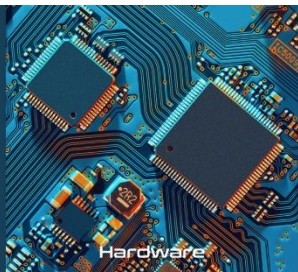


EDGE AI: Innovations in Flash and DRAM

Dominique van Doorn

Senior Sales Channel Manager – Innodisk Europe

D&E
EVENT



Het ontwerpen van
innovatieve elektronica

Woensdag 20 maart 2024
1931 Congrescentrum 's-Hertogenbosch

Agenda

- **Quick Intro**
- **Deep dive into Form Factors for Flash (E1.S + M.2)**
 - Performance
 - Density
 - Thermal design (1U Storage server + Fanless BoxPC)
- **iSLC (Pseudo SLC) technology for Flash**
 - Endurance benefits
 - DRAM usage
- **DRAM for Challenging environments**
 - 1st grade factory die
 - Ultra wide temperature specs
 - Very Low Profile UDIMM with ECC
 - DDR5 customizations
- **Q&A Session**

The banner features the **innodisk** logo in a red box at the top left. To its right is the **TELEREX** logo with the tagline "THE SAFEST CHOICE" above it. Below these logos is a horizontal strip of images showing people working in a technical environment. The text "D&E EVENT" is on the left, and "Het ontwerpen van innovatieve elektronica" is on the right. At the bottom, the date and location are listed: "Woensdag 20 maart 2024" and "1931 Congrescentrum 's-Hertogenbosch".

Quick Intro Dominique + Innodisk / Telerex



14 years active in Industrial Automation

From sensor to systems with a touch of AI 😊

- Isotron Systems – 's-Hertogenbosch
- Advantech Europe – Eindhoven
- Scailable, AI startup – Eindhoven
- Innodisk Europe - Eindhoven

Innodisk AIoT

A Global AIoT Solutions Provider

Pioneering the development of AIoT solutions by integrating its software and hardware technologies, Innodisk aims to cooperate with global partners to build an intelligent world.

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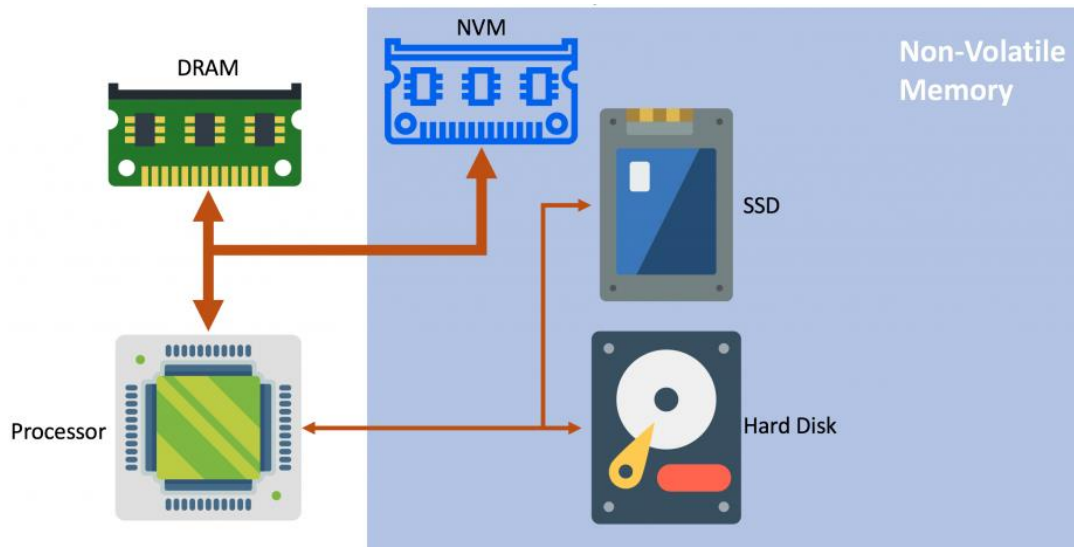
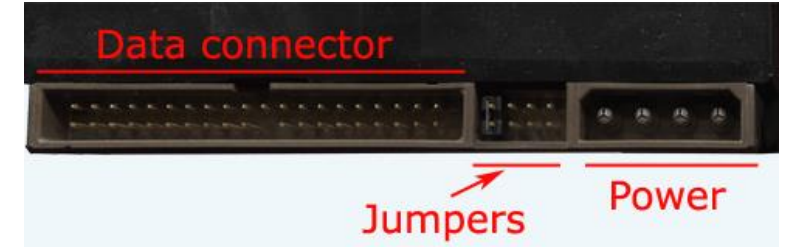
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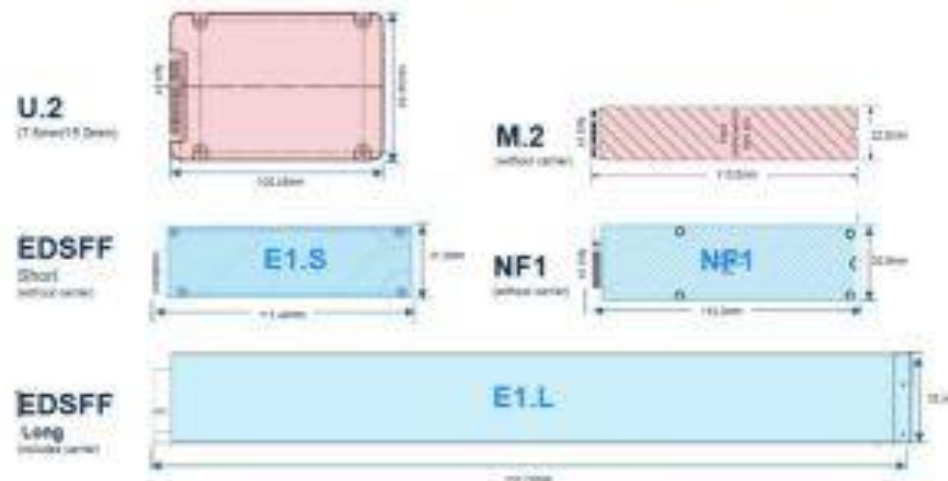
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Deep dive into Form Factors for Flash

