Optane Summer Research 2022

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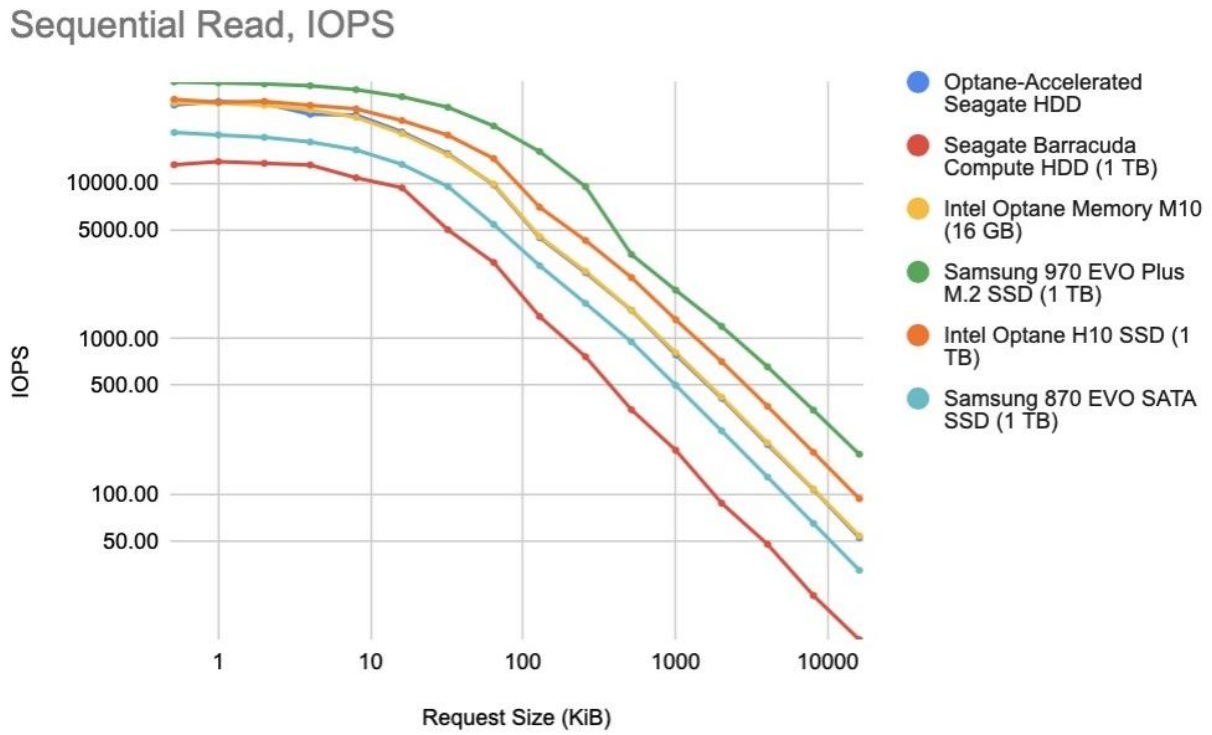
IOmeter Data

Procedure

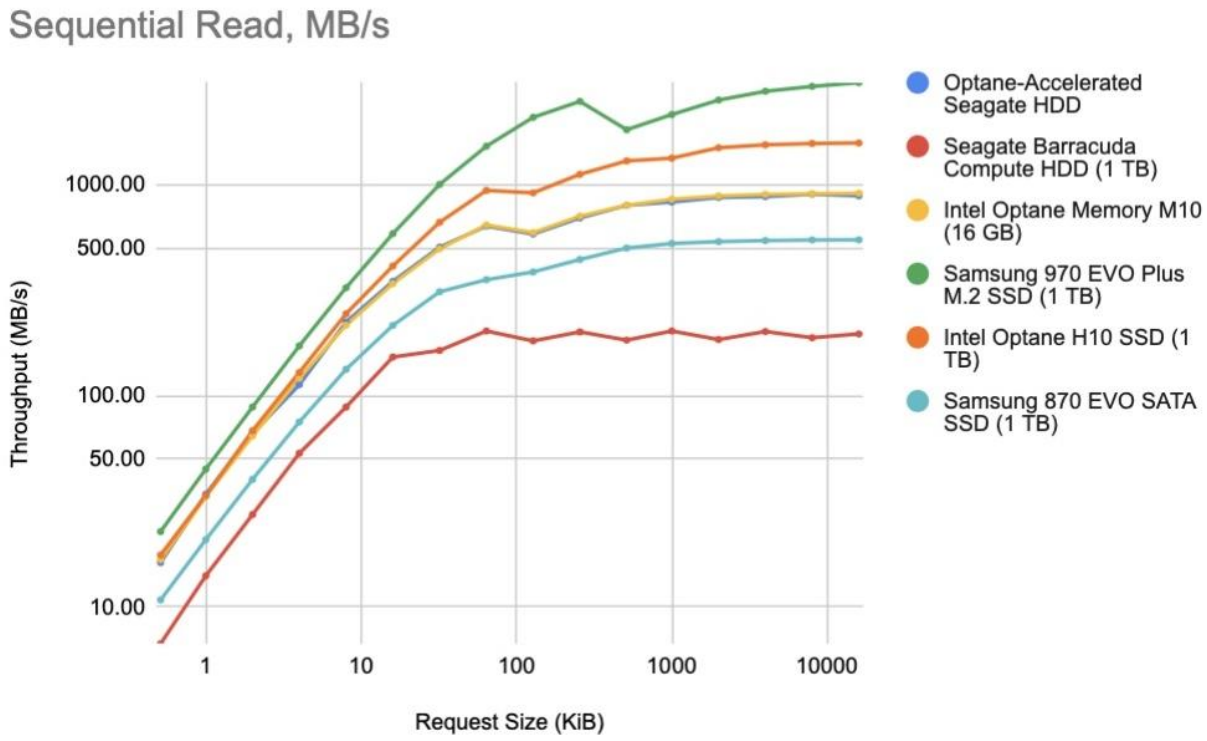
- Using IOmeter software, designed 64 tests starting at 512 B and doubling the request size until 16 MB for sequential r/w, random r/w
- Completed these 64 tests for at least 3 runs to calculate median value
  - Runs with high RSE were redone for more precise data
- Typed data on spreadsheet
- Organized data to make graphs to see how IOPS, MB/s, and response time changed with request size

Sequential Read

IOPS


Sequential Read, IOPS
IOPS
10000.00
5000.00
1000.00
500.00
100.00
50.00
1
10
100
1000
10000
Request Size (KiB)
Optane-Accelerated Seagate HDD
Seagate Barracuda Compute HDD (1 TB)
Intel Optane Memory M10 (16 GB)
Samsung 970 EVO Plus M.2 SSD (1 TB)
Intel Optane H10 SSD (1 TB)
Samsung 870 EVO SATA SSD (1 TB)

