Memory & Storage Moment

intel®
The Future of Leadership Memory and Storage Technology for PCs

David Lundell
General Manager, Intel Optane Group, Client Division
Client Product Overview

Ultimate Responsiveness
Performance and mainstream productivity, gaming, content creation

Intel® Optane™ Technology

- Intel® Optane™ memory H10 - NOW
- Intel® Optane™ memory H20 – Q2’21

Optimized Storage
Every day computing
Mainstream gaming / content creation

Intel® QLC 3D NAND

- Intel® SSD 660p/665p – NOW
- Intel® SSD 670p – Q1’21

Intel® Optane™ Technology + Intel® QLC 3D NAND

Under Embargo until December 16, 2020, 6:00 AM PST
Next-Gen 144-Layer QLC 3D NAND

- **32L TLC** Gen 1
  - 2016
  - 32L

- **64L QLC** Gen 2
  - 2017
  - 64L
  - 133% Bit Density Increase

- **96L QLC** Gen 3
  - 2019
  - 96L
  - ~50% Bit Density Increase

- **144L QLC** Gen 4
  - 2021
  - 144L
  - ~50% Bit Density Increase

Memory & Storage Moment 2020

Under Embargo until December 16, 2020, 6:00 AM PST
Introducing the Intel® SSD 670p
Next gen 144-layer QLC 3D NAND SSD for mainstream computing

- Next gen controller
- Pyrite 2.0 security
- Power loss notification support
- End-to-end data protection
- 150TBW per 512GB
- PCIe 3.0
Improved Dynamic SLC Cache

1. Increase in used capacity, triggers SLC span decrease

2. Decrease in used capacity, triggers SLC span increase
Improved Dynamic SLC Cache

Intel® SSD 670p extends the use of Dynamic SLC beyond prior gen QLC SSDs

Available SLC Cache SIZE vs USED capacity

<table>
<thead>
<tr>
<th>User data as a % of SSD capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Intel® SSD 660p</td>
</tr>
<tr>
<td>Intel® SSD 670p</td>
</tr>
</tbody>
</table>

Dynamic SLC
Size varies based on capacity used

Static SLC
Size fixed, independent of capacity used

Source: Intel representation of architecture based on mathematical model. Results may vary.
Intel® Optane™ Memory for the PC
Intel® Optane™ Memory Client Strategy

Exceed End User’s Needs

- Instant on
- Responsiveness
- Worry free battery life
- Seamless multitasking
- Ample data store

Through Innovation

- Intel® Optane™ Technology
- Intel® QLC 3D NAND Technology

On the Intel® Architecture Platform
SSDs with Intel® Optane™ memory are the fastest as compared to NAND SSDs.

Source: See Appendix for workloads and configurations. Results may vary.
Introducing Intel® Optane™ Memory H20 with solid state storage

Intel’s next gen performance and capacity storage for the PC, combining Intel® Optane™ Memory and Intel® QLC 3D NAND for thin and light notebooks, and space constrained platforms.
Intel® Optane™ Memory H20 with Solid State Storage

**Intel® Optane™ Technology**
- Accelerate your PC with breakthrough responsiveness so you can search and find files faster, and launch applications quicker
- Conquer storage-demanding applications with smart software that automatically learns your computing behaviors to accelerate frequent tasks

**Intel® QLC 3D NAND Technology**
- Get up to 1TB of storage capacity with an Intel® QLC 3D NAND SSD into a smaller footprint
- Transfer data at PCIe speeds, unleashing the full power of QLC, and getting from data to productivity faster

Single device fits in small spaces with its versatile M.2 form factor designed for mobile device and desktops
Intel® Optane™ Memory H20 with Solid State Storage

Expect improved performance, lower latencies, lower power consumption

**Specifications**
- Intel® Optane™ Technology & Intel® QLC 3D NAND Technology
- Interface: PCIe 3.0x4 with NVMe
- M.2 2280 Single Sided (2280-S3-M)

**Improvements**
- Upgraded 3D XPoint Media
- Next Gen QLC NAND
- New NAND and Intel Optane controllers
- Pyrite 2.0 Security

**Capacities**
- 32GB Intel® Optane™ Memory + 512GB Storage
- 32GB Intel® Optane™ Memory + 1TB Storage

**Use Cases**
- Office Productivity
- Content Creation
- Gaming

**System Requirements**

<table>
<thead>
<tr>
<th>Upcoming platform support planned</th>
</tr>
</thead>
<tbody>
<tr>
<td>11th Gen Intel® Core U Series Processor</td>
</tr>
<tr>
<td>Intel 500 Series Chipset</td>
</tr>
<tr>
<td>RST Driver 18.1</td>
</tr>
</tbody>
</table>
Future Leadership Technology

Intel® SSD 670p
Launch Target: Q1’21

Optimized Storage
Every day computing
Mainstream gaming / content creation

Intel® Optane™ Memory H20 with solid state storage
Launch Target: Q2’21

Ultimate Responsiveness
Performance and mainstream productivity, gaming, content creation
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Performance results are based on testing as of dates shown in the configurations and may not reflect all publicly available security updates. See backup for configuration details. No product or component can be absolutely secure.

