The Keys to Next Generation NAND Interface Technology

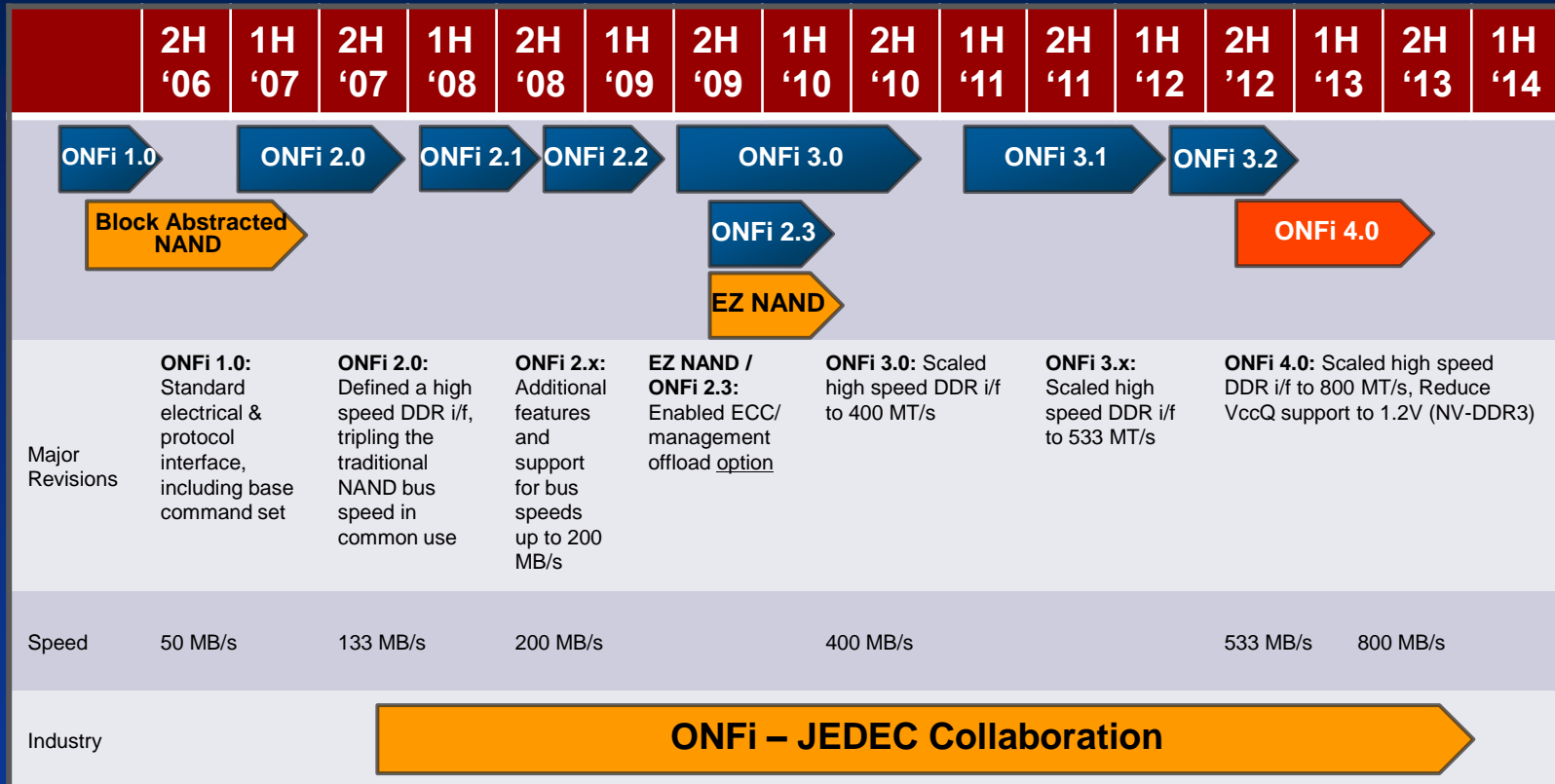## Terry Grunzke

Micron Technology

ONFI Specification History

- ONFI formed May 2006
- ONFI 1.0 release December 2006
- ONFI 2.0 release February 2008
- ONFI 2.1 release January 2009
- ONFI 2.2 release October 2009
- ONFI 2.3 release August 2010
- ONFI 3.0 release March 2011
- ONFI 3.1 release September 2012
- ONFI 3.2 release June 2013
- ONFI 4.0 under development

ONFI Workgroup Continues To Produce Results!