- Former Connectors: Pata / IDE, still used in legacy 80x86 systems.
- Current (most used) Connectors: Sata - Already different form factors: 2.5" and M.2
- New and upcoming NVMe



NVMe Form Factor Comparison



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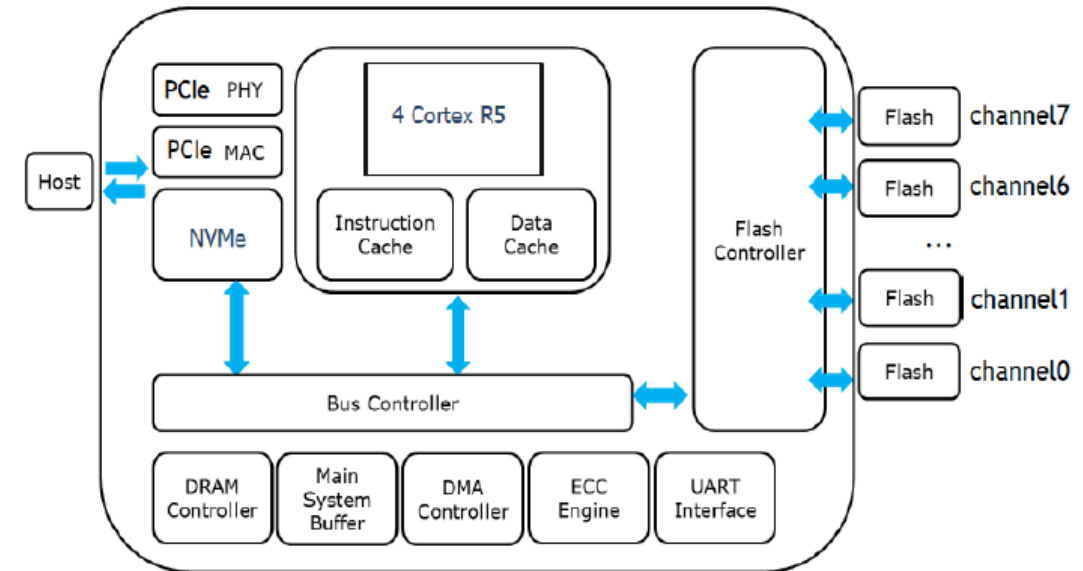
Deep dive into Form Factors for Flash