MB/s


Sequential Read, MB/s
Throughput (MB/s)
1000.00
500.00
100.00
50.00
10.00
1
10
100
1000
10000
Request Size (KiB)
Optane-Accelerated Seagate HDD
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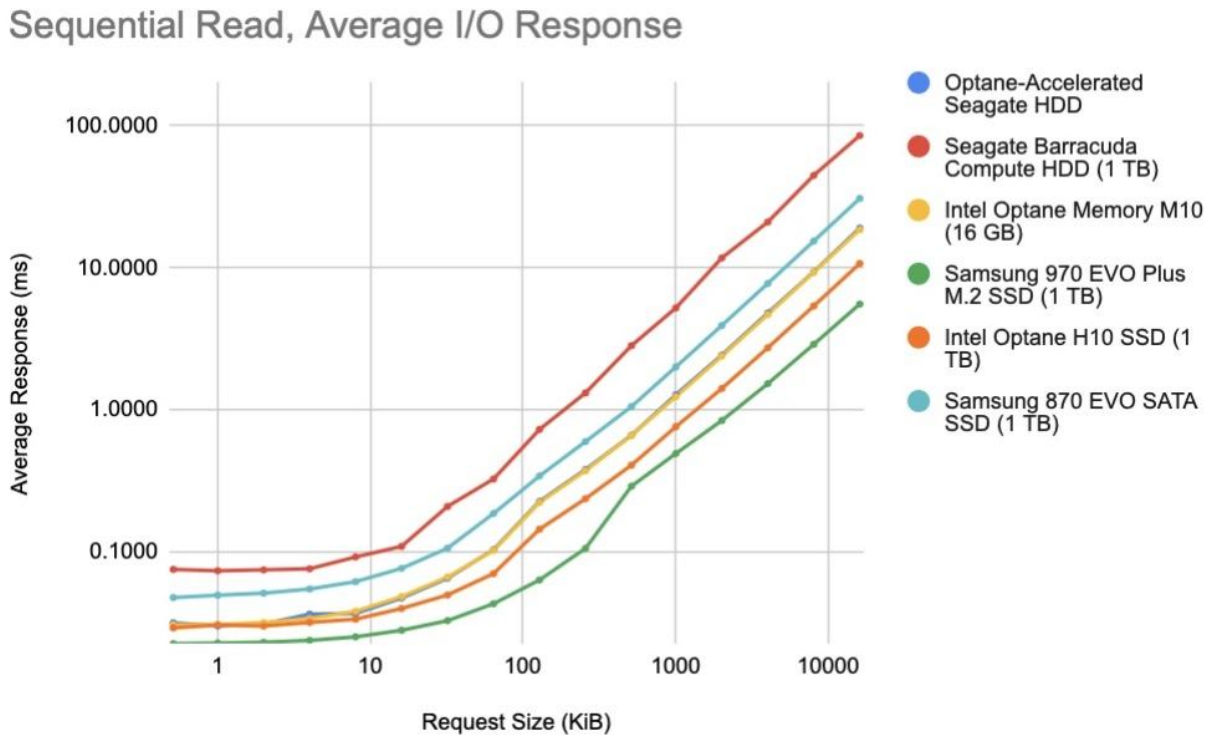
Latency


Sequential Read, Average I/O Response
Average Response (ms)
100.0000
10.0000
1.0000
0.1000
1
10
100
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10000
Request Size (KiB)
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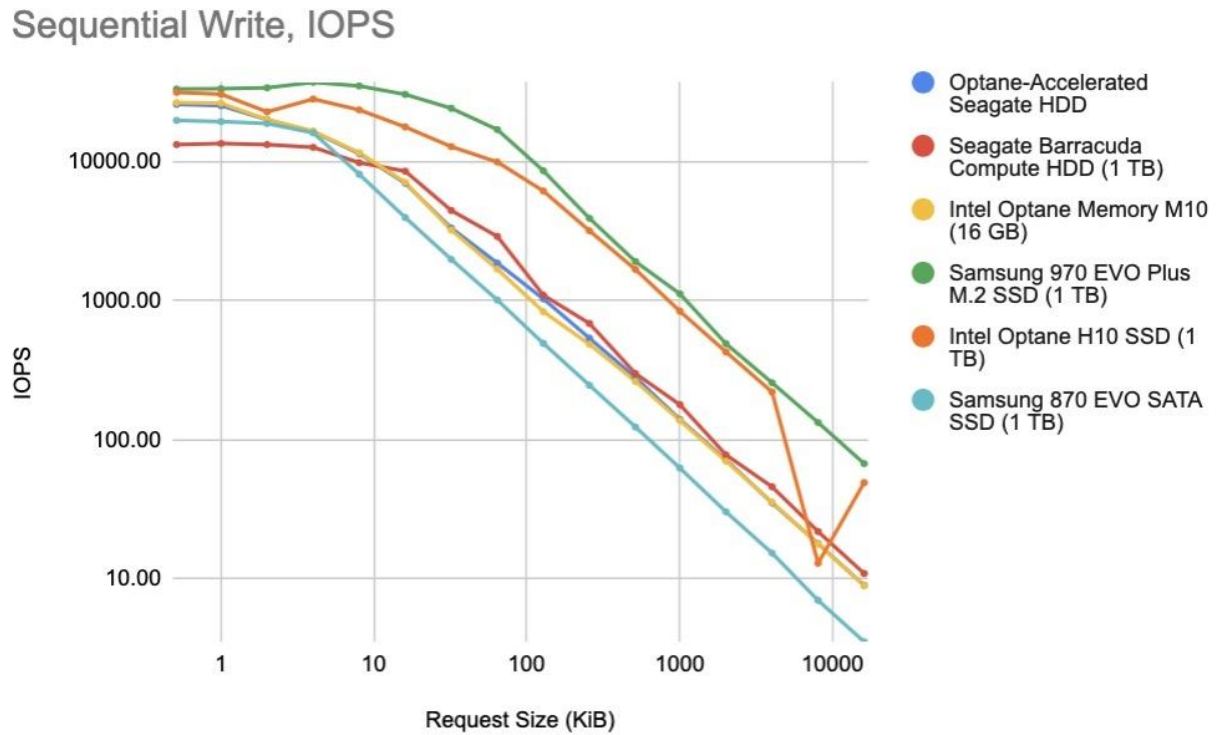
Sequential Write

