PWB Back Drilling Failure Analysis

Project Proposal - Definition Stage

Project Lead: PC Wong, PWB Interconnect Solutions, Inc.

Project Facilitator: John Davignon, HDP

San Jose Meeting: Feb 26, 2014

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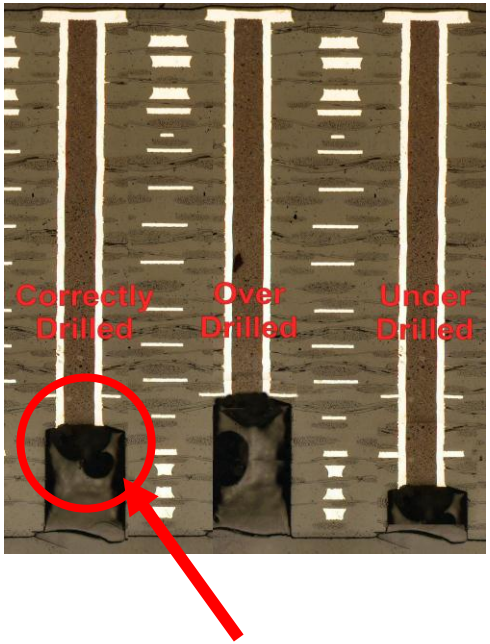
Project Background

- Back drilling or controlled depth drilling of plated through holes (PTH) is increasingly being used in High Speed Designs.

- While back drilling of PWBs helps to remove signal distortion by removing via related stubs, reliability issues attributed to this practice appear to be on the rise.



The critical parameter is the length of remaining copper via (Stub) from the targeted inner layer pad

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Project Drivers/Gaps

- Both the number of back drilled vias and the variation of depths (any & all layers) are increasing on each board.

- Design Rules are driven by Electrical requirements, not necessarily based on PWB reliability data or fabrication capabilities.

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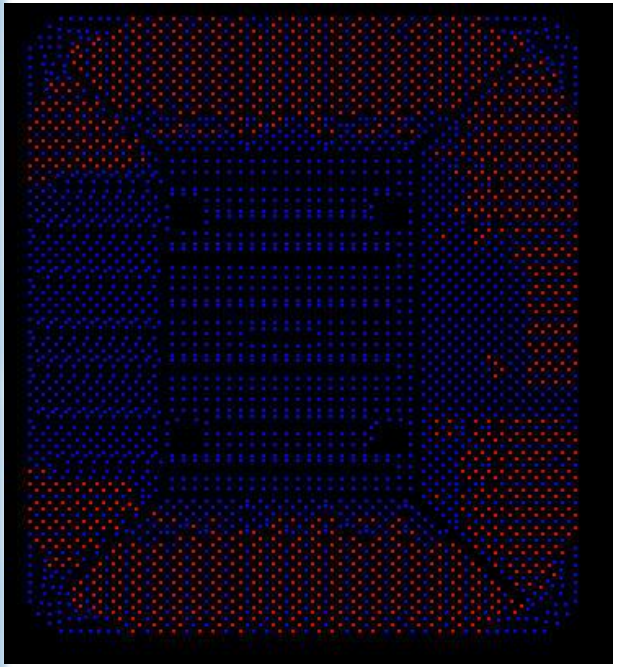
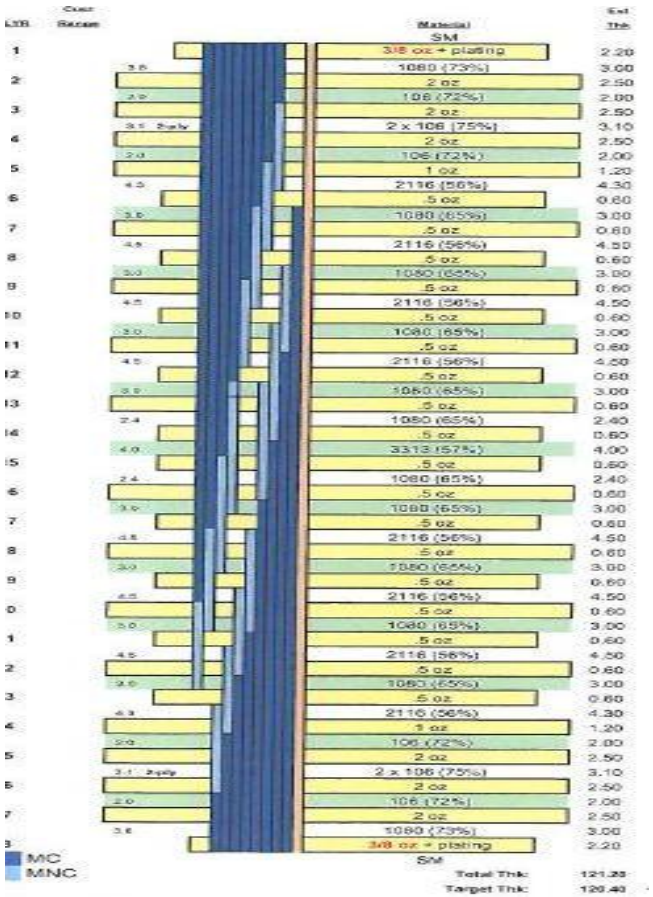
Products Using Back Drilling