Performance – IOPS

Table 2: Performance - 112 layers 3D TLC

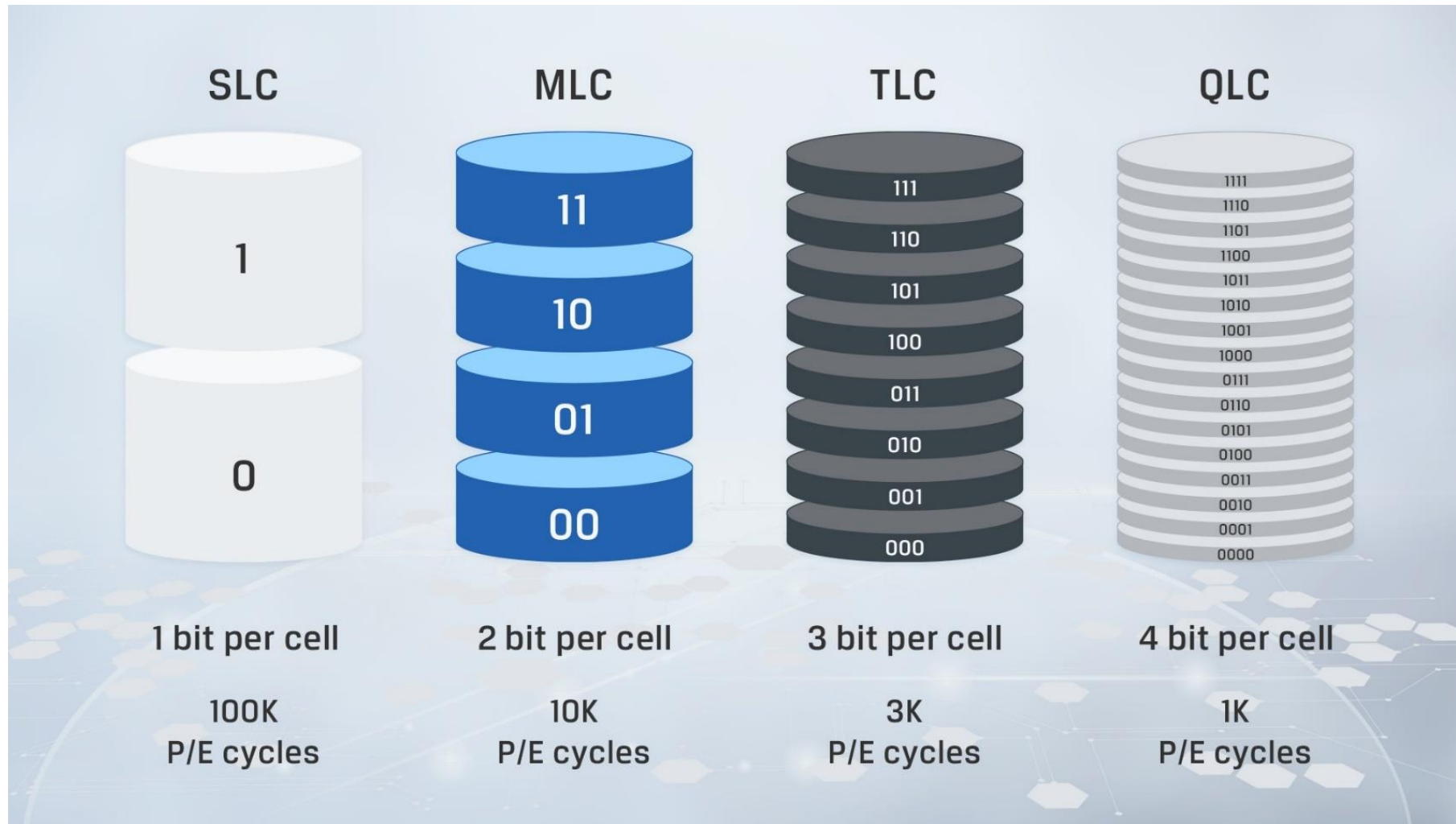
Capacity	Unit	512GB	1TB	2TB	4TB	8TB
Sequential** Read (Q8T1)	MB/s	5,700	6,950	6,650	6,650	6,400
Sequential** Write (Q8T1)		2,250	4,150	4,950	4,950	4,800
Sustained Sequential Read (Avg.)***		1,950	2,450	1,650	2,300	2,000
Sustained Sequential Write (Avg.)***		450	850	2,200	1,750	1,400
4KB Random** Read (Q32T16)	IOPS	478,000	815,000	815,000	821,000	819,000
4KB Random** Write (Q32T16)		594,000	695,000	708,000	722,000	712,000

* IOPS × TransferSizeInBytes = BytesPerSec

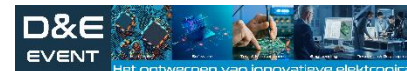


Deep dive into Form Factors for Flash

Endurance – P/E Cycles



[https://www.kingston.com/en/blog/pc-performance/difference-between-slc-mlc-tlc-3d-nand.](https://www.kingston.com/en/blog/pc-performance/difference-between-slc-mlc-tlc-3d-nand)



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Deep dive into Form Factors for Flash

Reliability – TBW

TBW* (Total Bytes Written) Unit: TB		
Capacity	Sequential workload	Client workload
512GB	1,363	703
1TB	2,727	1,636
2TB	5,545	3,958
4TB	10,908	7,904
8TB	21,816	16,246

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Woensdag 20 maart 2024
1931 Congressentrum 's-Hertogenbosch

Deep dive into Form Factors for Flash

Reliability – DWPD

DWPD or **DW/D** - Drive Writes Per Day.

