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High Speed Control Bus for Advanced TRE™

FORMFACTOR

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Outline

- Challenges with most advanced DRAM probe cards
  - Trends in parallel test
  - Test methods to increase parallel test
  - Increased usage of Advanced Tester Resource Enhancement (A-TRE)
- Need for higher integration – customized IC development
- Control methods of Advanced TRE
- Standardization

Trends in Parallel Test of DRAM

- Parallel test has increased significantly in the last 10 years

    - Test cost and cycle time reduction

- Test times are long and are increasing with memory density

- Touchdown count has increased

- Increase of parallel test is the most efficient way to reduce test cost and cycle time

Trend in Parallel Test of DRAM
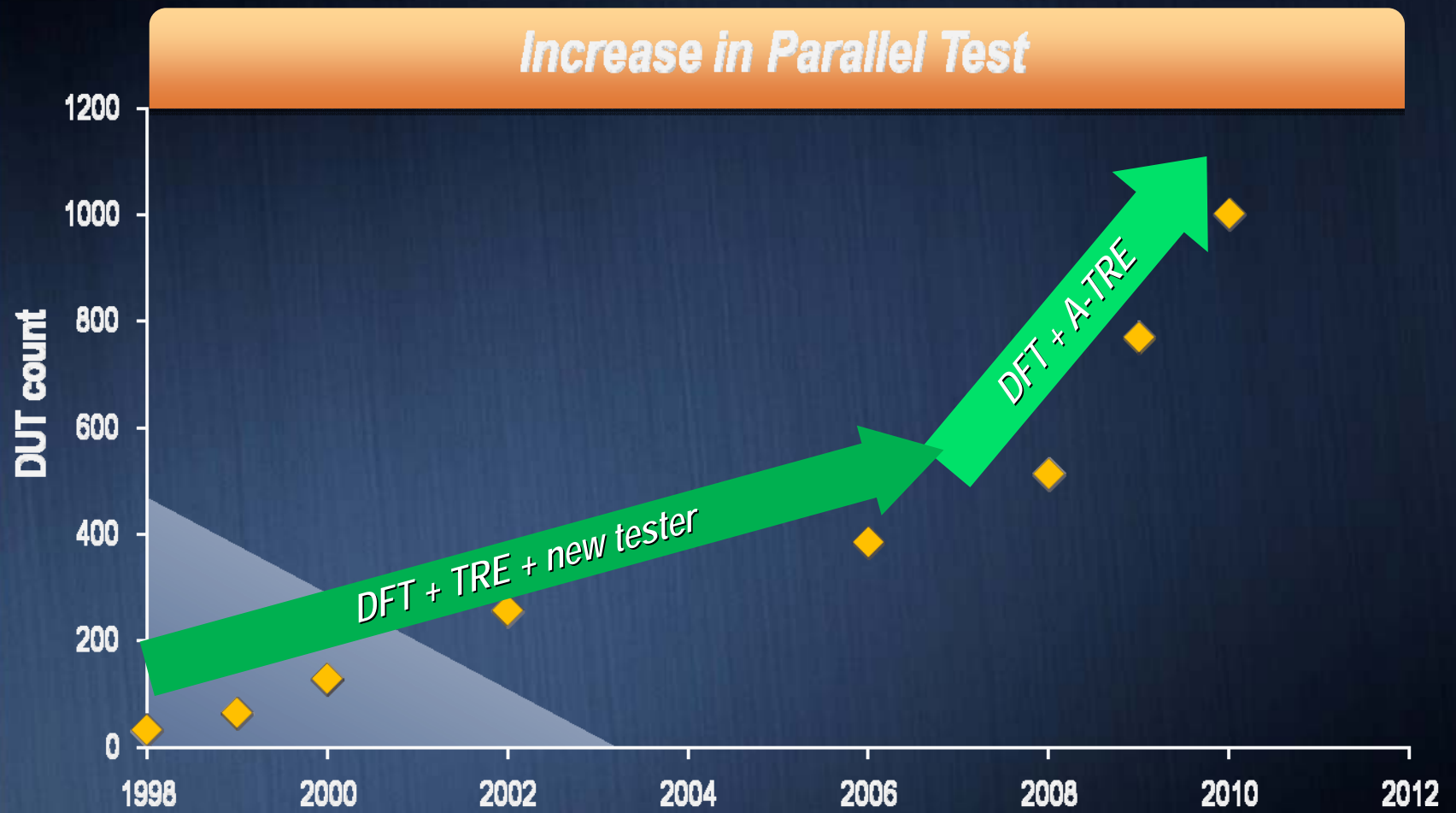
Trend in Parallel Test of DRAM