Blue shows the 3584 holes in the device.
Red shows 1142 are back drilled





Increasing numbers of designs specify multiple levels of back drilling throughout the construction

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Purpose of Project

- Quantify the reliability of specific BD holes designs compared to PTH holes
- Quantify the relative reliability of shallow, medium and deep BD holes.
- Quantify the influence of hole size, pad size and pitch on BD hole reliability (0.032”, 0.040” and 0.080” pitch).
- Compare the variation in BD hole reliability from different PWB suppliers

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Project Scope

- This project will baseline back drilling reliability and capability of high layer count boards for datacom, telecom & backplane products and to identify potential solutions and design guidelines to prevent future problems.
- This is not a laminate materials, drilling equipment, fabrication process or signal integrity study.
- This will be accomplished in 3 proposed phases
  - Phase 1: Survey
  - Phase 2: Reliability / Capability testing
  - Phase 3: Guideline documentation

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Goals

- Publish the results of where the OEM's are going with backdrill designs
- Baseline the capability of the industry for tolerance/variation of stub length and depth control through a specially designed Test Vehicle
- Quantify the reliability of backdrill vias at varying depths – short, medium and long through a specially designed Test Vehicle

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Objective/Strategy

- Design a Test Vehicle with coupons to measure the capability & reliability baseline of back drilling
- Modify an existing 20 layer, 1/2oz copper, FR4 based stack-up Test Vehicle. (Pb-free PWB Materials Reliability Project)
- Send out the design to OEM members for support in building this TV
- Build the TV at various PCB Fabricator sites
- Test/Evaluate the coupons to measure and establish an Industry baseline for capability & reliability
- Publish the results of the baseline both internally and externally at industry conferences

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Deliverables

- Publish results of backdrill OEM/PWB survey on capability and requirements.
- Publish a report documenting the capability of the industry to control stub length and depth drilling. Target date Q2 2015
- Publish a report documenting the reliability of various backdrill design features. Target date Q2 2015
- Publish a BD design guideline report
- A Backdrill Test Vehicle for future phases and use in the industry to verify backdrilling capabilities

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Benefits/Impact

A set of design parameters for HDP members that will guide OEM, ODM, system designers in designing a more reliable back drill products. *These design guidelines will help reduce development cost for redesigns and improve TTM.*

Provide PWB fabricators and equipment suppliers with the future backdrill technology direction for high end, high layer count products in the data/tele com sector. *This direction will allow strategic capital investment to align with future requirements.*

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Resources Needed / Committed

Task	Resource	Complete Date	
Survey – develop, consolidation and analysis	Cray / Oracle	2Q2014	
TV – design, review and release for fabrication	PWB / Introbotix	2Q2014	
TV – fabrication	TBD/OPEN	2Q2014	
TV – As received testing and data analysis	PWB /Introbotix	3Q2014	
Simulated Assembly Reflow	Open/ Need Help	4Q2014	
TV – After reflow testing and data analysis	PWB /Introbotix	4Q2014	
Report – writing, editing and release	PWB / Team	1Q2015	
Phase 1 Survey	PWB	4Q2014	
Phase 2 Reliability & Capability	PWB	2Q2015	
Phase 3 Guideline	PWB	3Q2015	