GB/day - Gigabytes written per day.

TBW - Total Bytes Written, usually expressed in terabytes - TBW (TB) or petabytes - TBW (PB).

Given **S** - disk capacity in GB and **T** - warranty / useful life period in years, conversion between different SSD endurance specifications can be performed as follows:

$$DWPD = GB/day \div S$$

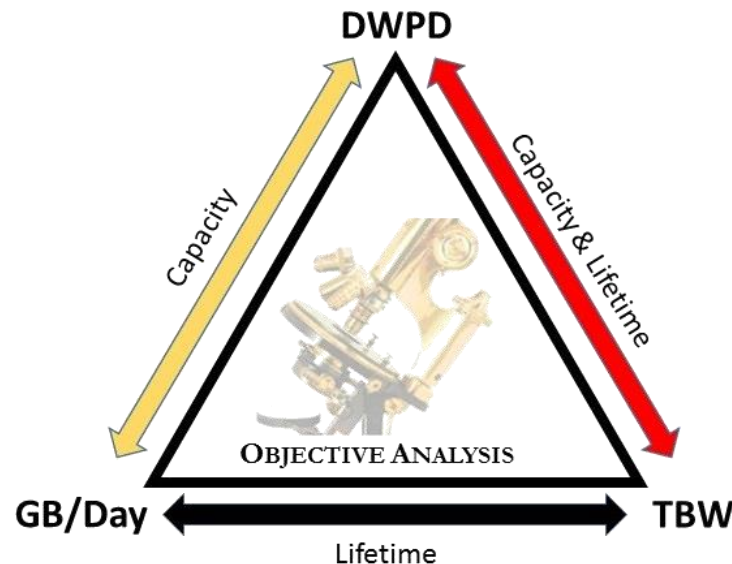
$$DWPD = (TBW_{(TB)} \times 1000) \div (S \times T \times 365)$$

$$GB/day = DWPD \times S$$

$$GB/day = (TBW_{(TB)} \times 1000) \div (T \times 365)$$

$$TBW_{(TB)} = (DWPD \times S \times T \times 365) \div 1000$$

$$TBW_{(TB)} = (GB/day \times T \times 365) \div 1000$$



Capacity	TBW	DWPD
512GB	703	1.4
1TB	1,636	1.7
2TB	3,958	2.0
4TB	7,904	2.0
8TB	16,246	2.1

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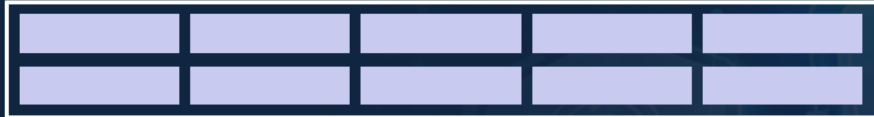
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Deep dive into Form Factors for Flash

- *Density + Thermal 1U server*

SSD Density Comparison (1U Server)