Tester Sites	16	32	64	96	64	96	96/128
Parallelism	16	32	256	384	512	768	~1000
Signal TRE	x1	x2	x4	x4/x6	x8	x6/x12	x8/x16
DFT	No	I/O compr.	I/O compr.	I/O compr.	I/O and control	I/O and control	I/O and control
A-TRE	none	none	none	none	DC-TRE PPS-TRE	DC-TRE PPS-TRE	DC-TRE PPS-TRE

- Which other capability will be needed in the future to get to the next step?
- Test time impact is very much in focus

Advanced TRE (Tester Resource Enhancement)

- TRE in the past was limited to control signals = signal TRE

  - One tester driver controls multiple DUTs

- Advanced TRE is expanding TRE to different classes of signals like DC-signals and Power supplies

- Example: DC-signals

  - DC-signals are used to force voltages - trimming

  - DC-signals are used to measure voltages - characterization

    - High accuracy is needed

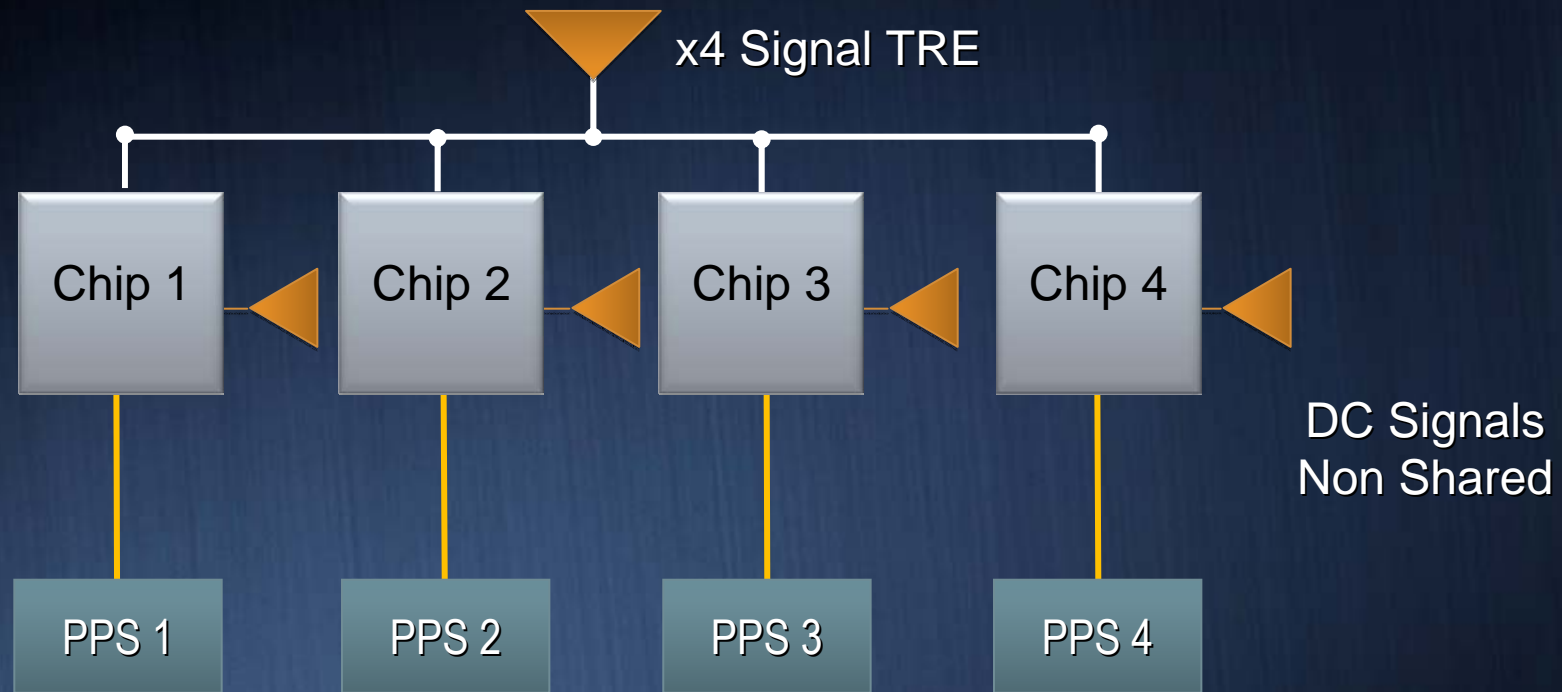 - DC-signals are more critical with regard to process related failures than control signal