IOPS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1000.00
100.00
10.00
IOPS
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10
100
1000
10000
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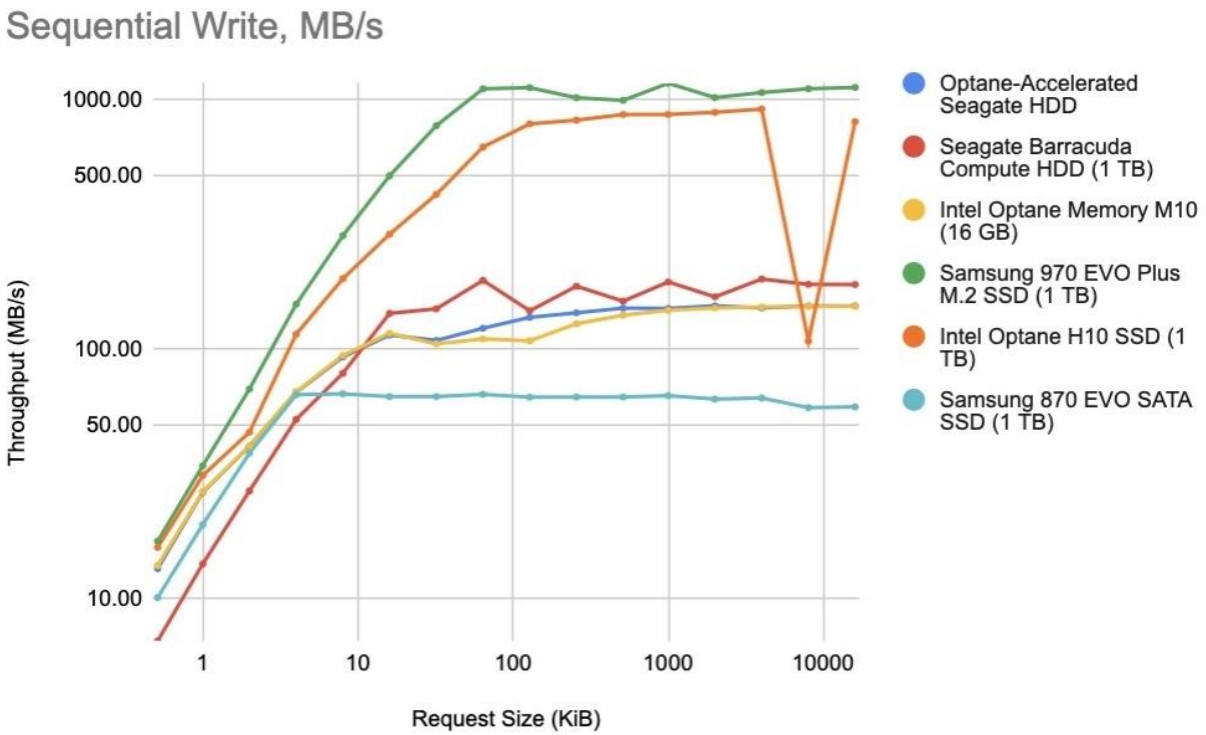
MB/s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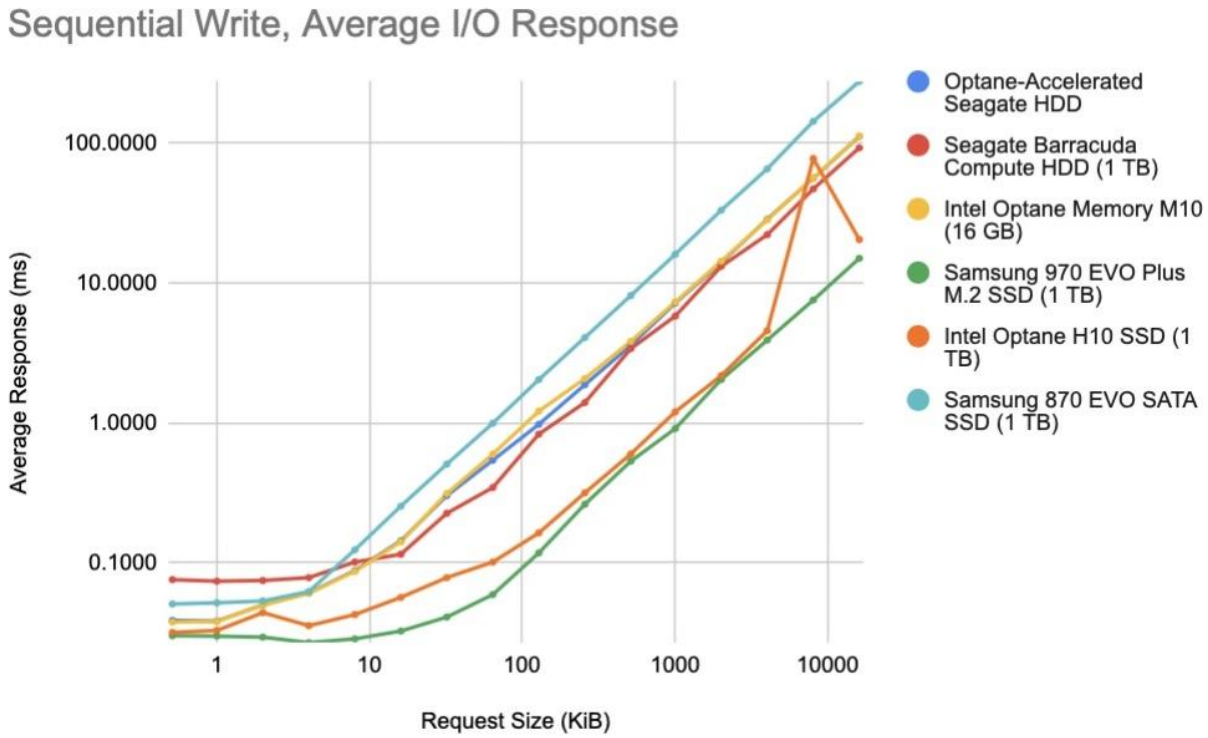
Latency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1.0000
0.1000
1
10
100
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10000
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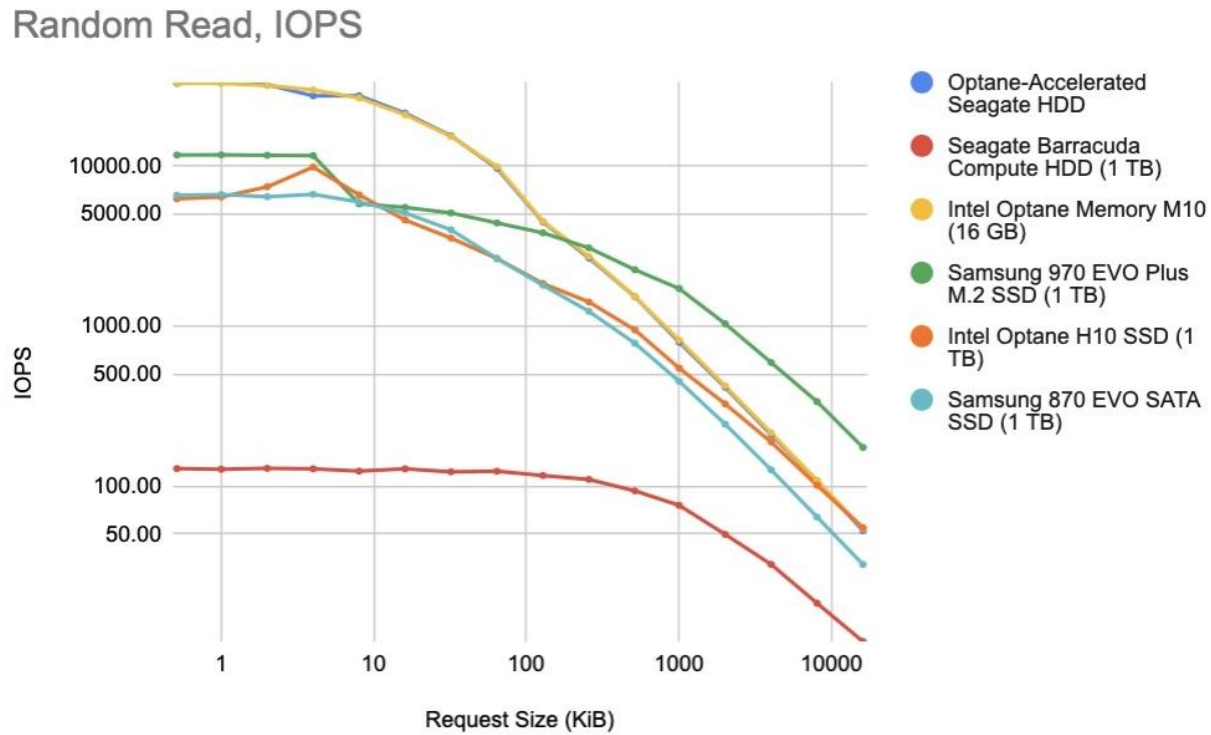
Random Read

IOPS


Random Read, IOPS
10000.00
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1000.00
500.00
100.00
50.00
IOPS
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10
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10000
Request Size (KiB)
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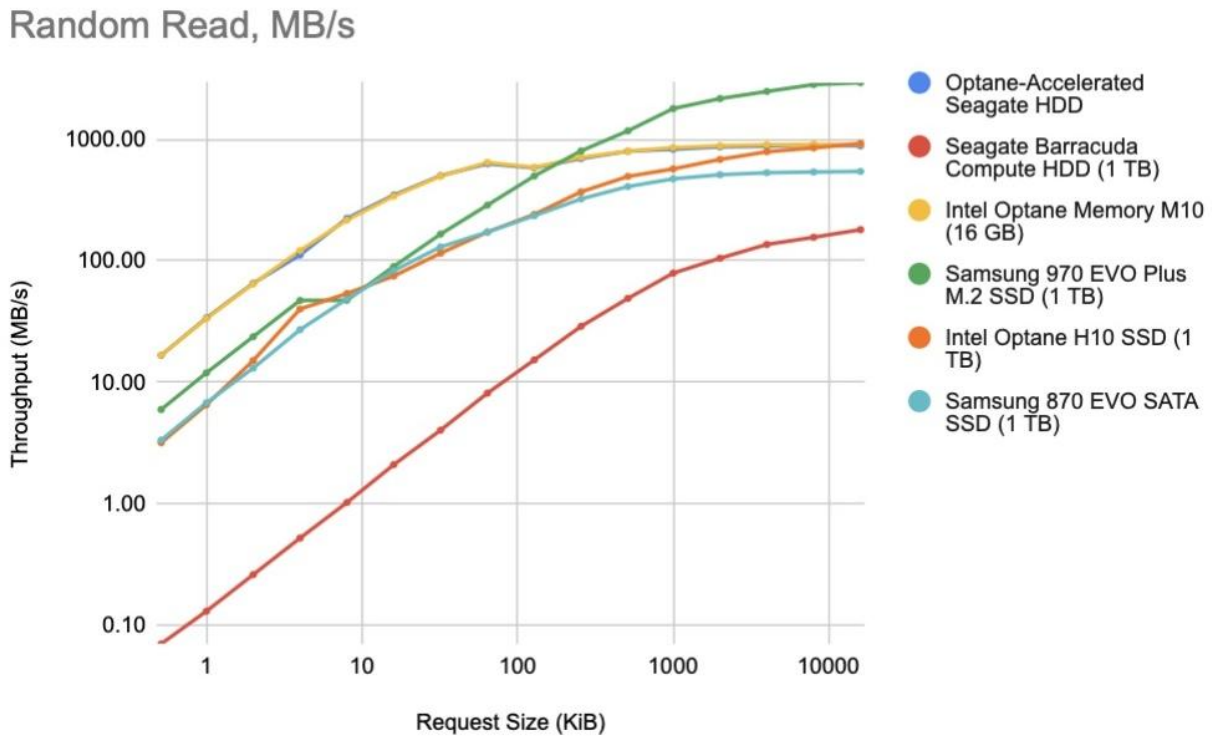
MB/s