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Results have been estimated or simulated.

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Appendix

Slide: “Intel® Optane™ Memory H10 with SSD”

1. Tested by Intel as of August 17, 2020, in the following common laptop use cases:
   (1) a collection of benchmarks and real-world workloads with drives at 50% prefill including PCMark 10 storage tests, CrystalDiskMark 7, email launch, PDF editor launch, photo editor launch, video editor launch, and selected games. (2) a series of Iometer tests at QD1 and QD2 with drives at 50% prefill. Tests were composed of various combinations of sequential and random read and write scenarios, designed to approximate real-world client PC usage based on Intel research, in both single and mixed modes with span size 8GB.

   System configuration: Intel® Core™ i7-1165G7 processor (4C8T, Turbo up to 4.7GHz) on Intel reference platform. Graphics: Intel Iris Xe. Memory: 16GB (2x8GB) DDR4. Storage: 32GB+1TB Intel Optane memory H10 with solid state storage (with Intel Rapid Storage Technology driver 18.0.0.1138) vs. Samsung 970 PRO, Samsung 970 EVO Plus, Sabrent Rocket NVMe 4.0, and Seagate FireCuda 520 (all 1TB NAND with Microsoft Windows 10 in-box PCIe driver). OS: Microsoft Windows 10 (version 18363.1056).

   Result: Intel Optane memory H10 with solid state storage prevails in the majority of tests against each NAND SSD.

2. As measured by Microsoft Word 365 launch with local file copy workload on 11th Gen Intel Core i7-1185G7 processor with 512GB Intel Optane memory H10 with solid state storage vs. 512GB Toshiba XG6 (PCIe 3.0 TLC NAND SSD).


   Performance results are based on testing as of August 26, 2020, and may not reflect all publicly available updates. No product or component can be absolutely secure.

4. As measured by League of Legends launch with local file copy workload on 11th Gen Intel Core i7-1185G7 processor with 512GB Intel Optane memory H10 with solid state storage vs. 512GB Toshiba XG6 (PCIe 3.0 TLC NAND SSD).


   Performance results are based on testing as of August 26, 2020, and may not reflect all publicly available updates. No product or component can be absolutely secure.

5. As measured by Adobe Photoshop launch with local file copy workload on 11th Gen Intel Core i7-1185G7 processor with 512GB Intel Optane memory H10 with solid state storage vs. 512GB Toshiba XG6 (PCIe 3.0 TLC NAND SSD).


   Performance results are based on testing as of August 26, 2020, and may not reflect all publicly available updates. No product or component can be absolutely secure.

Slide: Intel® Optane™ Memory H20 with solid state storage.

Battery life varies by use, configuration and other factors. Learn more at www.Intel.com/PerformanceIndex.
Floating Gate Cell vs. Charge Trap Cell

**Floating gate cell**
- Good program/erase threshold voltage window
- Good charge isolation between cells
- Good data retention

**Charge trap cell**
- Poor program/erase threshold voltage window
- Poor charge isolation between cells
- Poor data retention
Floating Gate NAND Delivers High Data Retention

- Smaller read window creates accuracy challenge
- Even smaller amounts of leakage can create read inaccuracies

<table>
<thead>
<tr>
<th>Bits/Cell Challenge</th>
<th>Charge Loss Over Time for 4 bits per cell$^1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>4b/c 16 states</td>
<td>Floating Gate vs. Charge Trap Flash cell</td>
</tr>
<tr>
<td>3b/c 8 states</td>
<td></td>
</tr>
<tr>
<td>2b/c 4 states</td>
<td></td>
</tr>
<tr>
<td>1b/c 2 states</td>
<td></td>
</tr>
</tbody>
</table>

- Floating gate NAND cell superior to charge trap flash for data retention → better QLC capability

$^1$Source: Measurements performed on components from QLC SSDs using Floating Gate and Charge Trap Flash technology. Measurement platform used was Teradyne Magnum. Memory test systems, and programming using random patterns and margins were quantified using customer commands. Data measured in 08/2019. Results may vary.

$^2$E_a assumed = 1.0eV