More capable TRE technology is needed

DC-Boost™- A DC-Signal Sharing Solution
Adding a new degree of intelligence to our wafer probe cards
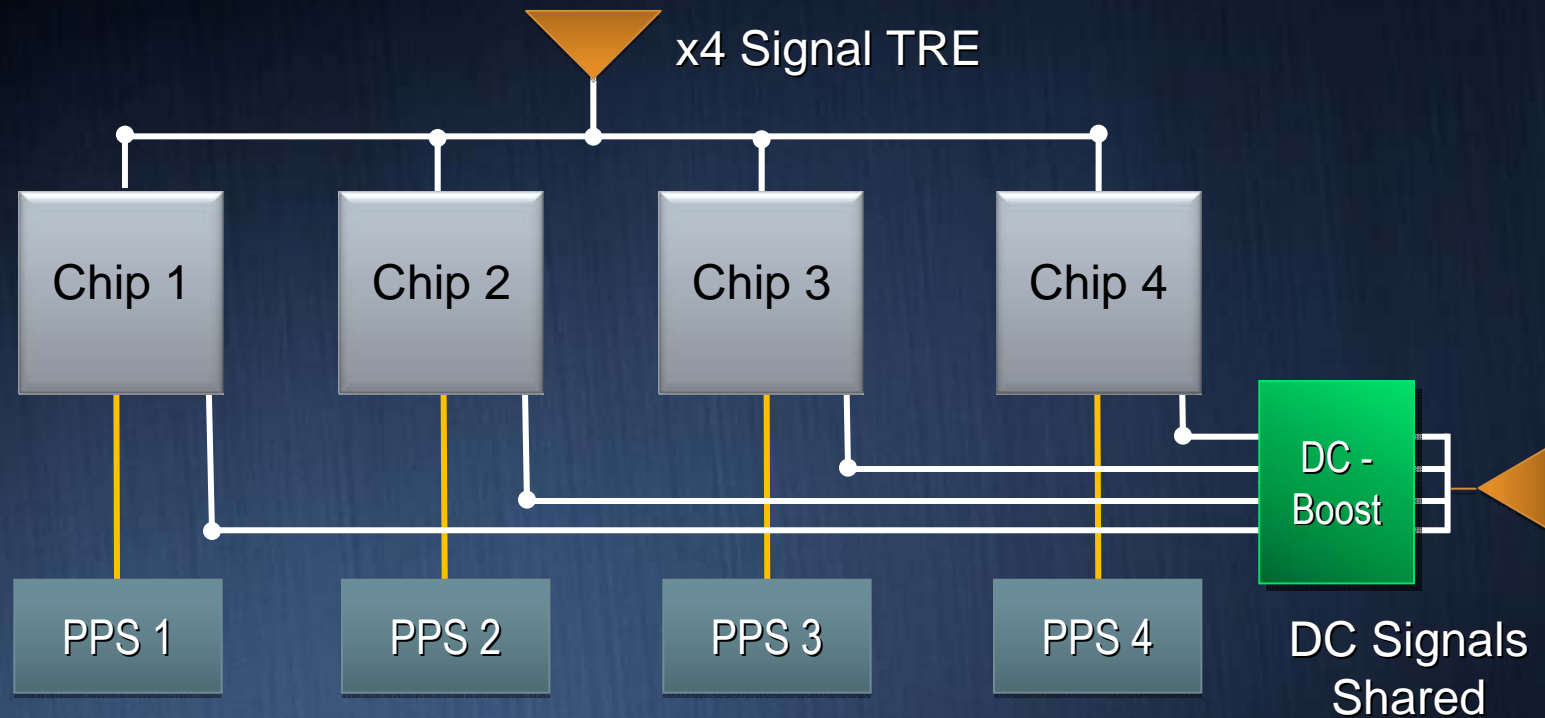
- First custom designed TRE chip

- Enables TRE on DC-signals:

  - One tester channel can be used for multiple DC-signals

  - Sequence control is provided for voltage measurements

    - Allow sequential measurements by connecting one signal at a time

  - Isolation capability is provided for disconnecting bad DUTs

    - Minimize yield loss

    - Increase accuracy of applied voltage levels

- Quad DC-Boost: 2nd generation version with higher integration being currently rolled-out to the market