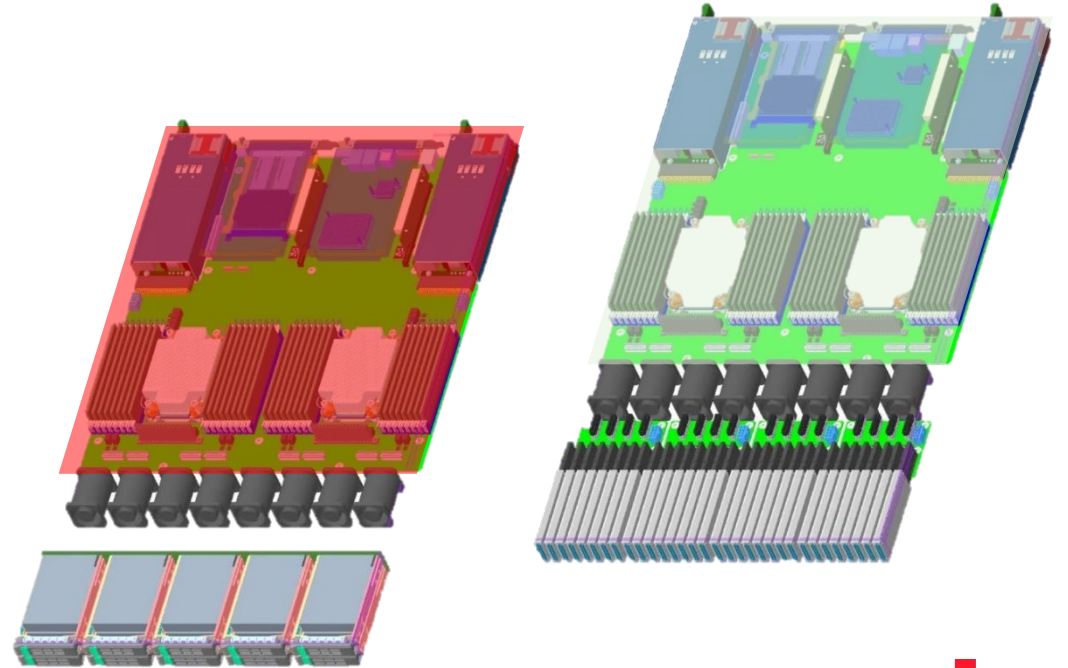
2.5" SSD x10



E1.S 15mm x24



E1.S 9.5mm x32



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Woensdag 20 maart 2024
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Deep dive into Form Factors for Flash

■ Thermal Design / Power Consumption Fanless-BoxPC

Mode	Power Consumption (W)
Read (RMS) ¹	2.1
Write (RMS) ¹	2.0
Idle	1.0
Boot Up	5.5

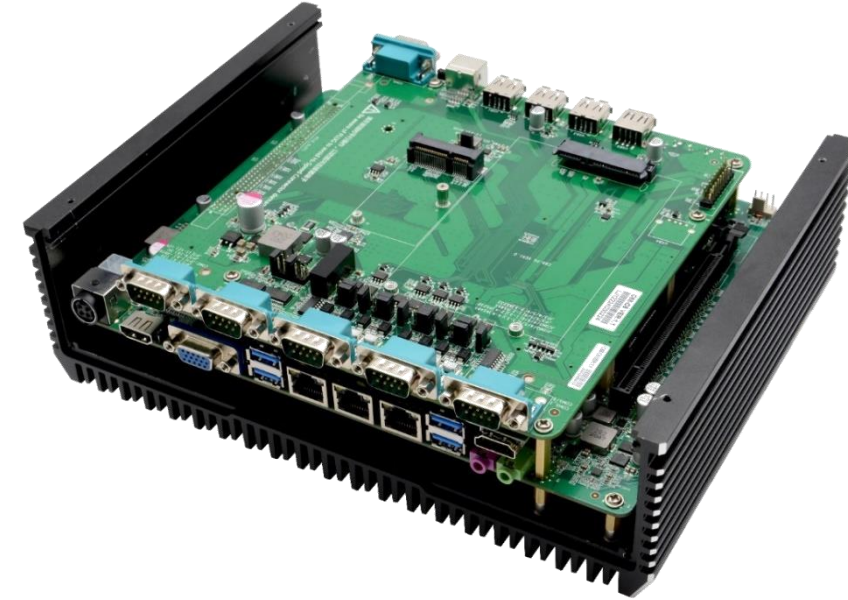
* Target: 2.5" SATA SSD 3TE7 2TB

Mode	Power Consumption (W)
Read	8.9
Write	7.2
Idle	2.4
Power-on peak	10.9

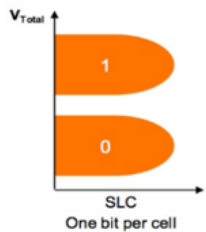
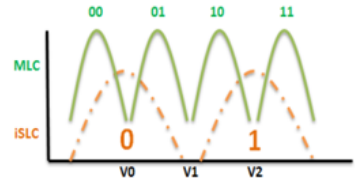
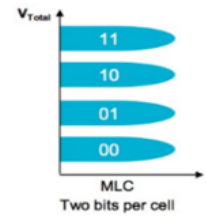
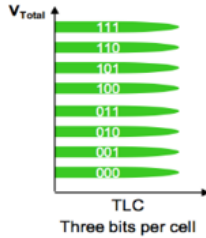
Target: 4TB M.2 (P80) 4TG2-P