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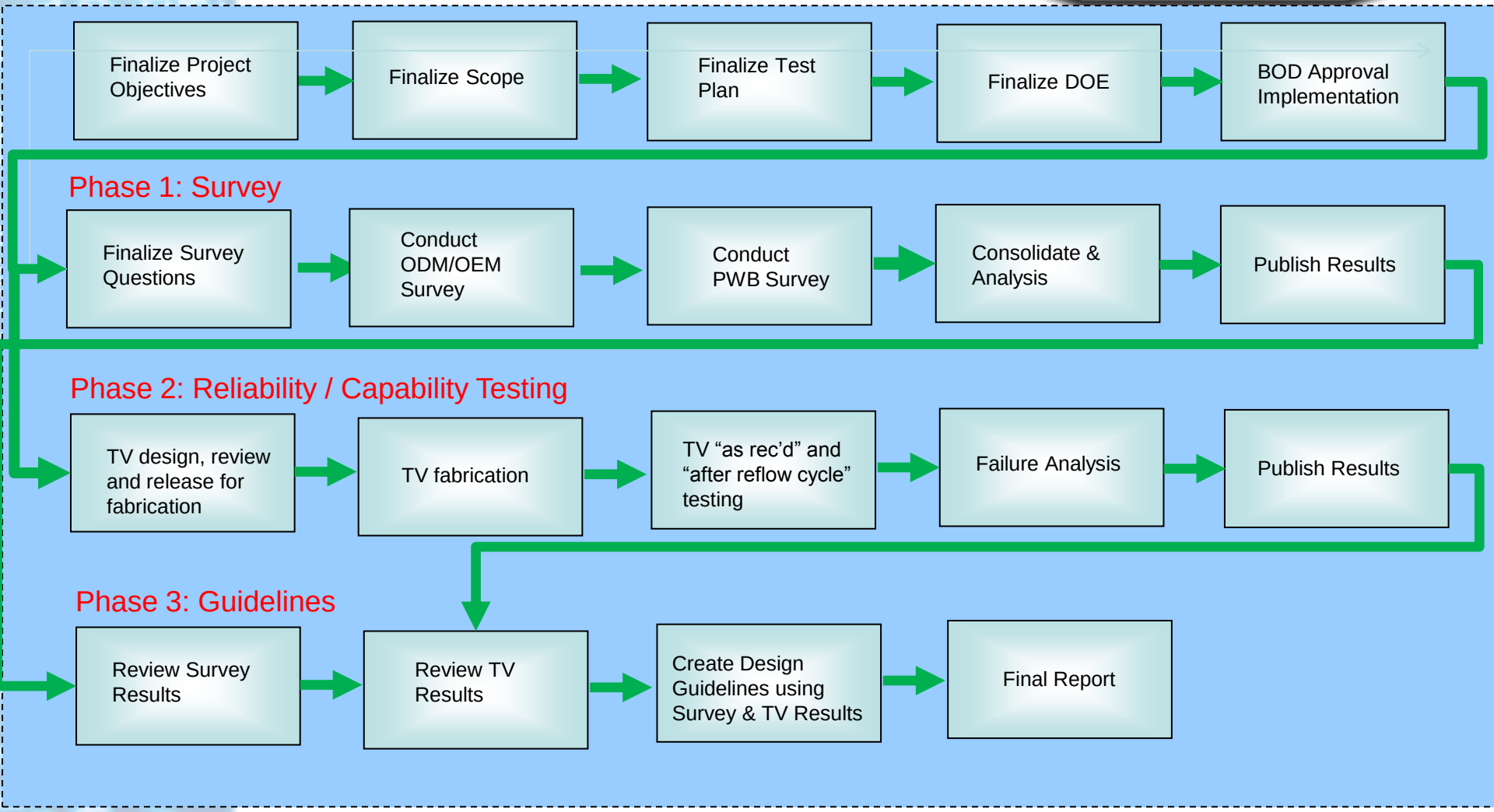
Project Flow Chart