	2H '06	1H '07	2H '07	1H '08	2H '08	1H '09	2H '09	1H '10	2H '10	1H '11	2H '11	1H '12	2H '12	1H '13	2H '13	1H '14
	ONFi 1.0		ONFi 2.0		ONFi 2.1	ONFi 2.2		ONFi 3.0			ONFi 3.1		ONFi 3.2			
		Block Abstracted NAND					ONFi 2.3						ONFi 4.0			
							EZ NAND									

Major Revisions	**ONFi 1.0:** Standard electrical & protocol interface, including base command set	**ONFi 2.0:** Defined a high speed DDR i/f, tripling the traditional NAND bus speed in common use	**ONFi 2.x:** Additional features and support for bus speeds up to 200 MB/s	**EZ NAND / ONFi 2.3:** Enabled ECC/ management offload option	**ONFi 3.0:** Scaled high speed DDR i/f to 400 MT/s	**ONFi 3.x:** Scaled high speed DDR i/f to 533 MT/s	**ONFi 4.0:** Scaled high speed DDR i/f to 800 MT/s, Reduce VccQ support to 1.2V (NV-DDR3)
Speed	50 MB/s	133 MB/s	200 MB/s		400 MB/s		533 MB/s 800 MB/s
Industry		**ONFi – JEDEC Collaboration**					

ONFi has and continues to deliver innovation & interoperability enabling faster NAND adoption

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ONFI 3.2 - Released June 2013