# Test Methods to Increase Parallel Test I

x4 Signal TRE

Chip 1   Chip 2   Chip 3   Chip 4

DC Signals
Non Shared

PPS 1   PPS 2   PPS 3   PPS 4

- Signal TRE x4
- No DC-TRE
- No PPS-TRE

Test Methods to Increase Parallel Test II

x4 Signal TRE

Chip 1   Chip 2   Chip 3   Chip 4

DC - Boost

PPS 1   PPS 2   PPS 3   PPS 4

DC Signals Shared
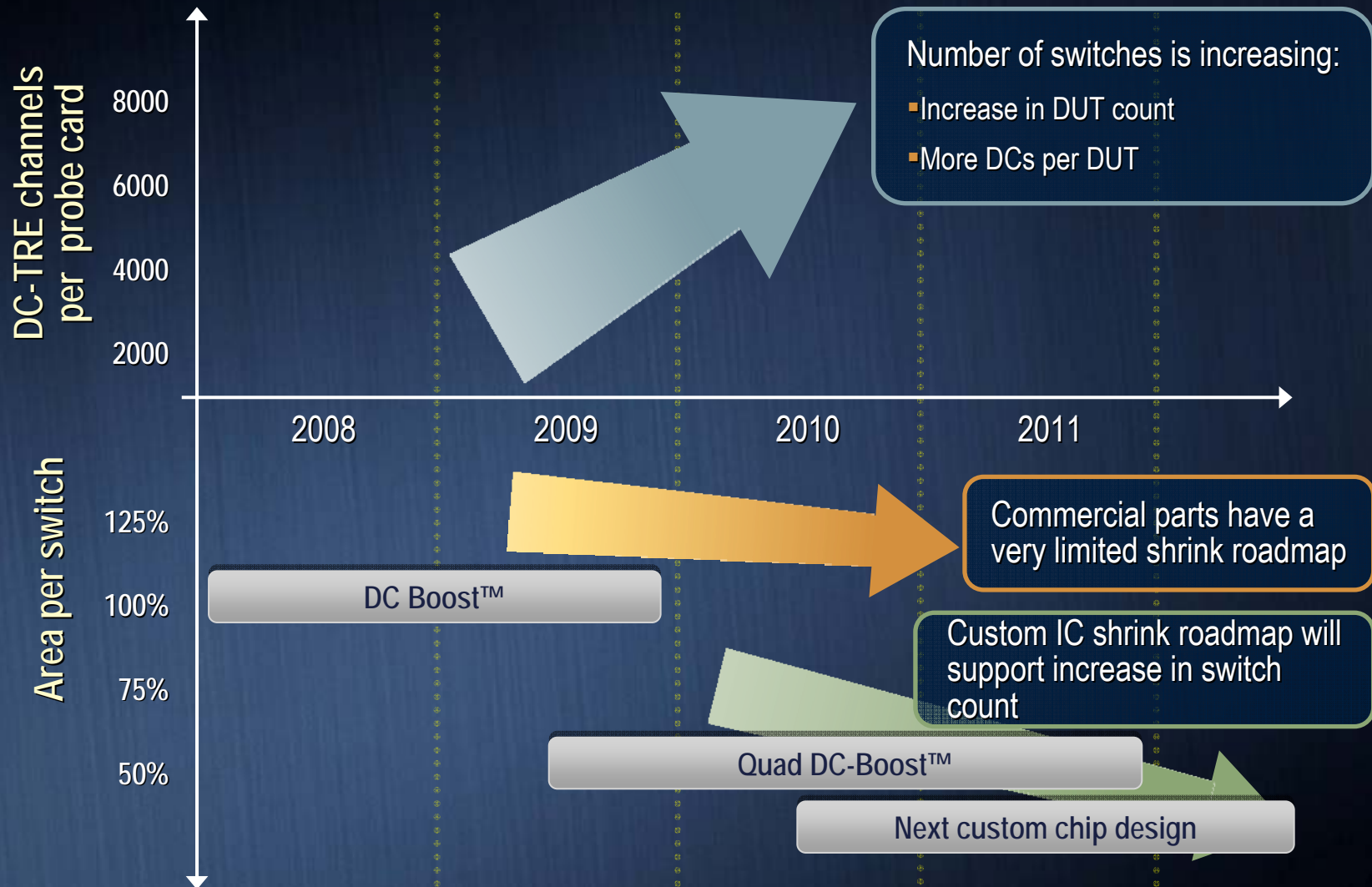
- Signal TRE x4
- DC-TRE to enable more DC-signals per DUT
- No PPS-TRE

