCle 3.0 4GB/s (4 lane)**: Highest Performance Not for Boot Limited Auto Grade offerings Cost Adder
- **UFS 3.0 2.9GB/s**: Limited SOC support Cost Adder
Certification and Compliance

- **IATF-16949** certified
- **JEDEC47** compliant
- **AEC-Q100** compliant
- Adhering to **ISO26262** NAND flash Safety Mechanisms guidelines
- **PPAP L3** documentation available
- **Automotive Audits** also performed by major EU and Asia customers
  - “Best Facility we have ever audited” - Asia OEM
  - “Best Supplier results during audit” - German Tier1
  - “Preferred Supplier” status - German OEM
Introducing Industry’s First Automotive 3D NAND Technology (Launched October 19th)

- Higher Reliability Cell

- Less Cell to Cell interference

- Tuned for automotive
  - Extra margins, data retention

- High reliability firmware
  - SLC Cache
  - LDPC Technology
  - Write verification
  - Automatic Refresh
e.MMC

iNAND® AT EM132 (former 7550A)
iNAND® AT EM122 (former 7250A)
Automotive iNAND® AT EM122

e.MMC 5.1 – Optimized for Read & Write Intensive Applications

Key Product Features

- 8-64 GB\(^1\), HS400
- High Reliability Design
- Advanced Automotive feature set
  - NDA with WDC required to get more details. Please check the public website for information on this product.
- Ambient Temp: -40°C to +85°C; -40°C to 105°C (Grade 3,2)
- Quality: Low DPPM Manufacturing Flow, AEC-Q100, PPAP, IATF 16949 certified

\(^1\) 1GB=1,000,000,000 bytes. Actual user storage less.
\(^2\) Based on internal testing; performance may vary based on capacity, application and usage. 1MB=1,000,000 bytes.
iNAND® AT EM132 Product Overview

e.MMC 5.1 – Designed for next-gen advanced applications

- 32–256 GB\(^1,2\), HS400
- **High Reliability Design:** NDA with WDC required to get more details. Please check the public website for more basic information on this product.
- [https://www.westerndigital.com/products/embedded-removable-flash#automotive](https://www.westerndigital.com/products/embedded-removable-flash#automotive)
- **Automotive feature set:** advanced health status monitor, enhanced power failure protection. NDA with WDC required for more details.
- **Operating Temp:** \(-40^\circ\text{C} \text{ to } +85^\circ\text{C}\); \(-40^\circ\text{C} \text{ to } 105^\circ\text{C}\) (Grade 3, 2)
- **Shipping now**

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\(^2\) Based on internal testing; performance may vary based on capacity, application and usage. 1MB=1,000,000 bytes.
UFS

iNAND® AT EU312
(formerly known as 8521A)
Automotive iNAND® AT EU312

UFS 2.1 – Optimized for Read & Write Intensive Applications

Key Product Features

• 16-256 GB\(^1,2\)
• UFS 2.1 + specific automotive features.
  • Please check Western Digital Website for public information. Additional information available under NDA. Please contact your WDC sales representative for more information.

\(^1\) 1GB=1,000,000,000 bytes. Actual user storage less.
\(^2\) Based on internal testing; performance may vary based on capacity, application and usage. 1MB=1,000,000 bytes.
SSDs
# eMMC vs. UFS vs. SSD Comparison

<table>
<thead>
<tr>
<th>Category</th>
<th>Parameter</th>
<th>Unit</th>
<th>eMMC</th>
<th>UFS</th>
<th>PCIe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface</td>
<td>Protocols</td>
<td></td>
<td>eMMC 5.1</td>
<td>UFS 2.1 G3 2L SCSI</td>
<td>PCIe Gen3x2 NVMe 1.3</td>
</tr>
<tr>
<td>Density / Capacity</td>
<td>GB</td>
<td>8 – 64</td>
<td>16 – 256</td>
<td>128 – 512</td>
<td></td>
</tr>
<tr>
<td>Form Factor</td>
<td>Area size</td>
<td>mm²</td>
<td>BGA: 11.5x13</td>
<td>BGA: 11.5x13</td>
<td>M.2: 22x42, 22x80</td>
</tr>
<tr>
<td>Performance</td>
<td>Queuing</td>
<td></td>
<td>Single Queue</td>
<td>Up to 32 queues</td>
<td>Up to 64K queues</td>
</tr>
<tr>
<td></td>
<td>Sequential Read</td>
<td>MB/s</td>
<td>Up to 300</td>
<td>Up to 800</td>
<td>Up to 1,700</td>
</tr>
<tr>
<td></td>
<td>Sequential Write</td>
<td>MB/s</td>
<td>Up to 125</td>
<td>Burst: up to 500 Sustained: up to 120</td>
<td>Burst: up to 1,400 Sustained: up to 730</td>
</tr>
<tr>
<td>Power</td>
<td>Active</td>
<td>mW</td>
<td>~900 (64GB)</td>
<td>~1,400 (256GB)</td>
<td>~2,600 (512GB)</td>
</tr>
<tr>
<td></td>
<td>Standby</td>
<td>mW</td>
<td>~1</td>
<td>~1</td>
<td>~2.5</td>
</tr>
</tbody>
</table>
Quality & Support
Quality & Reliability Focus

- Zero defect strategy
- Full vertical integration
- AEC-Q100 compliance, APQP/PPAP, ISO26262, IATF16949
- Excellent track record, dedicated RMA support
- Low manufacturing DPPM flows for grade 2 and grade 3
Shipping e.MMC and SD cards to automotive customers since 2008

- Shipping 15nm based e.MMC and cards, high reliability design, application specific feature set
- Full vertical integration ensures superior quality and industry leading support

Design-in support

- Engaged with leading automotive chipset partners for compatibility testing/AVLs
- Schematic and layout reviews, thermal models, software trace and use-case analysis

Industry’s first 3D NAND based Automotive UFS & e.MMC solution

- High capacity storage solutions
- Extends life of e.MMC
Enterprise Class Storage
Expansive Portfolio of Platforms and Systems
Spanning Enterprise, Private-Cloud, and Edge Data Centers

Platforms

- Ultrastar®
  - Flash and HDD Platforms

Composable Infrastructure

- OpenFlex™
  - Software Composable Infrastructure

Cloud

- ActiveScale™
  - Object Storage Geo-Distributed

Primary

- IntelliFlash™
  - Unified Block and File Storage

NVMe, All-Flash, and Hybrid

Density | Capacity | Durability | Integrity | Performance | Manageability