Mode	Power Consumption (W)
Read	10.0
Write	10.9
Idle	2.8
Power on peak	15.4

Target: 4TB E1.S 4TG2-P



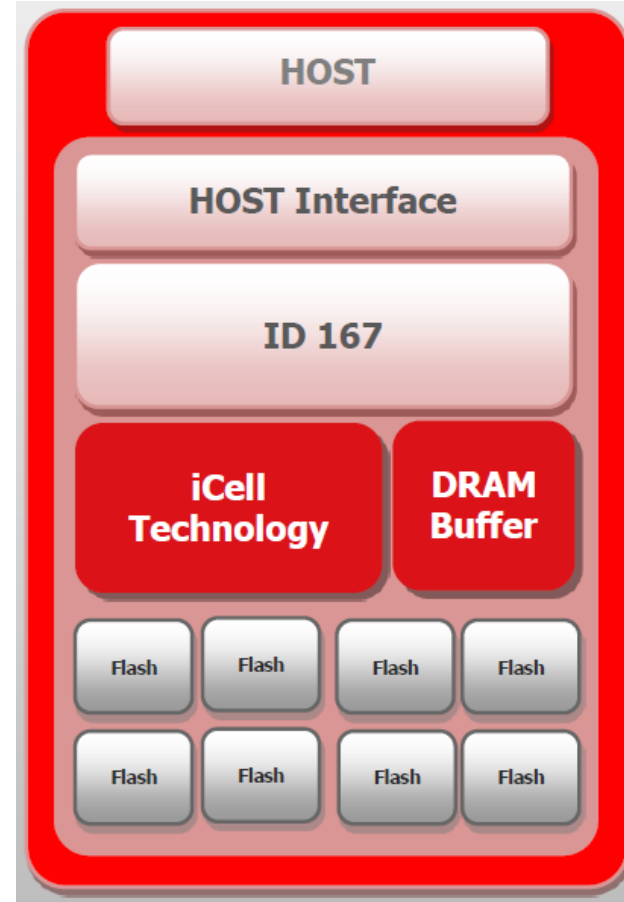
iSLC (Pseudo SLC) technology for Flash

Item	SLC Single Level Cell	iSLC Inno SLC mode	MLC Multi Level Cell	3D TLC Triple Level Cell						
Architecture	<p>SLC Flash has only two states: erased (empty) or programmed (full).</p>  <p>One bit per cell</p>	<p>Enhance iSLC, algorithm & Enhance ECC</p> 	<p>MLC Flash has four states: erased (empty), 1/3, 2/3, and programmed (full).</p>  <p>Two bits per cell</p>	<p>3D TLC Flash has eight states and multiple stacking layers.</p>  <p>Three bits per cell</p>						
Performance	★★★★★	★★★★★	★★★	★★						
ECC Requirement (per KB)	24 bit	<table border="1"> <tr> <td>MLC (2D NAND)</td> <td>TLC (3D NAND)</td> </tr> <tr> <td>40 bit</td> <td>120 bit</td> </tr> </table>	MLC (2D NAND)	TLC (3D NAND)	40 bit	120 bit	40 bit	120 bit		
MLC (2D NAND)	TLC (3D NAND)									
40 bit	120 bit									
Endurance (P/E Cycles)	60K	<table border="1"> <tr> <td>20K</td> <td>30K (100K*)</td> </tr> </table>	20K	30K (100K*)	3K	<table border="1"> <tr> <td>Industrial</td> <td>Enterprise</td> </tr> <tr> <td>3K</td> <td>10K</td> </tr> </table>	Industrial	Enterprise	3K	10K
20K	30K (100K*)									
Industrial	Enterprise									
3K	10K									
Data Retention @ Initial	10 Years	10 Years	10 Years	10 Years	5 Years					
Data Retention @ Life End	1 Year	1 Year	1 Year	1 Year	4 Month					
Density	3D TLC > iSLC(3D) = MLC > iSLC(2D) > SLC									



iSLC and capacitors (iCell) in Flash Technology

- *iSLC for better Endurance*
- *DRAM: Faster and more efficient*
- *Capacitors: Sudden shutdown of systems*