Test Methods to Increase Parallel Test III

x8 Signal TRE

Chip 1 Chip 2 Chip 3 Chip 4 • • • • Chip 8

PPS-TRE

DC - Boost

DC Driver

PPS 1 PPS 2
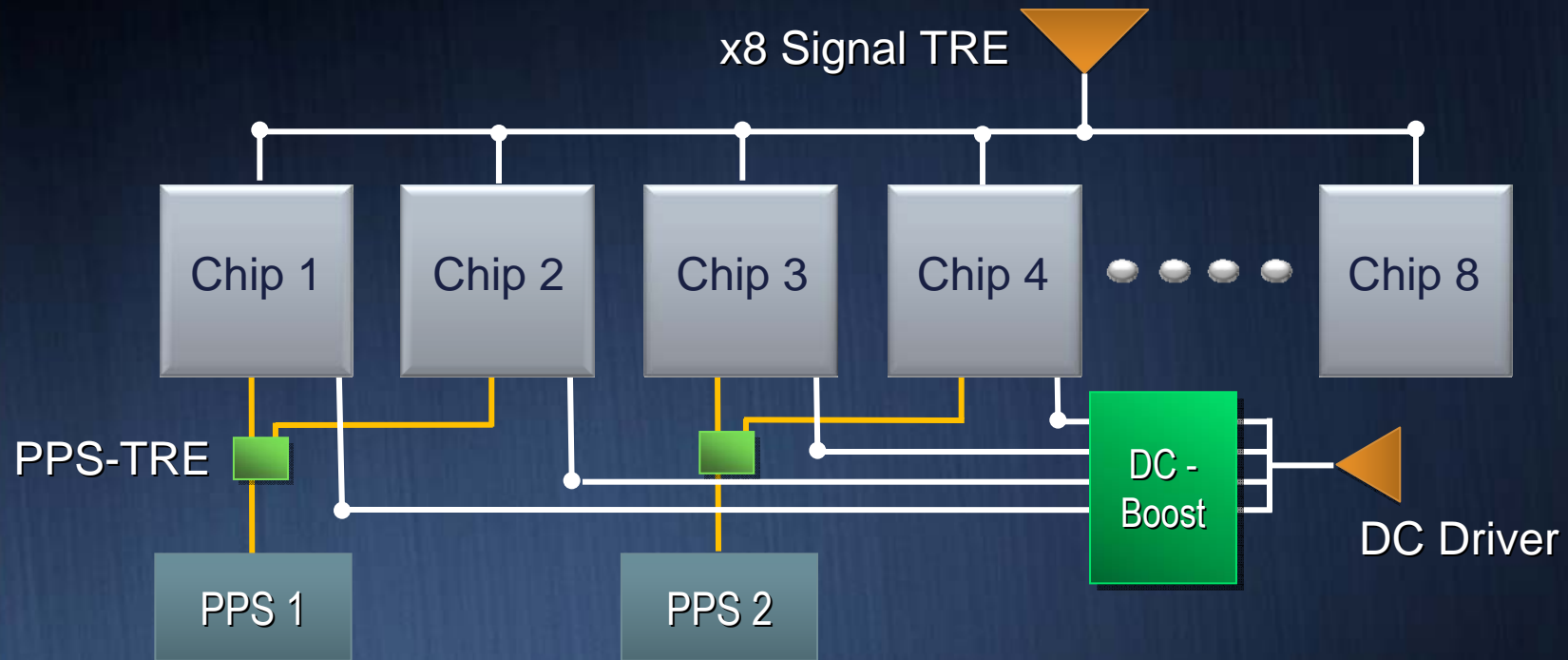
- Signal TRE x8 (up to x12 for even higher parallelism)
- DC-TRE
- PPS-TRE

Increased Usage of Advanced TRE

DC-TRE channels per probe card

8000

6000

4000

2000

2008   2009   2010   2011

Number of switches is increasing:
- Increase in DUT count
- More DCs per DUT

Area per switch

125%

100% — DC Boost™

75%

50% — Quad DC-Boost™

Next custom chip design

Commercial parts have a very limited shrink roadmap

Custom IC shrink roadmap will support increase in switch count

# Need for Higher Integration – Customized ICs

- **Probe cards have special requirements**
  - Small foot print, small area per switch
    - Ensure feasibility of highest switch count designs
    - Avoid daughter cards to increase reliability
  - High temperature: With chuck temperatures up to 125C the components on the probe card are exposed to high temperatures
  - Package and pin assignment optimized for easy routing of the PCB
  - Special functions or combinations of features unique to IC test
  - Easy and fast control
    - Limited number of control channels
    - No test time impact due to switch operation
    - Lowest possible routing effort on the PCB