Random Read, MB/s
Throughput (MB/s)
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10.00
1.00
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10000
Request Size (KiB)
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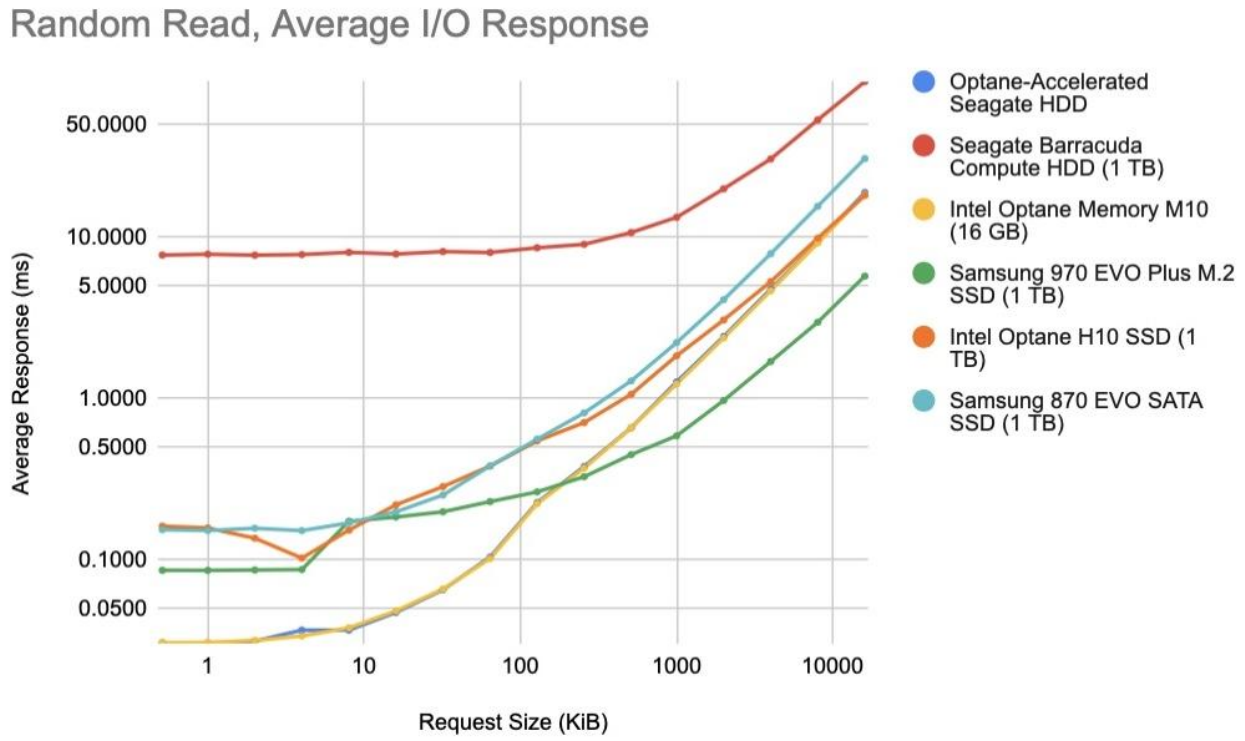
Latency


Random Read, Average I/O Response
Average Response (ms)
50.0000
10.0000
5.0000
1.0000
0.5000
0.1000
0.0500
1
10
100
1000
10000
Request Size (KiB)
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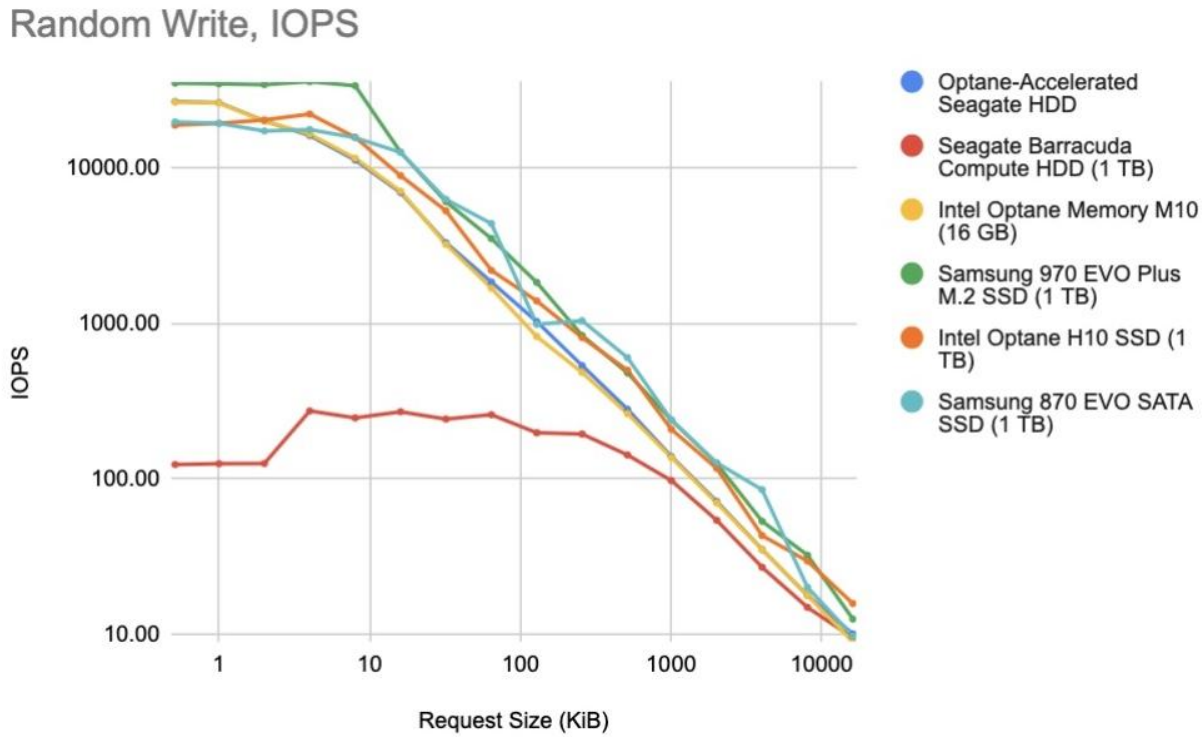
Random Write

IOPS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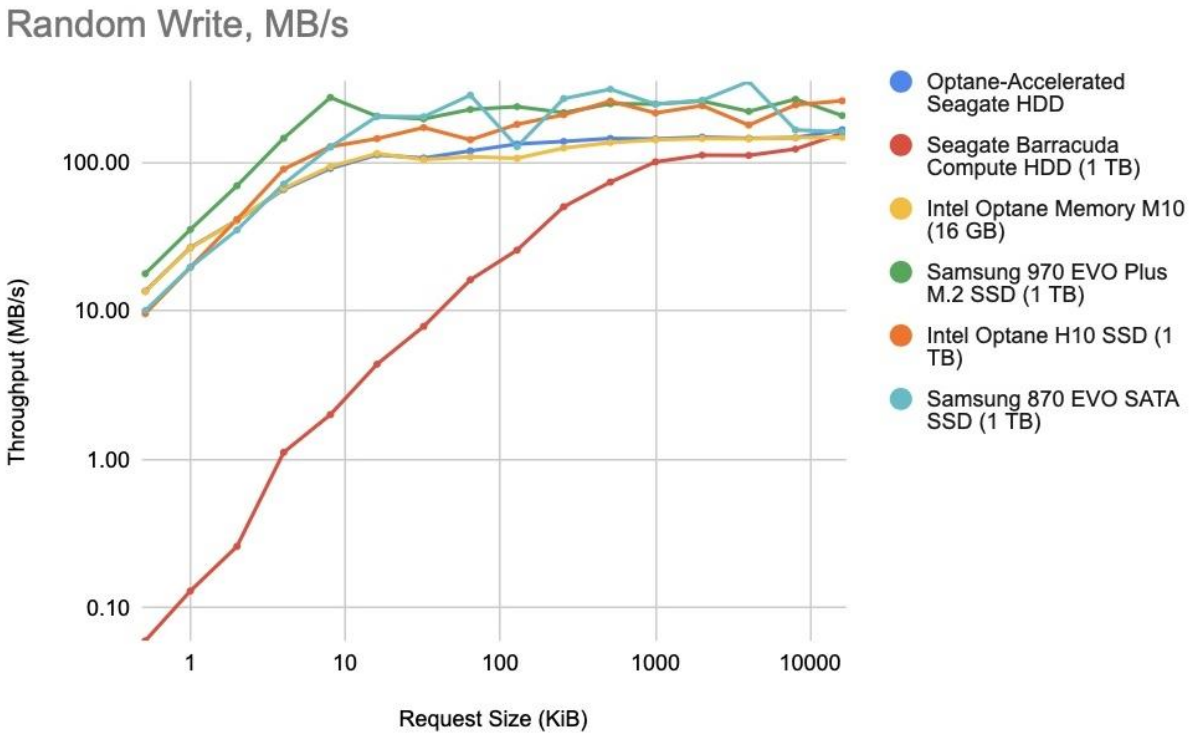
MB/s