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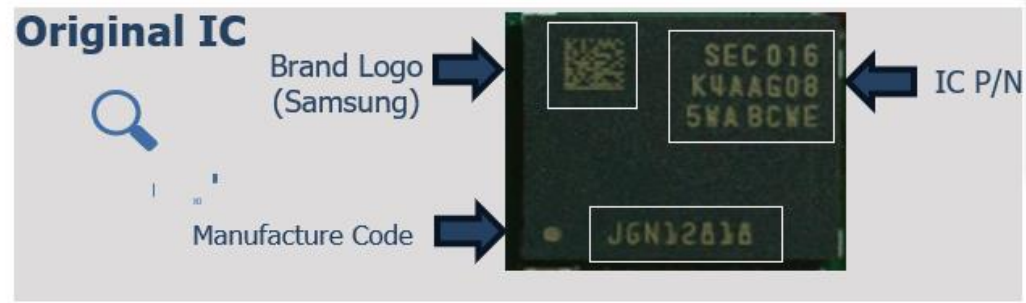
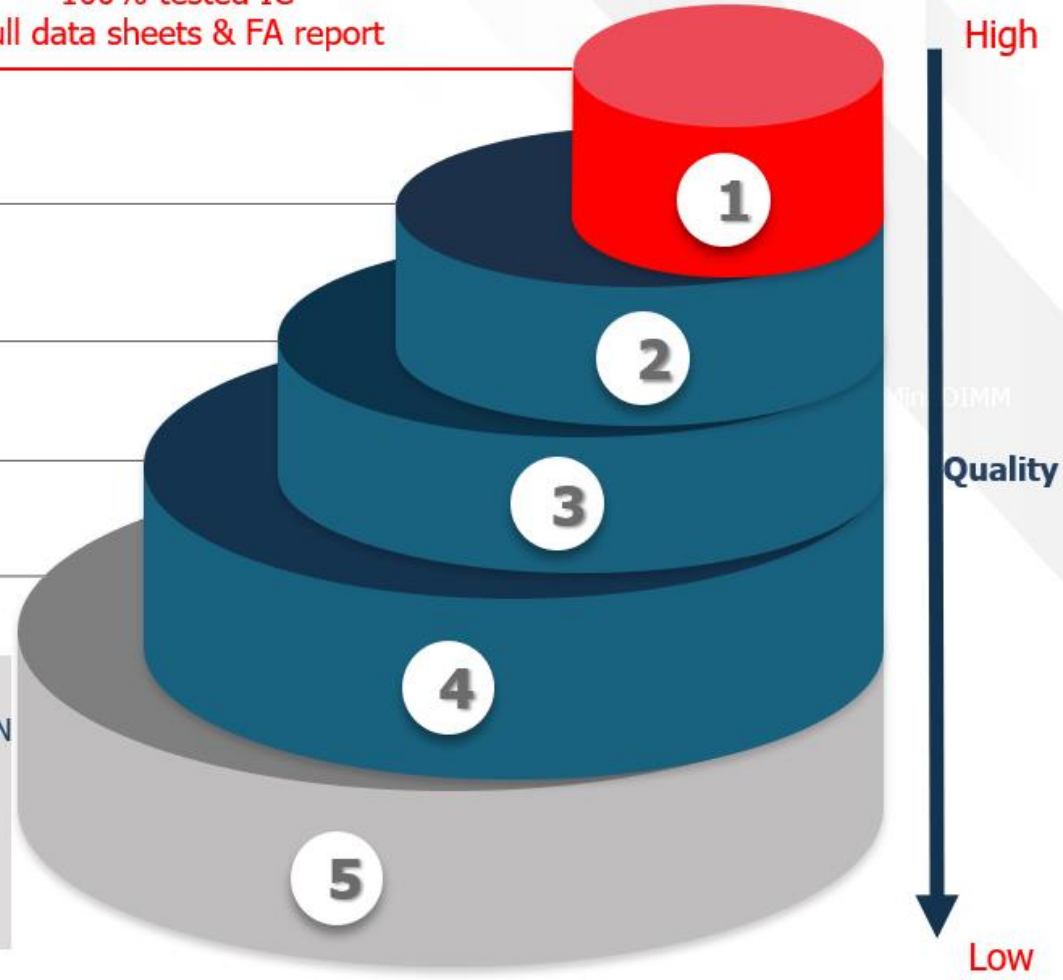
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1931 Congressentrum 's-Hertogenbosch

DRAM for Challenging environments

IC Brand Logo	Test	Specification	
😊	😊	😊	Original IC
☹️	☹️ <small>(NOT fully tested)</small>	😐	<u>eTT</u>
☹️	☹️ <small>(NOT tested)</small>	😐	<u>uTT</u>
☹️	☹️	☹️ <small>(Sorted out by NG items)</small>	FT
☹️	☹️	☹️	Down Grade

100% tested IC
Full data sheets & FA report



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Woensdag 20 maart 2024
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DRAM for Challenging environments

- *Ultra Temperature DRAM Modules offer robust performance in extreme conditions.*
- *Extensive operating temperature range of **-40** to **125 °C** for DDR4 and **-40** to **105 °C** for DDR5*



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Very Low Profile UDIMM with ECC