- Enabled 533 MT/s for NV-DDR2
  - Reduced latency
  - Improved sequential performance
- Introduced new 4 channel packages
  - Enables smaller SSD form factors
- Included several ECNs to improve specification
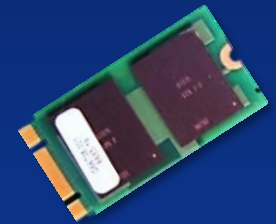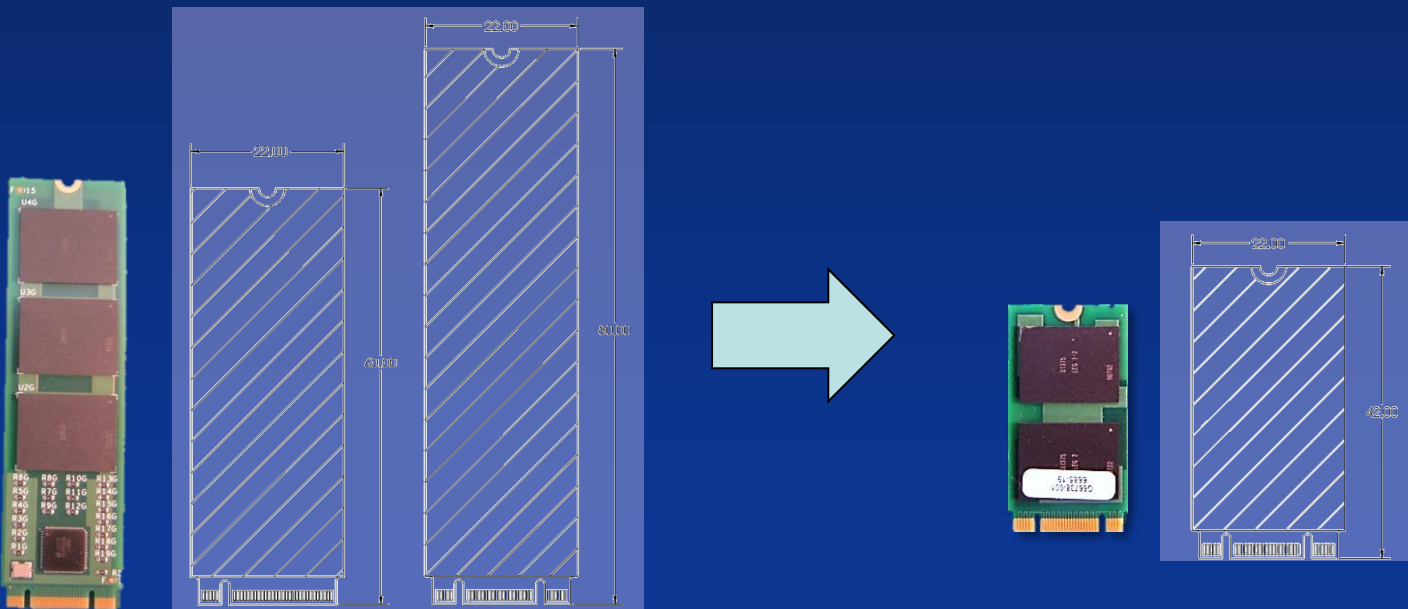
ONFI 3.2 NV-DDR2 I/O Performance
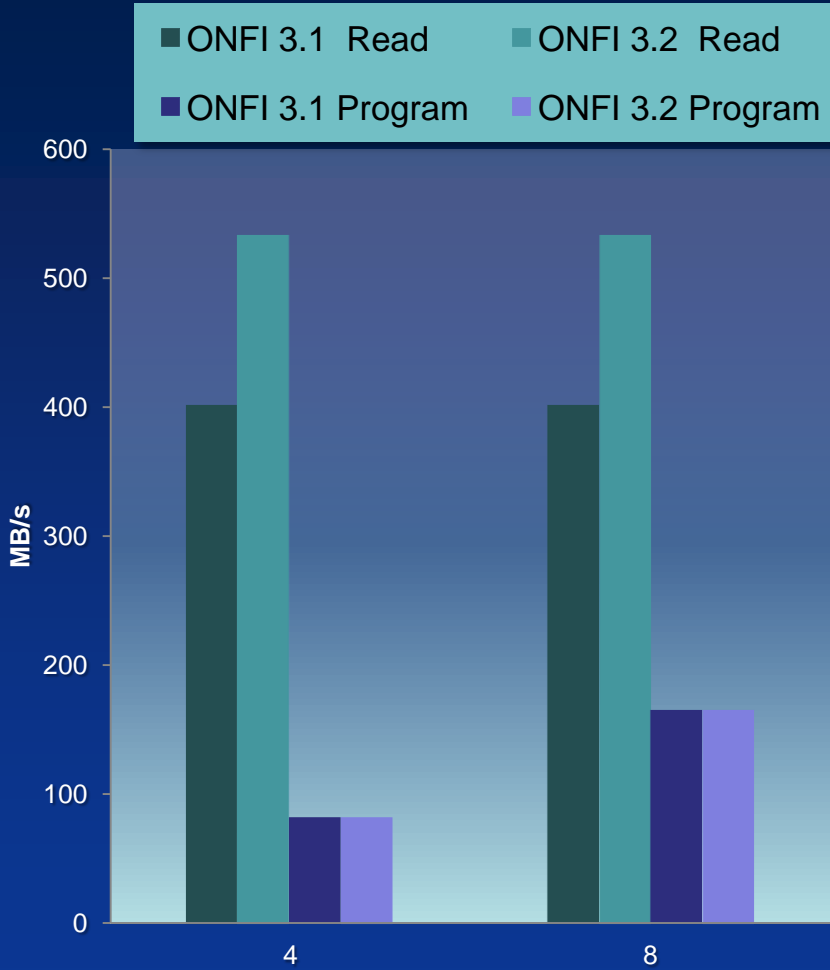
MLC performance with NAND die per channel