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Technical Discussions

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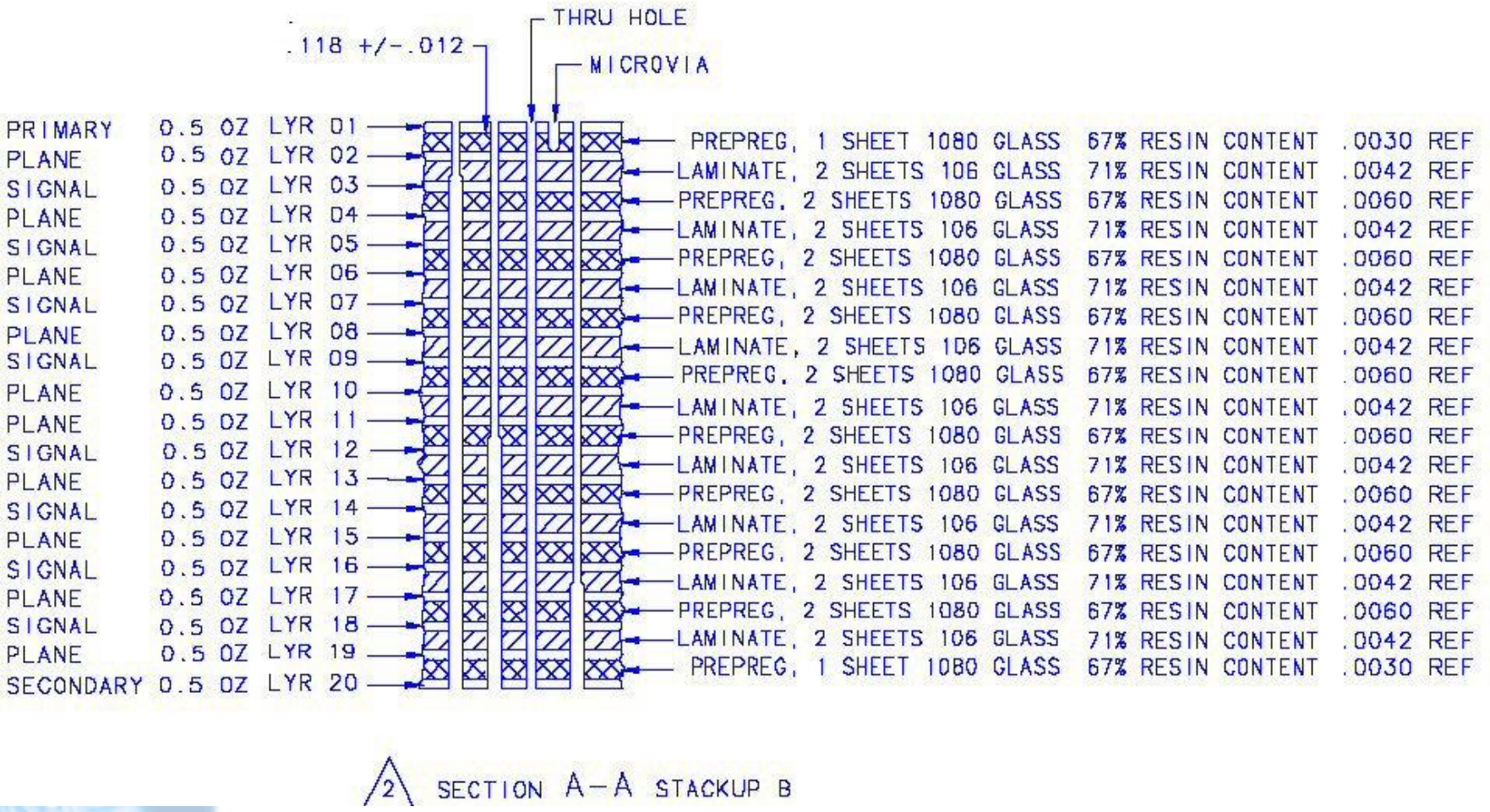
TV Stack up