Random Write, MB/s
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10.00
1.00
0.10
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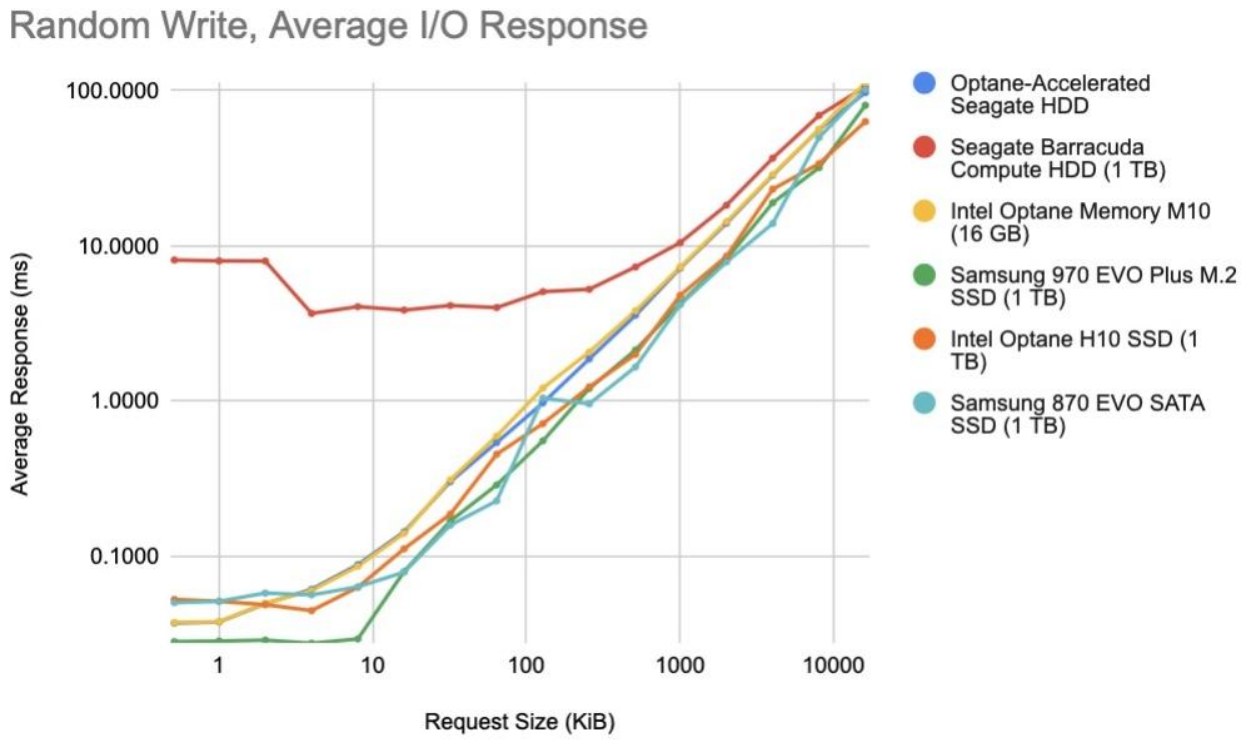
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1.0000
0.1000
Average Response (ms)
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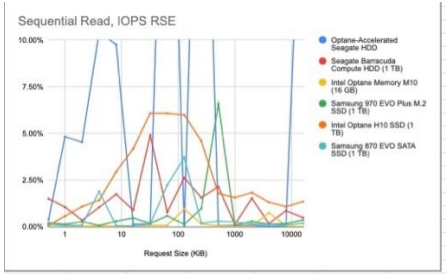
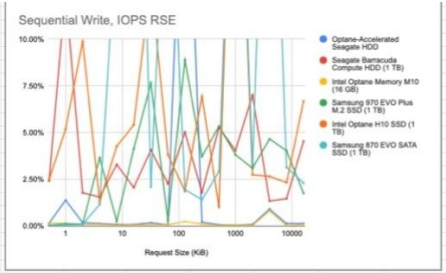
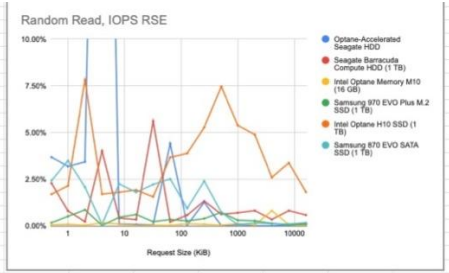
Relative Standard Error

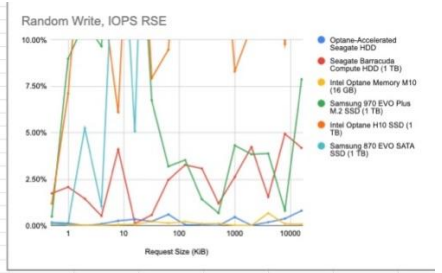
RSE

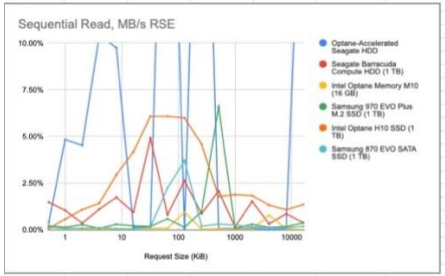
Takeaway: Optane device offered much more stability in performance than any other device