SLC performance with NAND die per channel

Legend: ONFI 3.1 Read, ONFI 3.2 Read, ONFI 3.1 Program, ONFI 3.2 Program
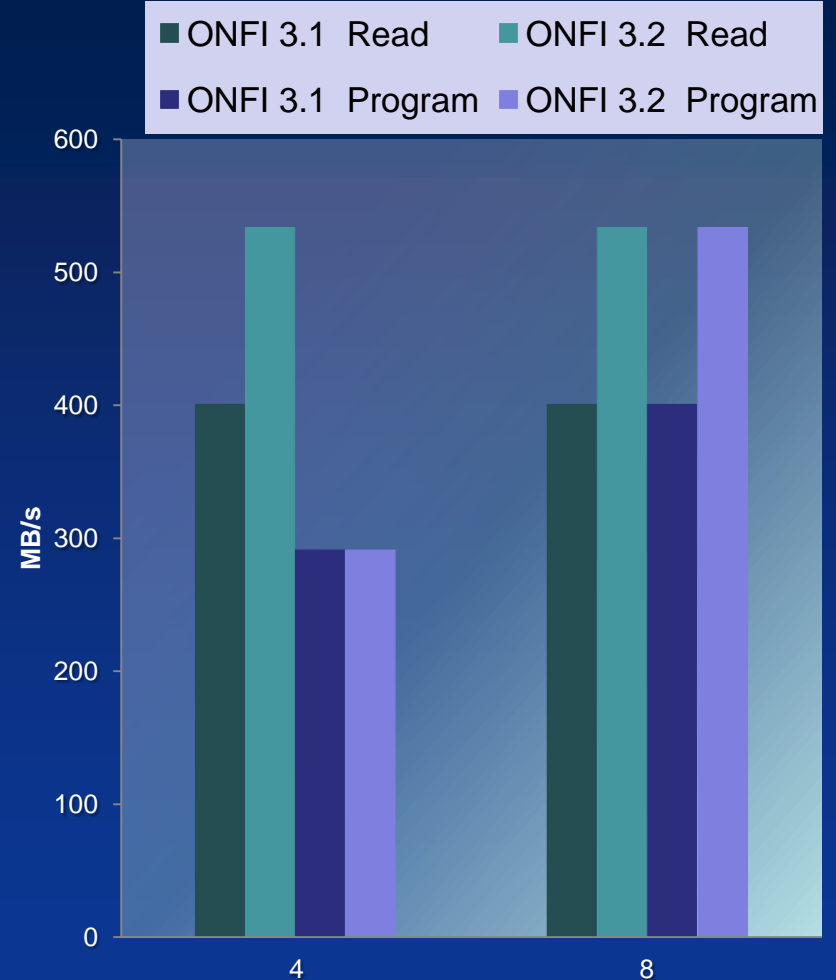
New Packages Enable Smaller SSD Form Factors

- **New 4 channel packages reduce number of required NAND packages**
  - **8 Channel controller 4 packages ➡ 2 packages**

Requirements for Next Generation

- Improve power I/O consumption
  - Lower I/O voltage
  - Reduced termination requirements
- Increase I/O performance
  - Scale I/O speeds faster as NAND page sizes grow
  - Soft data requirements
- Strive to achieve interoperability between vendors
 - Continue collaboration in JC42.4 ONFI/JEDEC Joint Task Group