Control Methods for A-TRE: Massive Parallel
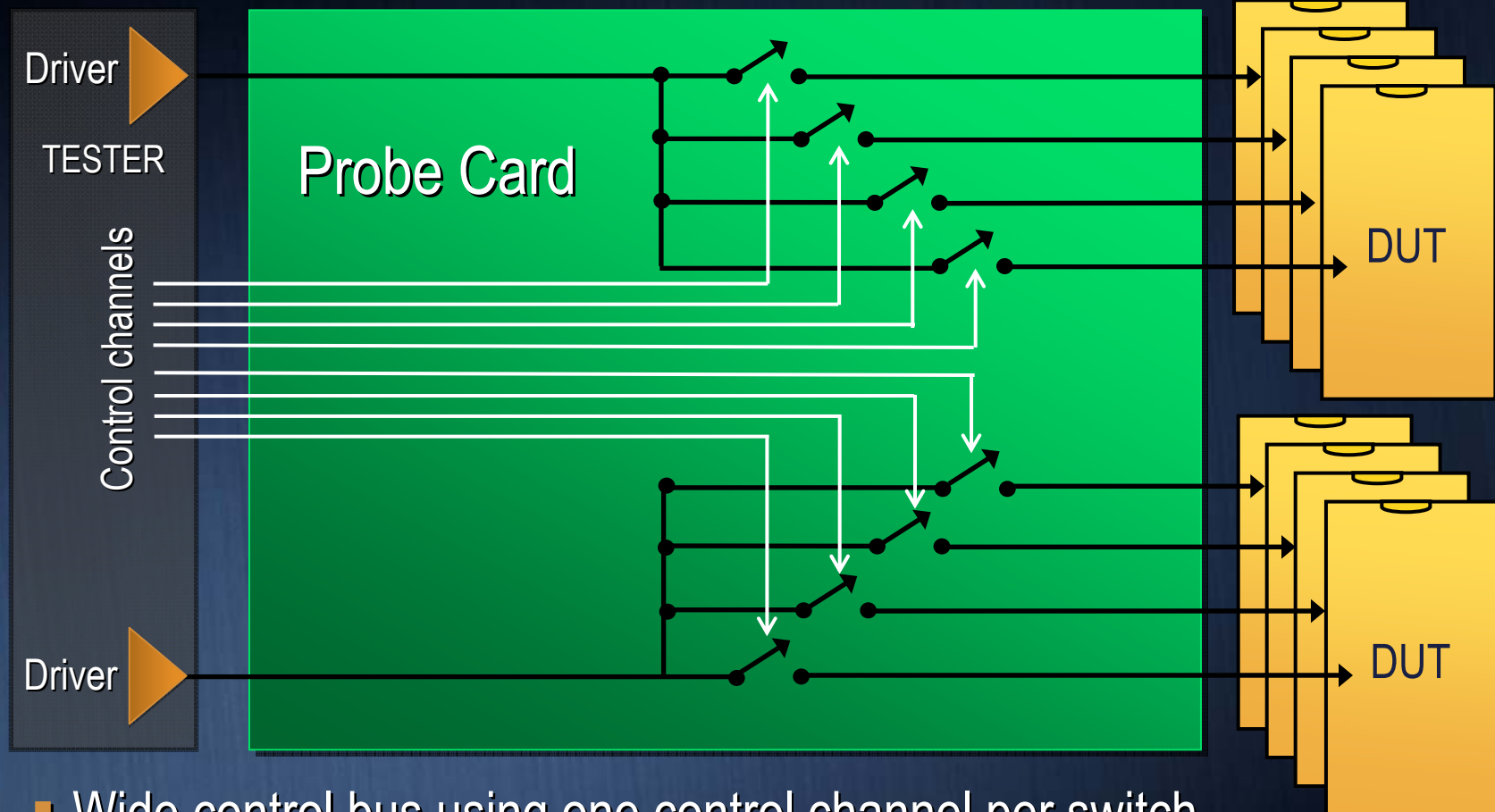
- Wide control bus using one control channel per switch
  - Limited by the number of available control channels
  - Creates significant routing problem