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DOE/TV details

Coupon	Via to Via Spacing	Drilled Hole Diameter	Pad Diameter	Anti-Pad Diameter	Over-Size Drill Diameter
1A	0.032”	0.010”	0.019”	0.026”	0.018”
1B	0.040”	0.010”	0.022”	0.030”	0.018”
2	0.080”	0.026”	0.038”	0.046”	0.034”

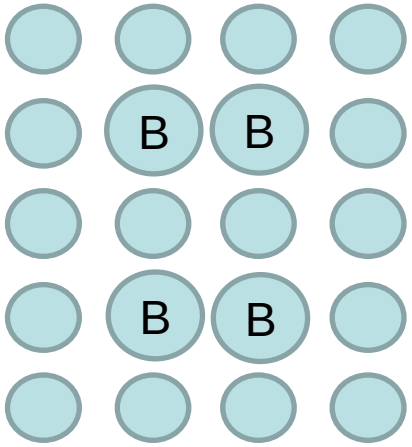
Back-drilling will accommodate 3 levels – “Shallow” L2 or L3, Middle L10 or L11, “Deep” L18 or L19.

Each pair of back-drilled holes will be surrounded by traditional plated through holes.

Each coupon design will have two “sections” – 1) PTH, 2) PTH with back-drilled vias interspersed.

Each back-drill depth with be an independent coupon design (3 design types * 3 depths = 9 coupon designs)

B = Back-drilled hole
Representing typical diff pair



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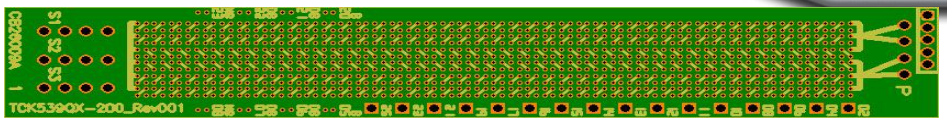
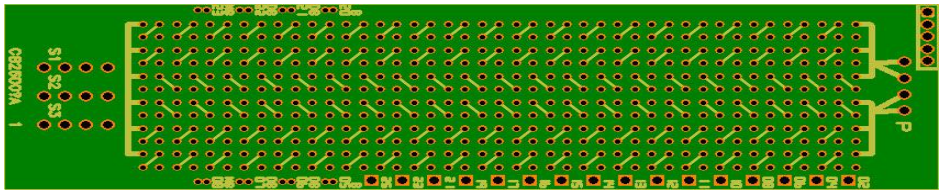
TV Design: Coupons/Sub-Panel (~5”x ~14.5”)

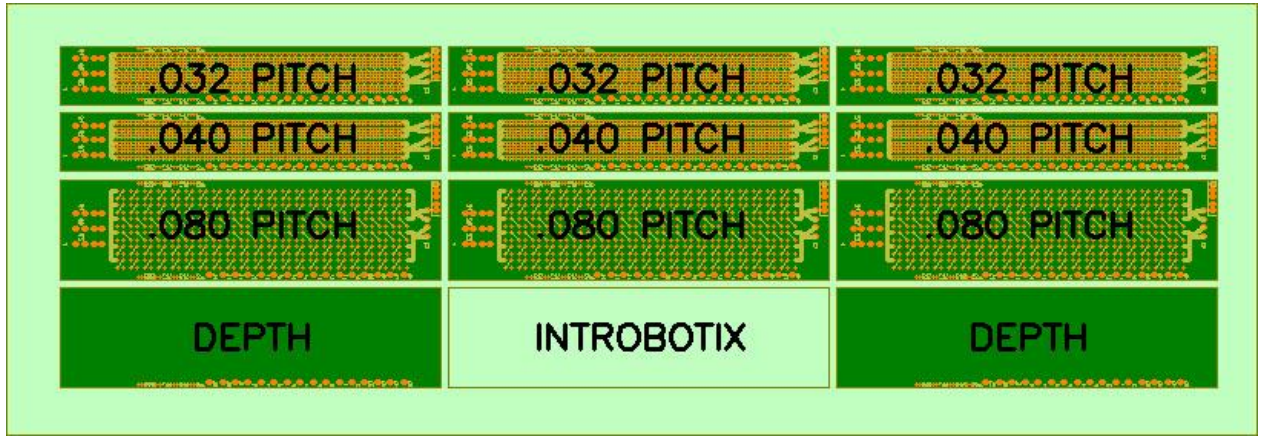
1B



2



Coupons – 1B (.040” grid) and 2 (.080” grid)