ONFI 4.0 Coming Soon

- Evolutionary
  - Backwards compatible
- Faster I/O speeds
  - Up to 800 MT/s
- New features
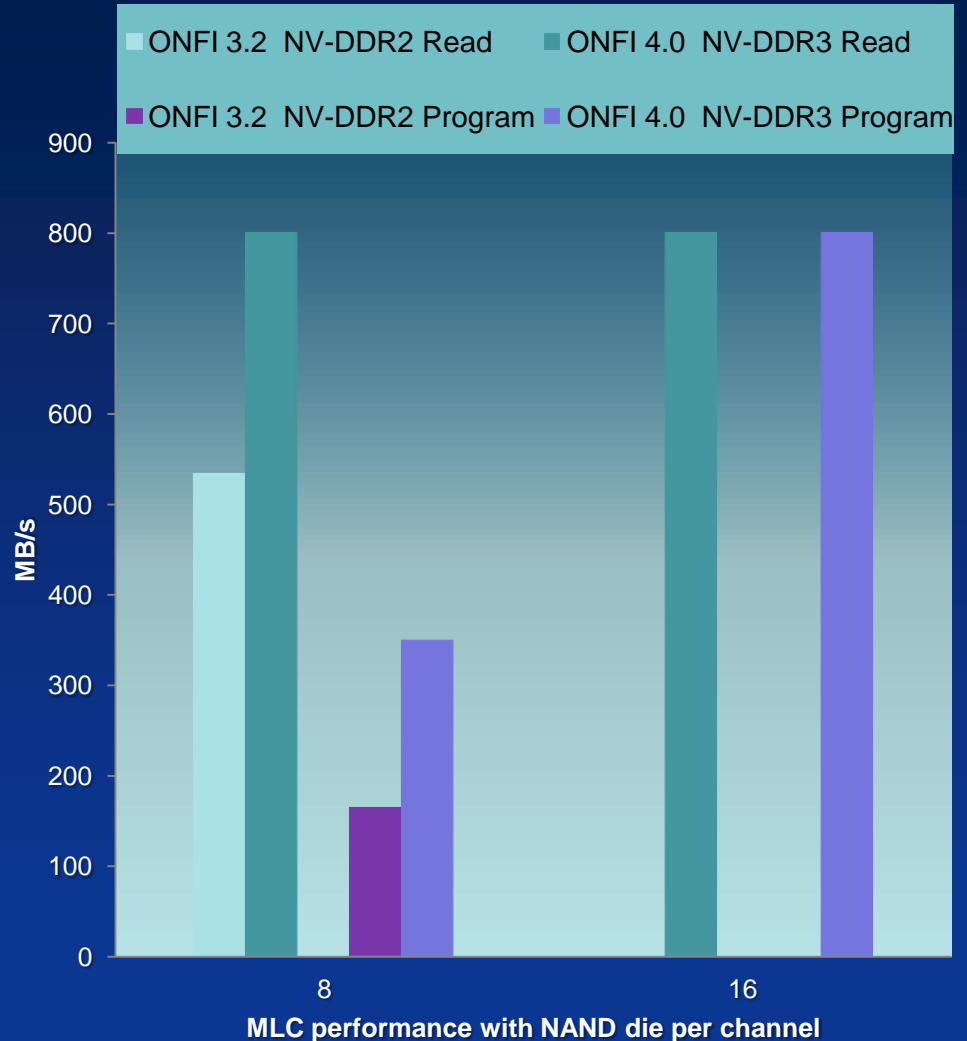 - ZQ calibration
- Reduced I/O voltage
  - 1.2V (NV-DDR3)