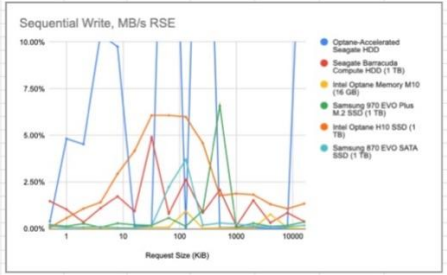


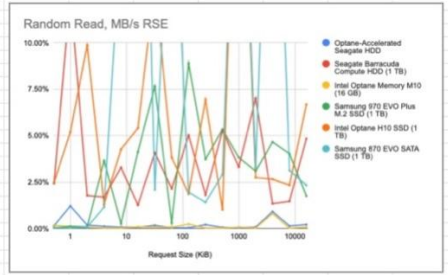


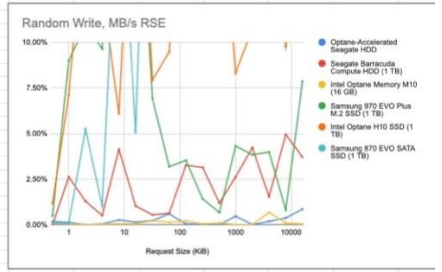


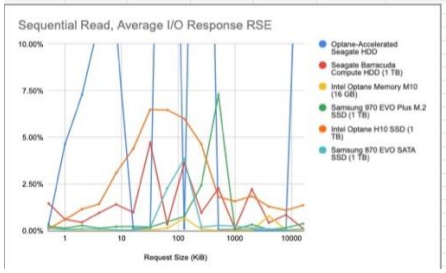


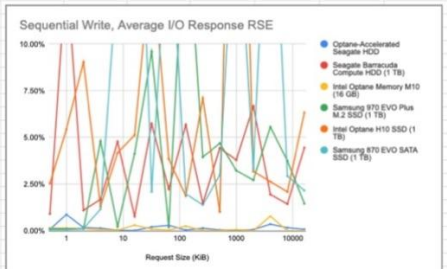


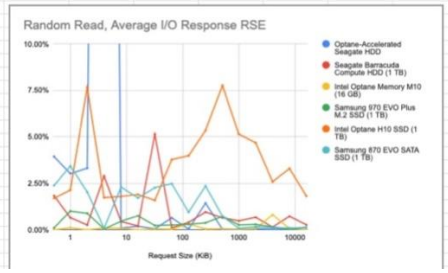


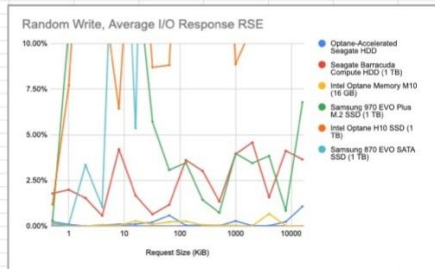












Power Consumption Data

Procedure

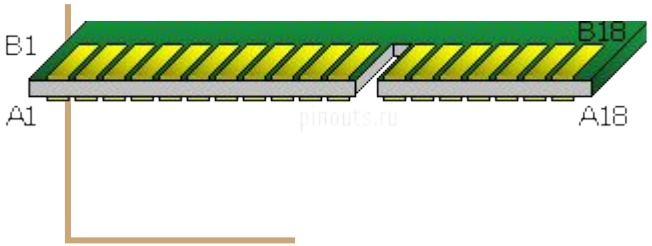
-found the corresponding voltage power lines

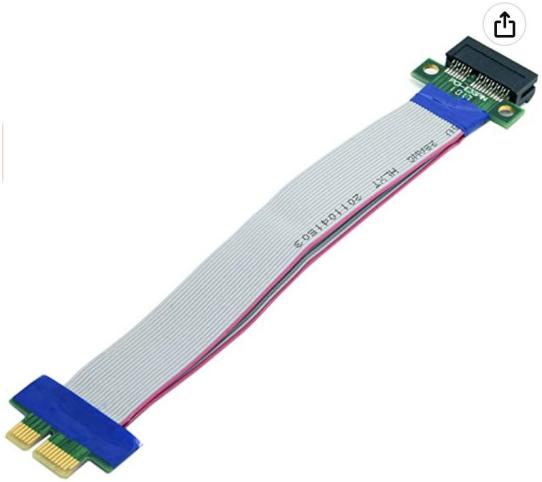
-discovered that the 12V power lines had no current

-cut open corresponding wires on riser cable

-connected to 10 Ohm resistor

-measured Voltage





Pin	Side B Connector		Side A Connector	
#	Name	Description	Name	Description
1	+12v	+12 volt power	PRSNT#1	Hot plug presence detect
2	+12v	+12 volt power	+12v	+12 volt power
3	+12v	+12 volt power	+12v	+12 volt power
4	GND	Ground	GND	Ground
5	SMCLK	SMBus clock	JTAG2	TCK
6	SMDAT	SMBus data	JTAG3	TDI
7	GND	Ground	JTAG4	TDO
8	+3.3v	+3.3 volt power	JTAG5	TMS
9	JTAG1	+TRST#	+3.3v	+3.3 volt power
10	3.3Vaux	3.3v volt power	+3.3v	+3.3 volt power
11	WAKE#	Link Reactivation	PERST#	PCI-Express Reset signal
Mechanical Key				
12	RSVD	Reserved	GND	Ground
13	GND	Ground	REFCLK+	Reference Clock Differential pair
14	HSOp(0)	Transmitter Lane 0, Differential pair	REFCLK-	
15	HSOn(0)		GND	Ground
16	GND	Ground	HSIp(0)	Receiver Lane 0, Differential pair
17	PRSNT#2	Hotplug detect	HSIn(0)	
18	GND	Ground	GND	Ground

Results

- Measured across Wire 9 on Side A

Settings	Voltage	Power
Idle	7.6 mV	2.508 mW
Read	22.5 mV +- 2 mV	7.425 mW
Write	30 mV +- 5 mV	9.9 mW

$I_{measured} = V_{measured} / (10\ \Omega)$

$P = (3.3\ V) (I_{measured})$

NOTE: I was only able to measure across one of the four power wires

Limitations of Phase Change Memory

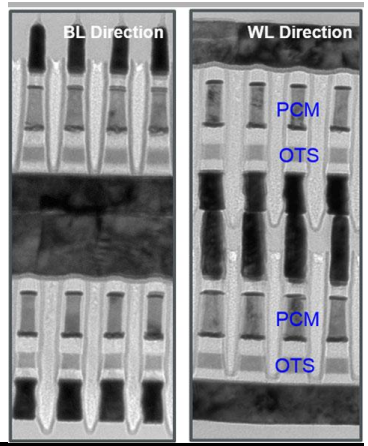
How Does Optane Operate Under Non-Ideal Conditions

Three Main Questions

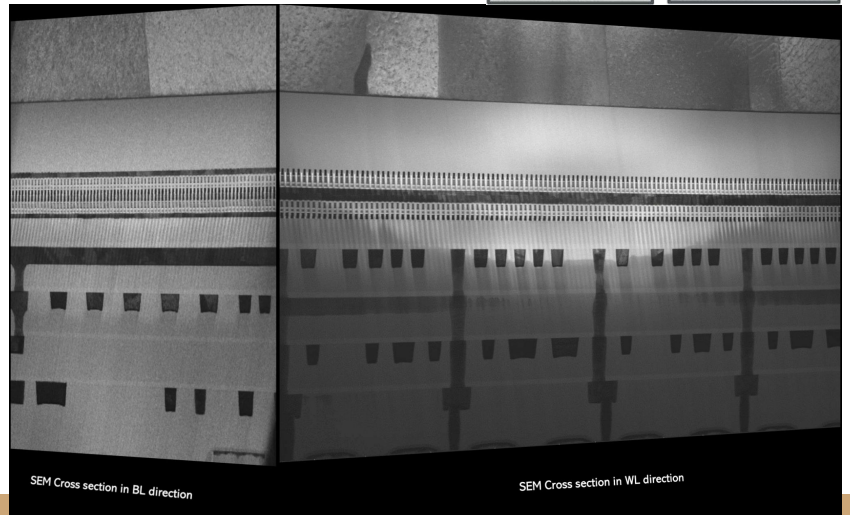
- How does the Chip Breakdown?
- When does the Chip Breakdown?
- Why is this Information Important?

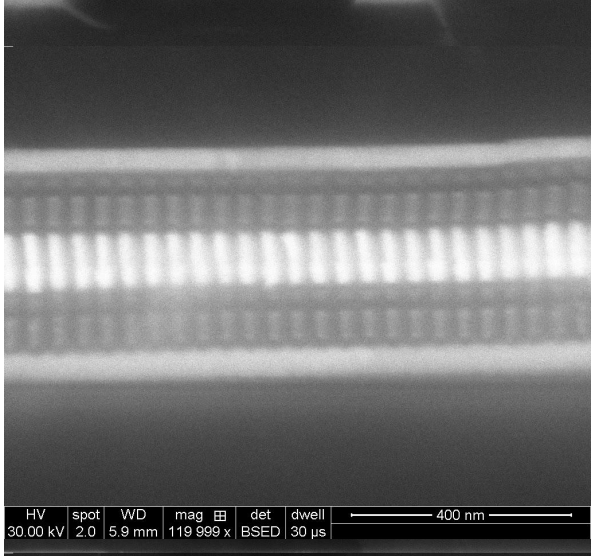
How Does Intel Optane Breakdown?