Sub-Panel (~5”x ~14.5”)

not to scale: Introbotix coupons design to be added later

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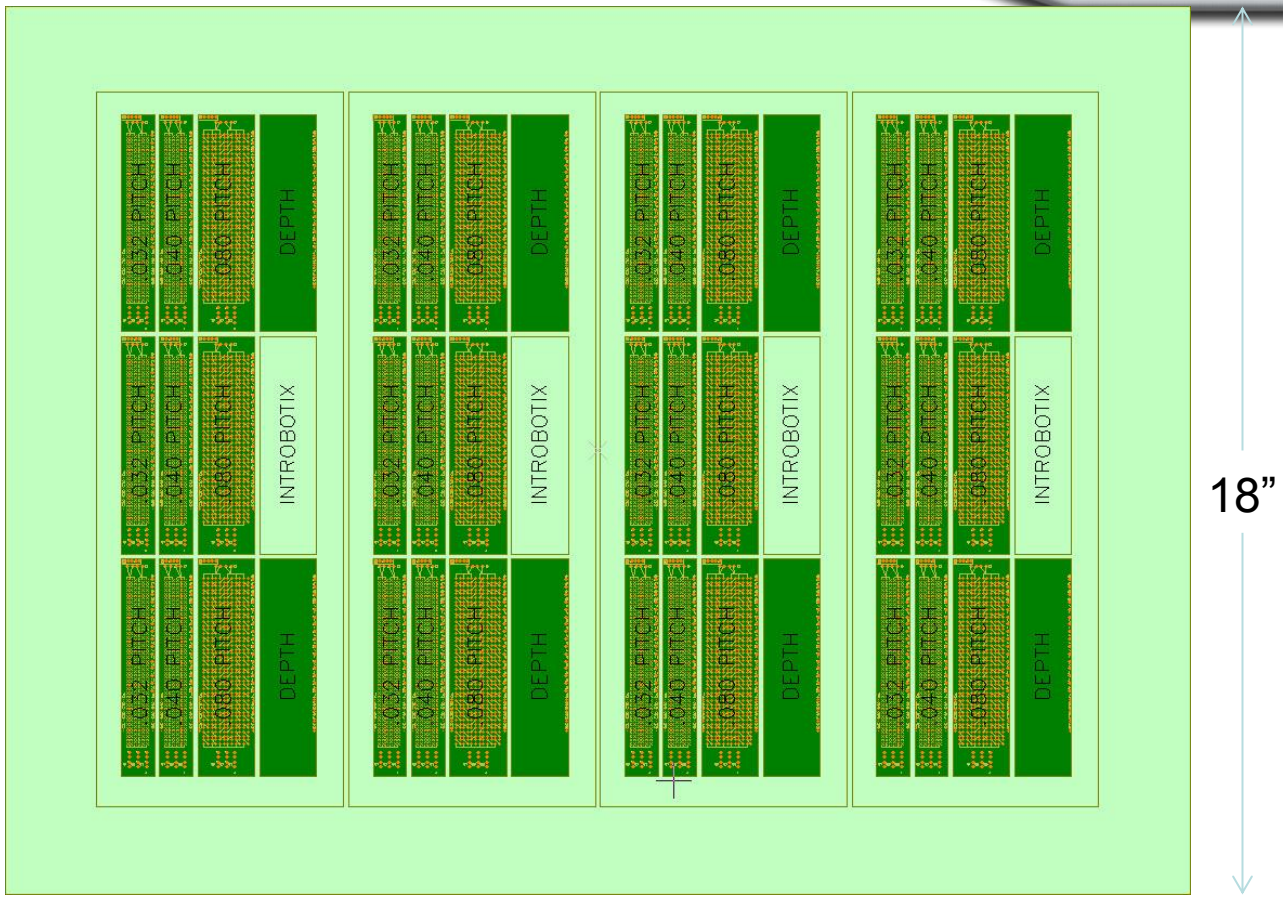
Production Panel