NAND I/O Channel is Diverse

- Short Channel: eMMC, USB, SD, uSD, etc
- Long Channel: SSDs (M.2, 2.5", HHHL, etc)
- Lightly loaded, heavily loaded
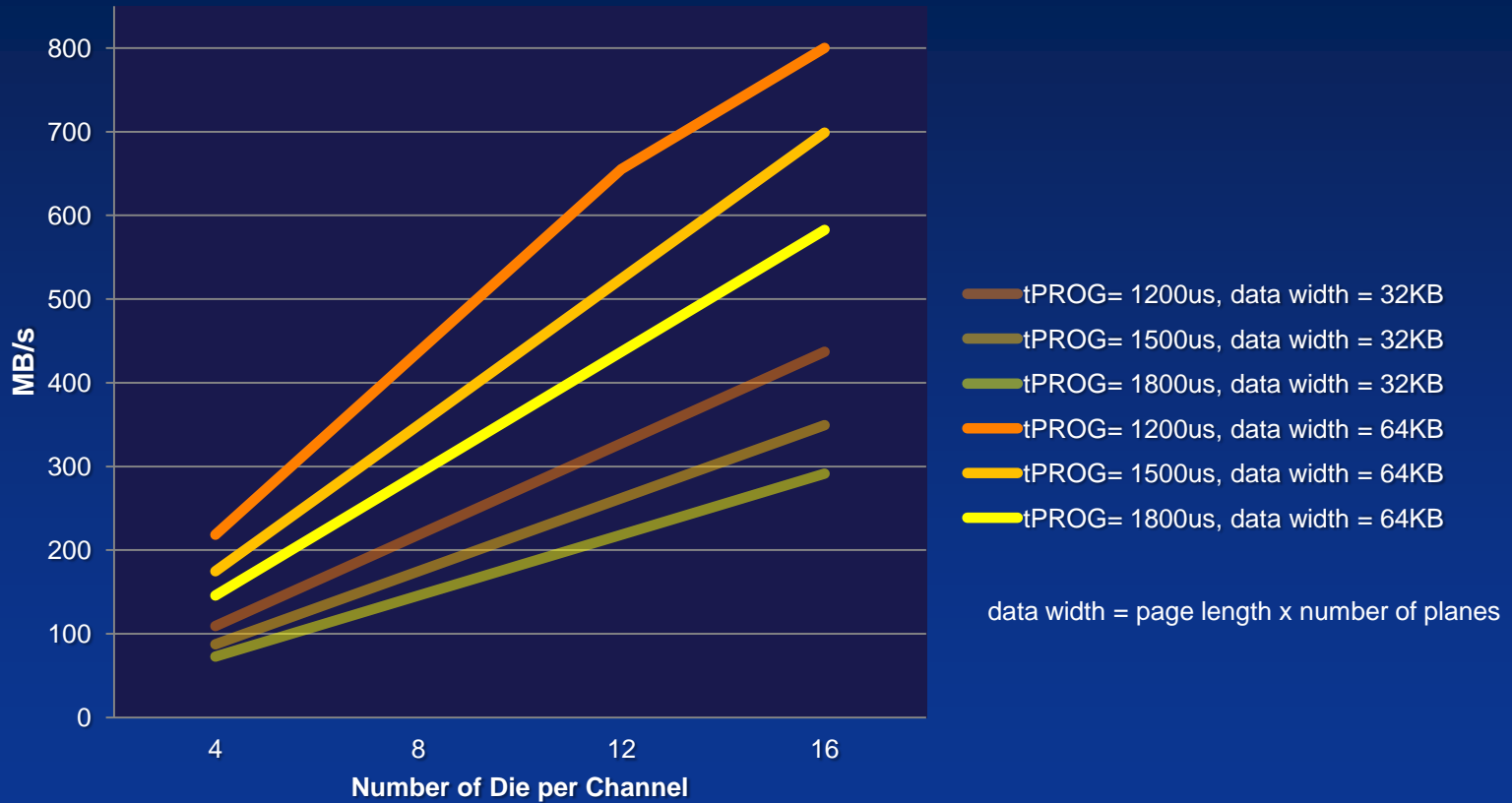- Single package, multiple packages per channel
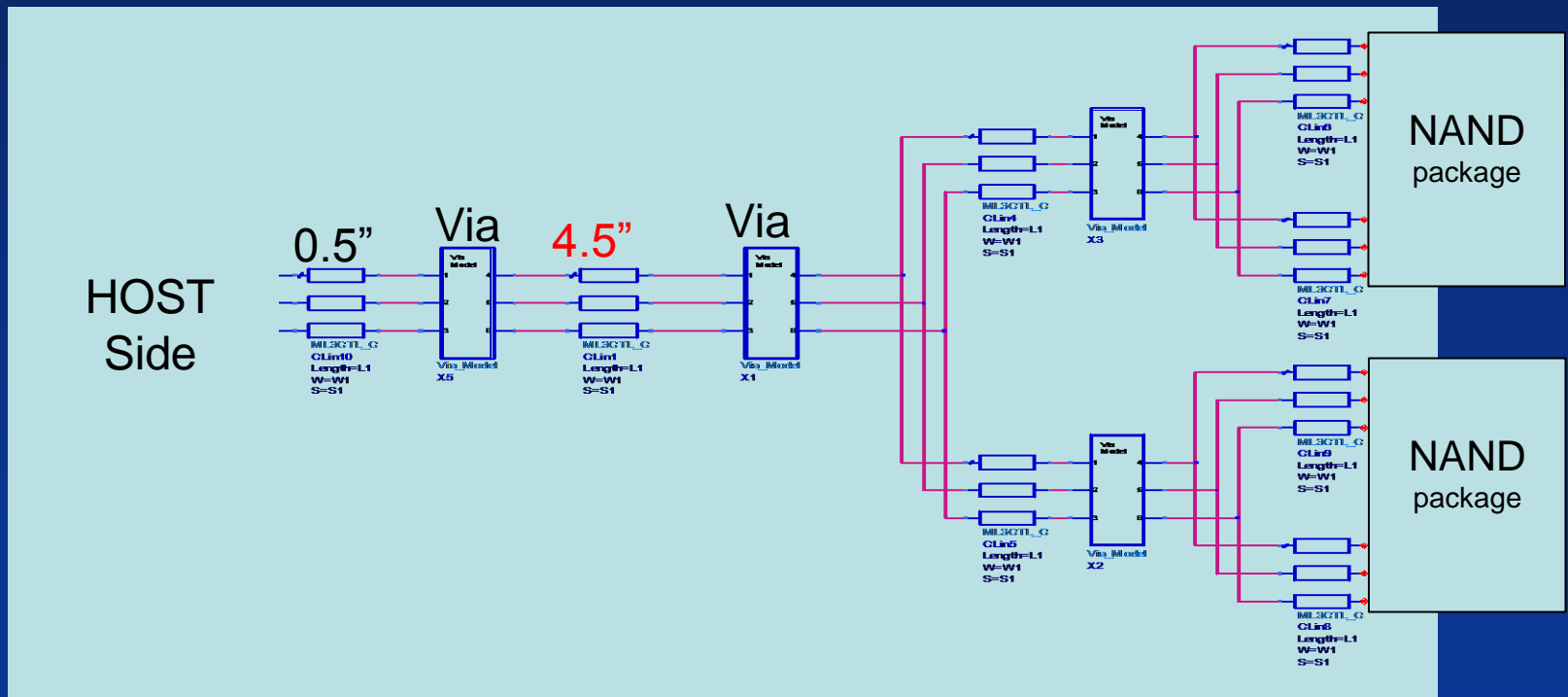
ONFI 4.0 Performance