Control Methods for A-TRE: FFI Approach
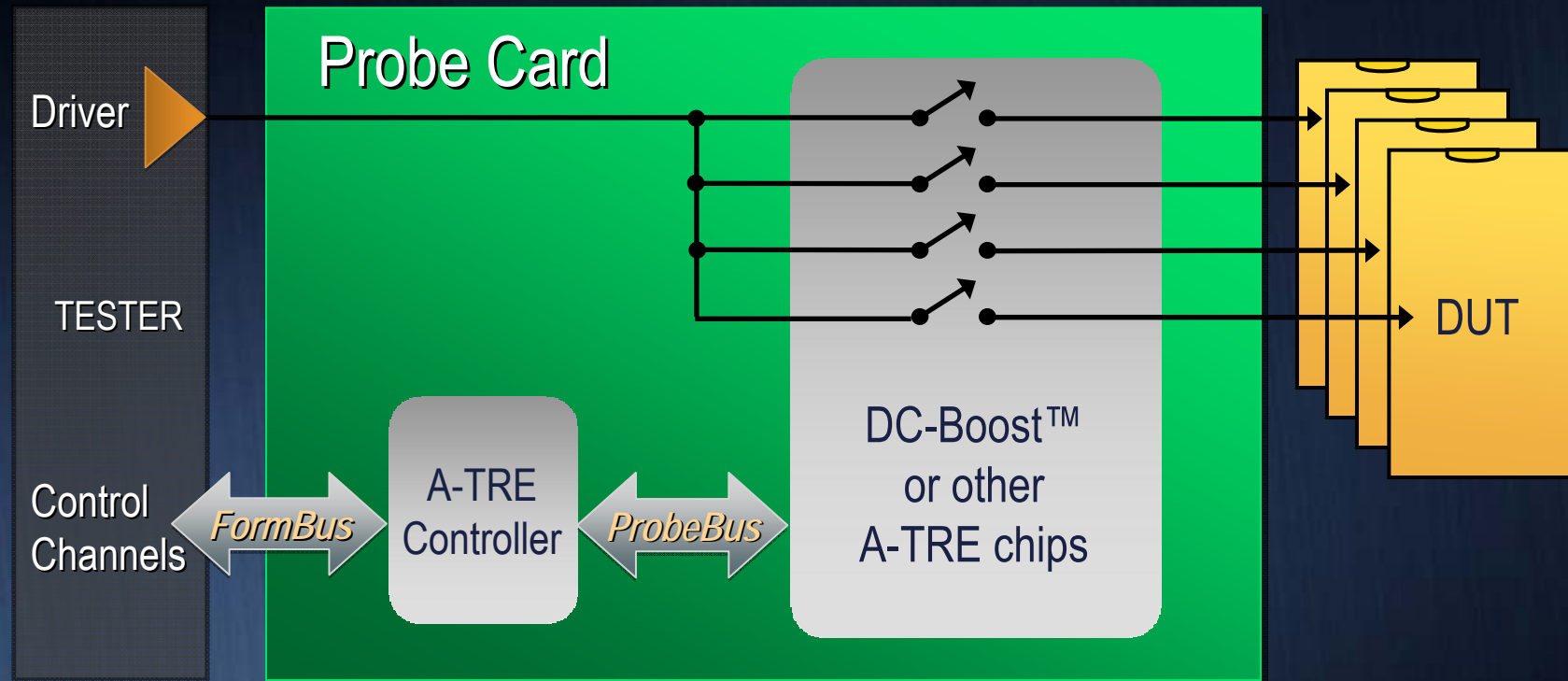
- A-TRE controller on the probe card is controlling DC-Boost
- ProbeBus™ Technology: High speed control bus for all A-TRE chips on the probe card
- FormBus™ Technology: Communication between the test program and the A-TRE controller

Control Methods for A-TRE – FormBus™
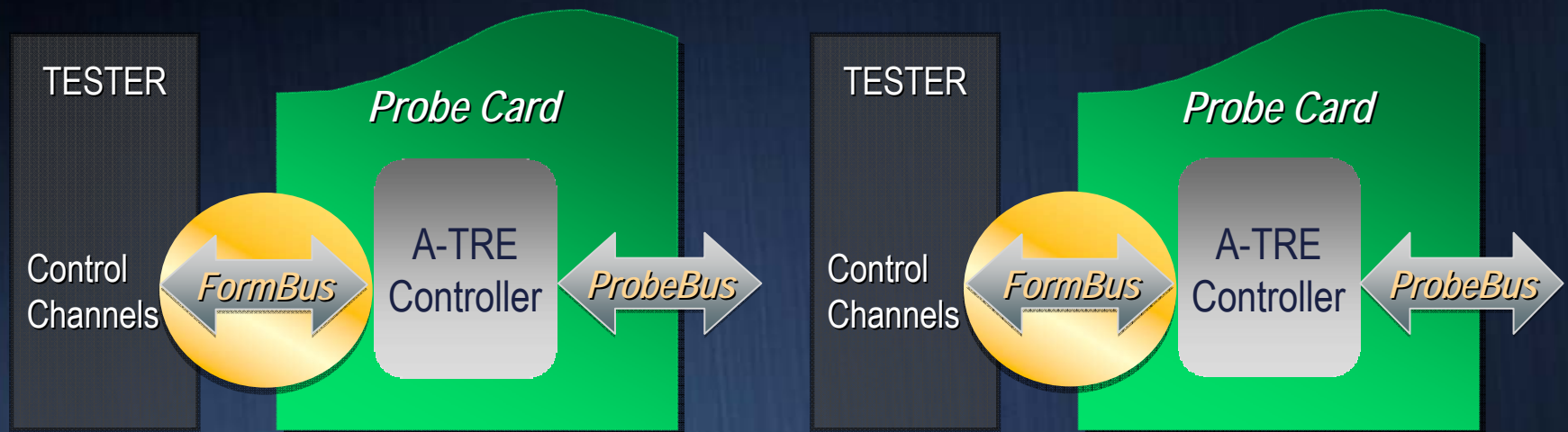
- FormBus™: Communication between the tester and A-TRE controller
  - Wider bus (typical 18 bit) using tester control channels   or
  - Very narrow (4 bit) bus using high speed tester channels:
    - Scalable to increasing switch count
    - Scalable to increasing data traffic coming with additional functionality:
      - Data read back
      - More complex control requirements