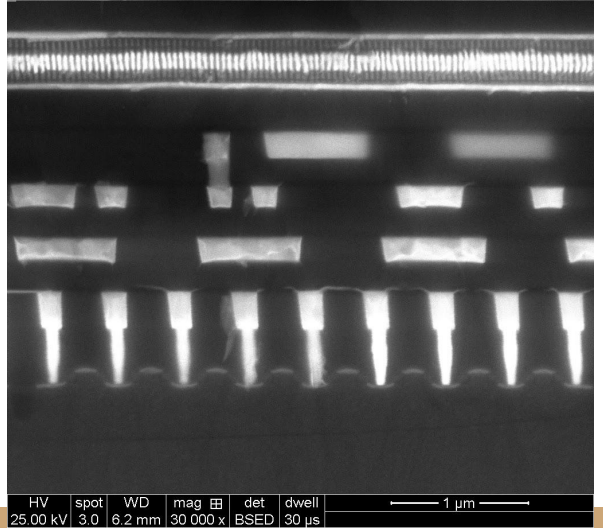
Cell Structure →



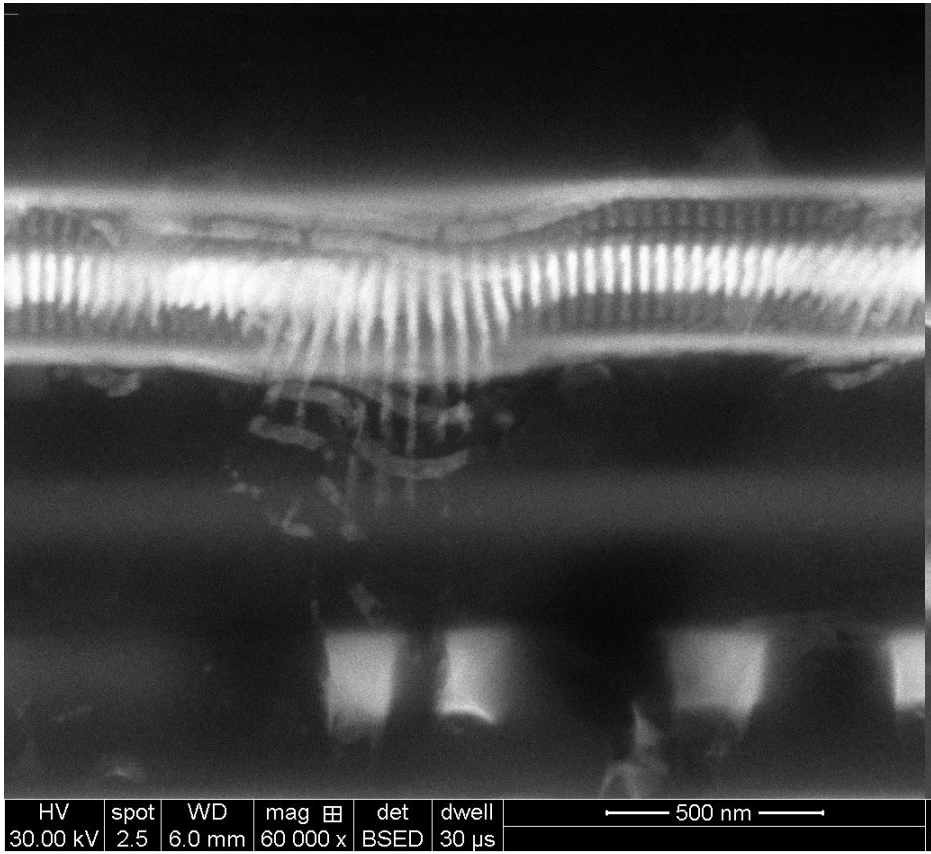
Overall Structure ↓

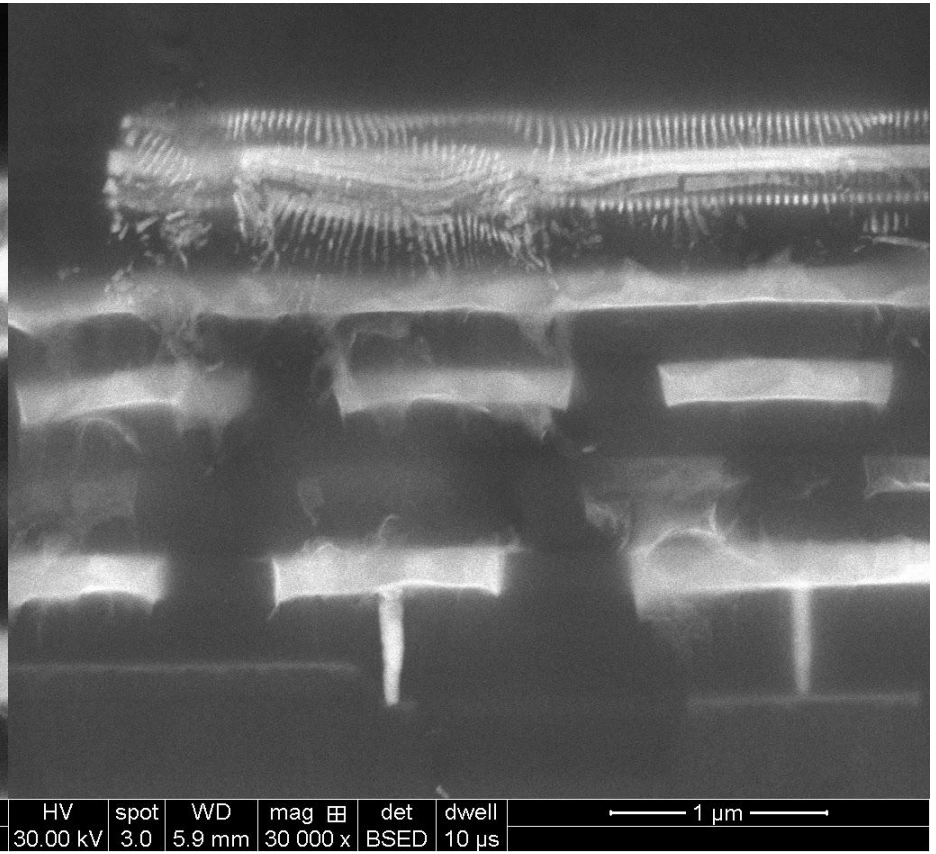




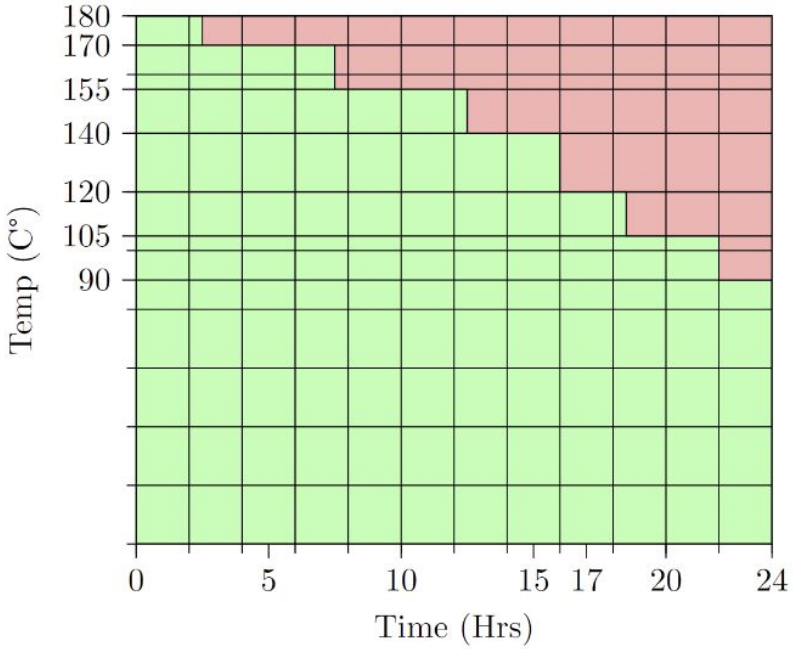


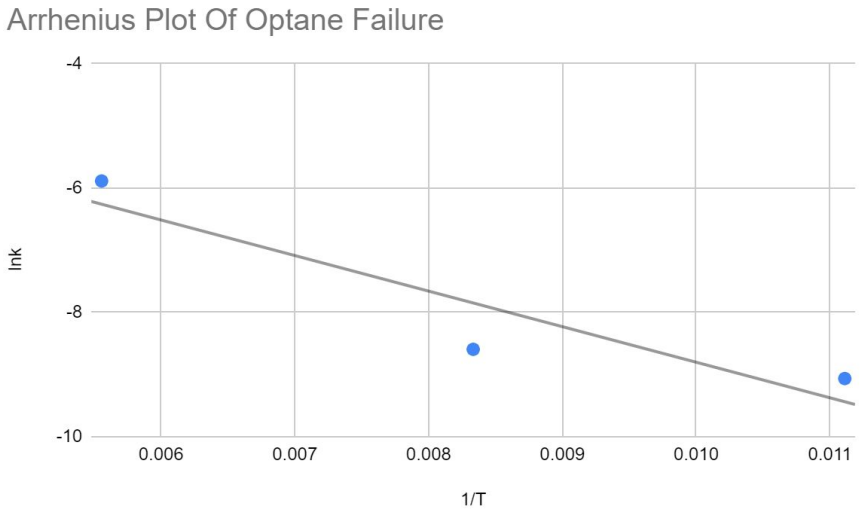
How Does Intel Optane Breakdown?