- Numbers are highly dependent on NAND architecture
  - Page size
  - Number of planes
  - tPROG

Legend: ONFI 3.2 NV-DDR2 Read, ONFI 4.0 NV-DDR3 Read, ONFI 3.2 NV-DDR2 Program, ONFI 4.0 NV-DDR3 Program

MB/s vs MLC performance with NAND die per channel (8, 16)

NAND Architecture Dependency

Systems That Use NAND Have Diverse Power Requirements

Application area	Form Factor	System Power Budget
Mobile	MCP	~1W
Client	M.2, 1.8", 2.5"	3W to 5W
Enterprise	2.5", HHHL, FHHL	9W to 25W

System Power Budget is divided among:

- Controller
- NAND
- Controller to NAND Interface
  - If changes are not made to the interface it will use too much of the power budget

ONFI 4.0 Power Estimates

**Power per Controller Channel
8-Die per channel (2 QDP)**

Legend:
- I/O power Write (mW)
- I/O power Read (mW)

Y-axis: Bus Power (mw) — 0, 100, 200, 300, 400, 500, 600

X-axis categories:
- ONFI 3-400 NV-DDR2
- ONFI 4-400 NV-DDR3
- ONFI 4-533 NV-DDR3
- ONFI 4-667 NV-DDR3
- ONFI 4-800 NV-DDR3
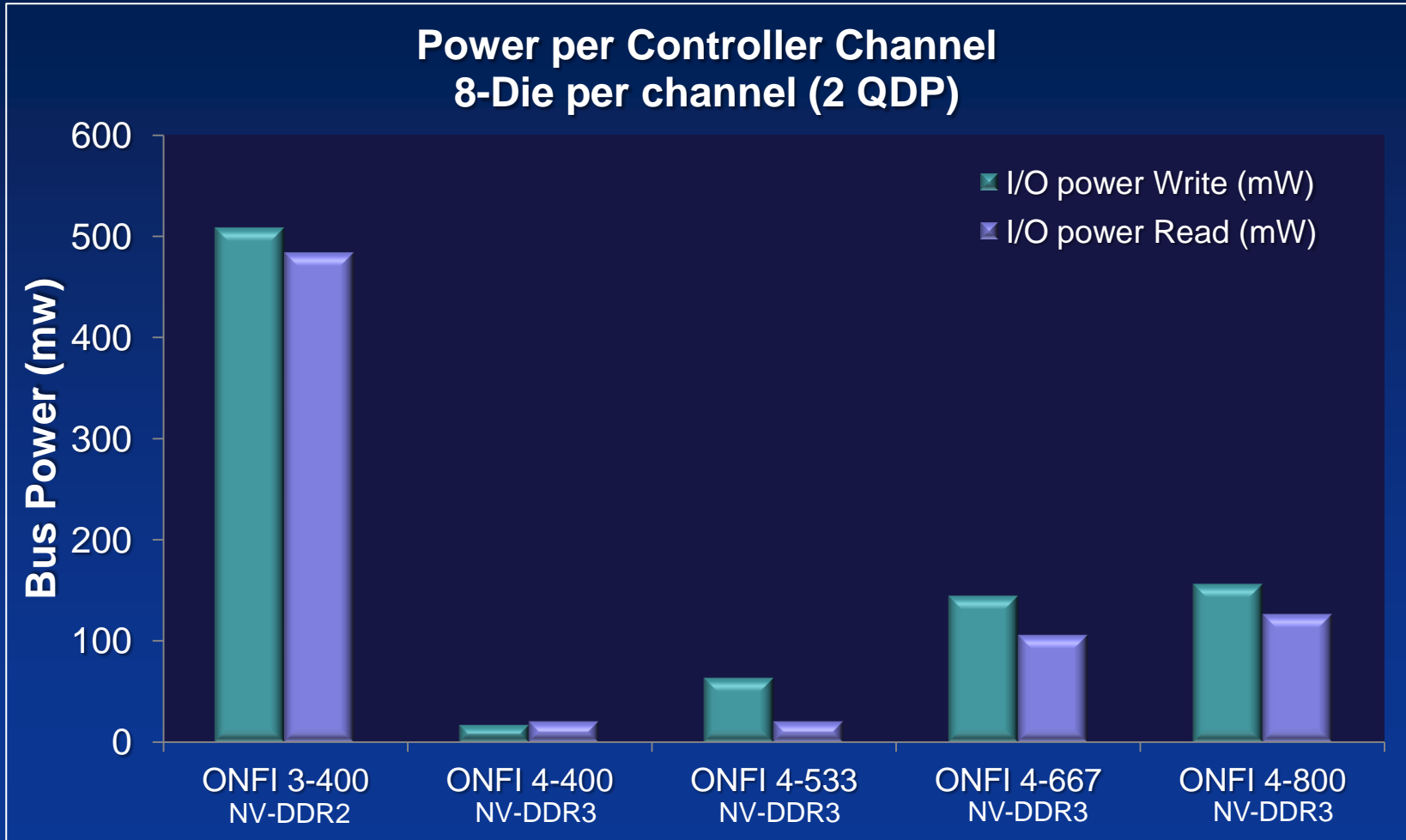
JC42.4 ONFI/JEDEC Joint Task Group

- ONFI NV-DDR2 interface superset of Toggle Mode

- Discussions ongoing to ensure interoperability between ONFI NV-DDR3 and alternative next generation interfaces

ONFI 4.0 Under Development

- Currently being developed to meet needs of the Future NAND interface
  - Improved power I/O consumption
  - Increased I/O performance
  - Interoperability

- Still time to get involved!
  - Join ONFI: www.onfi.org