Control Methods for A-TRE – ProbeBus™

Probe Card

FormBus	A-TRE Controller	*ProbeBus*	DC-Boost™ or other A-TRE chips
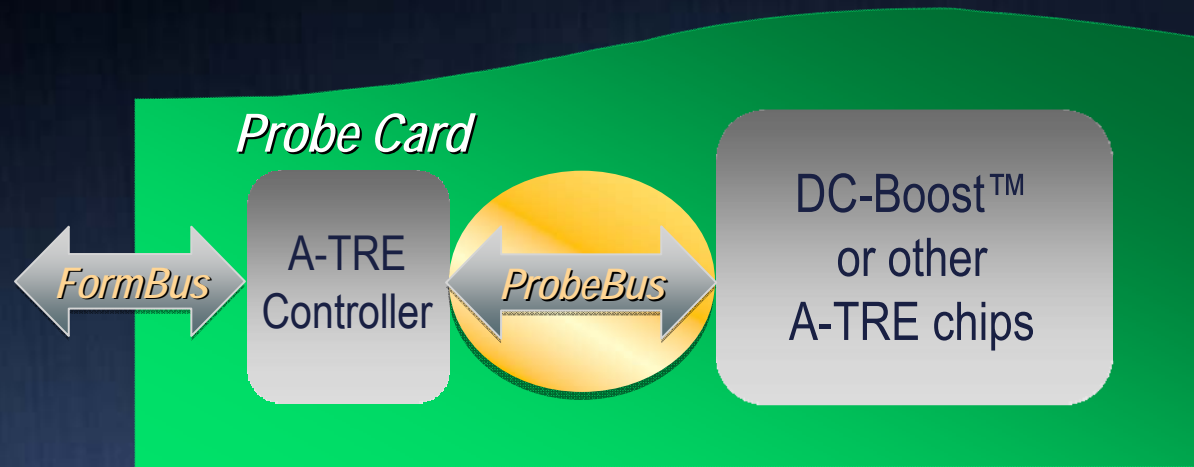
- ProbeBus™: High speed control bus for all A-TRE chips
  - Allow full control as well as data read back
  - Bus is designed for optimized routing of the PCB
  - DC-Boost and other future A-TRE chips can use this bus standard structure
- The A-TRE controller takes care of all data management and provides an easy interface to the test through the FormBus
  - Minimizing the programming effort and the data traffic between tester and probe card

Standardization Efforts

- Probe card with this level of complexity requires a significant amount of engineering

- Standardization of core components is a must to meet cycle time, resource and cost targets

  - Design – use standard components and placement schemes
  - Verification and outgoing test – use standard testers for outgoing test
    - Commercially available probe card testers cannot perform that function
  - Standard communication between tester and probe card are highly desirable

Standardization Efforts - User Requirements

- Different customers have very different test strategies
  - Different implementations of A-TRE
  - Different ways of controlling A-TRE on a probe card
- The current approach provides
  - Most flexible way to respond to different requirements while keeping standards on the key components (communication protocol, controller, firmware, architecture)
  - Scalability for increasing usage of A-TRE
  - Flexibility to adopt new features

Summary

- Parallel test has continued to increase enabled by A-TRE and DFT

- Increasing use of A-TRE requires:
  - Customized A-TRE chips
  - Well thought through probe card architecture

- The presented architecture fulfills the requirements in the best possible way

- The use of standard building blocks enables:
  - Short lead time and reasonable effort for these highly complex and customized products
  - Stable design and building process – "first time right"
  - Scalability to further increase the usage of A-TRE

Acknowledgements

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