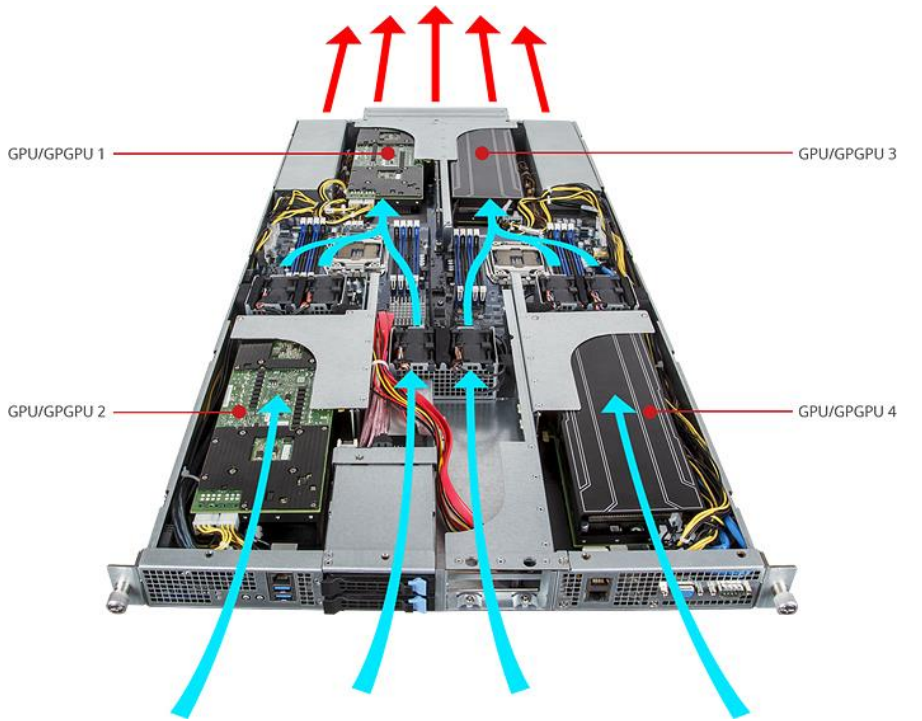
- *DDR4 UDIMM*



- *DDR4 VLP*



- *DDR4 VLP Mini*



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DDR5 customizations



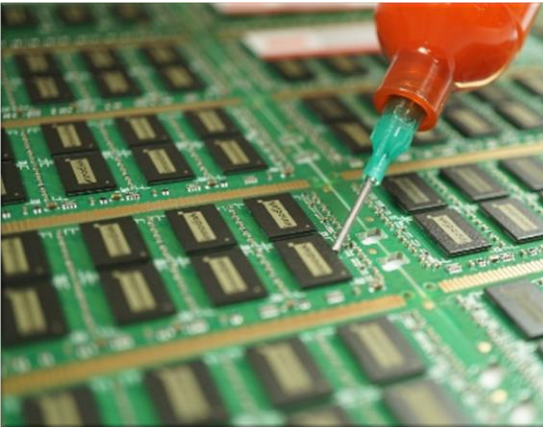
Anti-Sulfuration

Anti-sulfuration resists against sulfide



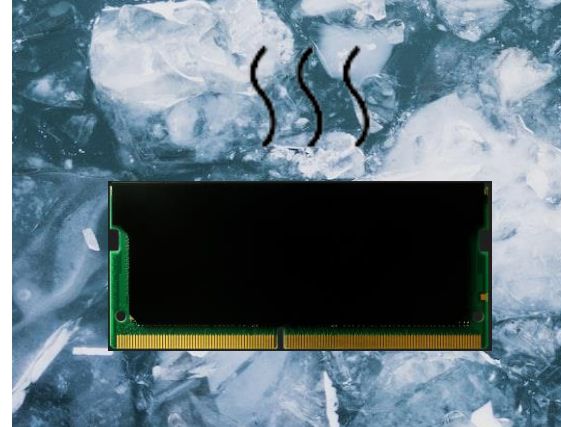
Automatic Conformal Coating

Against humidity, dust contaminants and chemicals



Side Fill

Better equipped for tough situations and thermal extension



Heat Spreader

2 solutions offered:
Aluminum (plate)
Carbon nanotube (sheet)

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Woensdag 20 maart 2024
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Q&A Session

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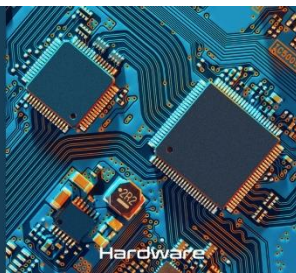
Innodisk Europe B.V.
Pisanostraat 57, Eindhoven

Dominique_van_Doorn@innodisk.com



SCAN FOR LINKEDIN

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Hardware



Software



Test & Measurement



Engineering



Research & Development

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