When Does Intel Optane Breakdown?





Non-GAAP adjustment or measure	Definition	Usefulness to management and investors
Optane inventory impairment	In Q2 2022, we initiated the winding down of our Intel Optane memory business.	We exclude these impairments for purposes of calculating certain non-GAAP measures because these charges do not reflect our current operating performance. This adjustment facilitates a useful evaluation of our current operating performance and comparisons to past operating results.

(Image credit: Intel)

“The company will not develop any further generations, instead now taking a $559m inventory write-off”

Relevance of Optane Failure

- Not competitive (under ideal conditions)
  - Intel shut it down after millions of dollars and decades of time
  - Its slow (1 orders of magnitude slower)
  - Its high power (another 2 orders of magnitude higher)
- What happens when pushing it into conditions other memories don’t want to go to
  - Theoretically could survive higher temperatures especially because can change crystallization temp of phase change material
  - If it could, would save data centers a lot of money in cooling power
    - Currently can’t
  - Space, Cars

Next Steps

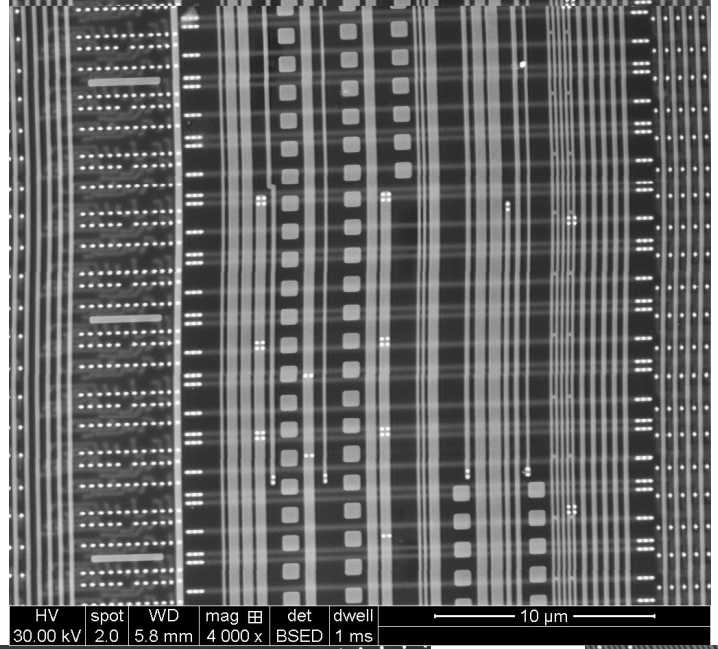
Next Steps

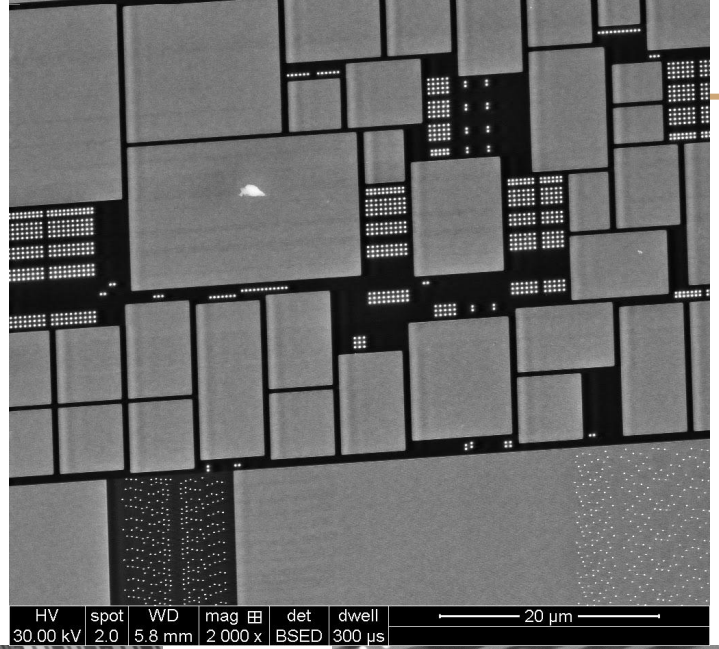
- Collect data from Optane/SATA SSD accelerated setup
  - Expect to have similar data as Optane/HDD accelerated setup, maybe similar to Optane SSD data
- Design PCB testing board with current-sense amplifiers for more accurate power consumption measurements (started, not finished)
- Get the development board
- Find failure points to know mean error time at a given temperature

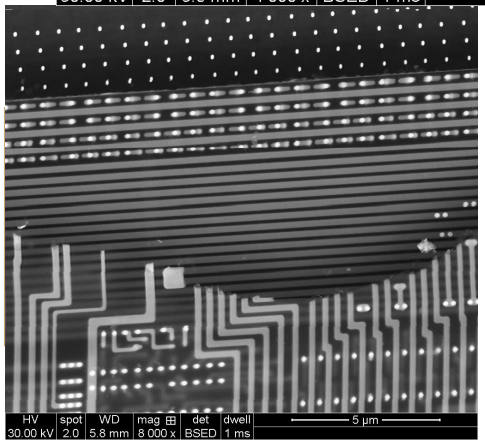
Questions?

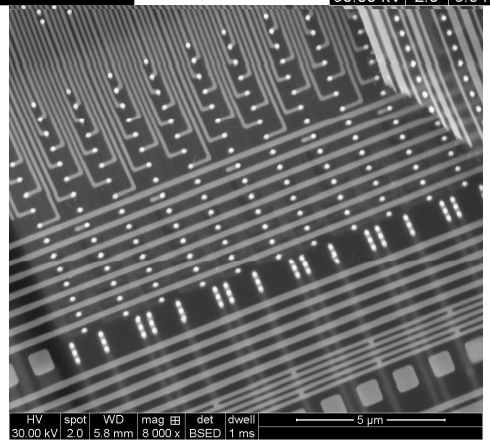
Thank You For Our Instructive Summer!

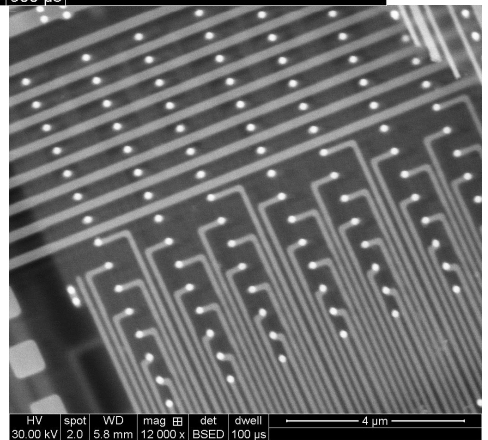
SEM Images


HV
30.00 kV
spot
2.0
WD
5.8 mm
mag
4 000 x
det
BSED
dwell
1 ms
10 µm


HV
30.00 kV
spot
2.0
WD
5.8 mm
mag
2 000 x
det
BSED
dwell
300 µs
20 µm


HV
30.00 kV
spot
2.0
WD
5.8 mm
mag
8 000 x
det
BSED
dwell
1 ms
5 µm


HV
30.00 kV
spot
2.0
WD
5.8 mm
mag
8 000 x
det
BSED
dwell
1 ms
5 µm


HV
30.00 kV
spot
2.0
WD
5.8 mm
mag
12 000 x
det
BSED
dwell
100 µs
4 µm