18”

24”

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Expected DOE Results

- Reliability of the 3 depths vs. PTH (with and without assembly thermal stress)
- Reliability of BD geometry (coupon design geometry)
- Reliability of PCB source (relative to peers who submitted samples)
- Variation of BD depth in relation to position on panel
- Correlation of Depth Control measurement methods
- Electrically quantifying/measuring true depth of no-cut layer (how deep fabricators need to go)
- Electrically determine if any copper on sidewall or copper debris in hole remains

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Project Schedule/Timeline

Project Task	Schedule
BOD Implementation Approval	Q2’2014
Phase 1: Finalize Survey	Q2’2014
Phase 1: Conduct Survey	Q2’2014
Phase 1: Consolidate Survey Results	Q3’2014
Phase 2: TV Design	Q2’2014
Phase 2: TV Fabrication	Q3’2014
Phase 2: TV Reliability Testing	Q1’2015
Phase 2: Consolidate Testing Result	Q2’2015
Phase 3: Guideline	Q3’2015

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Team Members

- PC Wong, Project Lead,PWB Interconnect Solutions
- Joe Smetana, Alcatel-Lucent
- Paul Brown, Alcatel-Lucent
- Richard Coyle, Alcatel-Lucent
- Thilo Sack, Celestica
- James Armstrong, Ciena
- Mike Wingrove, Ciena
- David Wice, Ciena
- Ivan Straznicky, Curtiss-Wright
- Paul Wenaas, Cray
- Al Ortiz, Ericsson
- Igor Perez-Uria, Ericsson
- Ove Isaksson, Ericsson
- Akiko Matsui, Fujitsu
- Brian Smith, HDP
- Marshall Andrews, HDP
- John Davignon, HDP
- Brandon Sherrieb, Integrated Test (ITC)
- Dana Freeman, Integrated Test (ITC)
- Girish Wable, Jabil
- Leif Hutchinson, Juniper
- Mike Freda, Oracle
- Karl Sauter, Oracle
- Bill Birch, PWB Interconnect
- Dan Turpuseema, RD Circuits
- Mulugeta Abtew, Sanmina
- Kevin Zhang, Sytech
- Tarja Rapala, TTM
- Marika Immonen, TTM
- Timo Jokela, TTM
- Alan Cochrane, TUC

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Back-up Slides

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Coupon Fabrication / Testing Matrix

Description	Quantity
Number of production panels : Ideal Minimum	 12 6
Number of unique coupon designs per sub-panel (3 depths x 3 grids) + 1x Introbotix coupon + 2x BD coupon	12
Total number of coupons Ideal (12 production panels x 4 subpanels x 12 coupon designs) Minimum (6 production panels x 4 subpanels x 12 coupons designs)	 576 288
Quantity per coupon design : Ideal Minimum	 48 24
Capacitance Measurements: "As-received" Preconditioning using reflow oven Preconditioning using IST	 8 8 8
IST testing (after capacitance measurements)	24

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Project Scope: Three Phase Project

- ***Phase 1:*** Assessing the backdrill situation in the Industry through a 1:1 survey. All inputs will be company coded to keep all data anonymous.
  - Part 1: OEM/ODM Survey to document what design tolerances/stub lengths are being designed into products now and 3 years into the future.
  - Part 2. PWB Fabricator Survey to document what problems manufacturers see in supporting the level of technology/tolerance and what would be needed to comply with the requirements.

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Project Scope: Three Phase Project

- ***Phase 2:*** Test and verify the reliability and capabilities of backdrill designs. This will be done by designing electrically tested coupons and test vehicles that will be built and tested by the project. (micro-sectioning only as needed to verify ET results)

- ***Phase 3:*** Develop a realistic set of design guidelines based on reliability data for the OEM designs.

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