Bruker ContourSP
Multi-Chip Module/High Density Interconnect PCB Substrate
High Volume Inspection for Process Monitoring

Atomic Force Microscopy
3D Optical Microscopy
Tribology
Automated AFM
Stylus Profilometry
Mechanical Testing, Nanoindentation

Innovation with Integrity
Overview

• **Introductions**

• **Multichip Module High Volume Inspection**
  • **Industry Problem**: Smaller features, higher density – yield challenge
  • **Bruker Solution**: ContourSP for substrate panel metrology
  • **Example Applications**: Provide some examples of features, metrology

• **Summary/Q&A**
Introductions
Bruker Nano Surfaces Division

- Scanning Probe Microscopy
- 3D Optical Microscopy
- Stylus Profilometry
- Tribology and Mechanical Testing
Introductions
Bruker Stylus and Optical Metrology

- Technology Leadership
  - 60+ Patents
  - 3 R&D 100 Awards
  - 6 Photonics Circle of Excellence Awards

- Manufacturing Excellence
  - Lean, six sigma-based process
  - >100 systems/quarter capacity
  - Rapid production ramp capability

Bruker NSD SOM is part of Bruker Materials (BMAT), a division of Bruker
Introductions

Speaker

Matt Novak, Ph.D.
Director, Technology and Applications
Stylus and Optical Metrology

- Joined Bruker 2011 (3 years)
- Industry experience (17 years) optical engineering, fabrication and metrology
- Earned Ph.D. while working in private sector metrology capital equipment (instrument design/assembly/test)
Who Will Benefit?

Intended Webinar Audience

- People interested in fast, non-contact metrology to quantify production quality of relevant features for PCB substrate manufacture

- Those unfamiliar with PCB substrate/multi-chip modules will have gain a basic understanding of this technique for saving space and also how Bruker’s ContourSP can help in their production

- Those looking for metrology to monitor changes in surface topography from nm to µm scales with accuracy and repeatability for other process monitoring will see a specific example for a market area with common needs
What is a PCB?

• A printed circuit board (PCB) mechanically supports and electrically connects electronic components using conductive trace, pads and other features etched from copper sheets laminated onto a non-conductive dielectric.
Substrate is the interface between PCB and IC Chip, the most advanced technology among PCB industry.

Bruker SP systems only sold to Substrate Manufacturer.
Types of PCB

- Conventional PCB
  - Single Sided
  - Double Sided
  - Multilayers

- HDI PCB

- Rigid–Flex PCB
HDI (High Density Interconnector)

- HDI PCB is defined as a PCB with a higher wiring density per unit area than conventional PCB.

- HDI PCB has finer lines and spaces, is made through Micro Via (< 150um diameter) and buried vias, sequential lamination with insulation materials and conductor wiring for higher density of routing.
HDI – MCM

Advanced substrate technology enables MCM

High Density Interconnect, Multi-Chip Modules are...

• Multiple chips, dies, discrete elements
• All on one substrate, attached to PCB
Challenge: Smaller means High Density
Increased Demands on Metrology Tools

Convergence / Integration
• Mobile Ubiquity
• Higher Quality Display, U/I
• Cost / yielded Product

Higher I/O Density
• Thermal Management
• Z-axis constraints
• Cost / yielded Part

Smaller/Higher Density Features
• Greater complexity (more layers, fiber reinforcement, etc)
• Increasingly thin
• Increased Cost / yielded bumped, singulated board

Metrology Capability
• Smaller/denser features
• Thinner boards
• Expanding range of measurements, GR&R

Cost / Measured Panel
• Higher Throughput
• Max. Up-time MTBF
• Minimum recipe/ deployment time
• Maximize operator efficiency
Trend Towards Finer Features
Increased Value/Chip – Drives Metrology Demand

Semi Growth forecast: CAGR of 4.1 per cent from 2011-2016, reaching $368 billion in 2016 (IDC Jan 13).
Defects and CD Variations of Any Layer Can Decrease Performance, Lower Yields, and Increase End of Line Scrap and Product Cost
ContourSP HDI PCB Substrate Metrology
Comprehensive High Volume HDI/MCM Substrate Analysis

Ra Surface Roughness

• Accurate & repeatable 3D Ra
• Inner-Core, build-up, Dielectric and other important process layers

Trace Analysis

• Width, height, and spacing of traces on a flat substrate
• Needle density calculations (similar to anchor calculations)
**Overlay Analysis**

- Measure relative concentricity to detect shifts in layer alignment
- 3D analysis used to avoid focus variation problems

**Surface Anchor Ra Analysis**

- Number of anchor regions
- Area of each region
- Anchor region depth
- Anchor volume
ContourSP HDI PCB Substrate Metrology
Comprehensive High Volume HDI/MCM Substrate Analysis

Advanced VIA Analysis

- Depth, top and bottom diameter
- Roughness of anchor & via regions
- **Dynamic Signal Segmentation** for accuracy in Presence of Fiber Layers

Circle Connect Analysis

- Finds and measure center and diameter of circular features
- Measure lines extending from or connecting circles
Pad Clearance Analysis

- Calculates the gap (clearance) between the edge pads and the closest panel feature

Auto Alignment & Critical Dimension Analysis

- Easy set-up of a large variety of fiducials for automated alignment
- Optional s/w ensures fast, accurate location of desired features
Panel Recess (Dimple) Analysis

- Measurement of “dimples” on the central features
- Depth of recess of the dimple
- Thickness of the pad on which the dimple is located

Solder Mask & Opening Analysis

- Dimensions and heights of mask, pads and substrate within the mask
- Displays the relative heights of all features the x and y dimensions or diameter of the mask and pad features
Dynamic Signal Segmentation

- Patent-pending method uses enhanced signal from interferometry
- Separates out Signals from
  - Substrate
  - Fiber Layer
  - Bottom Beneath the Fibers
- Calculates
  - Shelf Depth
  - Shelf Width
  - Bottom Diameter
  - Length of Residual Fiber

Provides Most Accurate Bottom VIA Diameter and Residual Fiber Length Analysis For Reinforced PCB Substrates
ContourSP HDI PCB Substrate Metrology
High Efficiency, Streamlined Next Generation Metrology

- Streamlined, Easy to Use Software Interface
- 64 bit multi-core processing
- Enhanced **Ease of Use and Stage Automation Creation**
- **Recipe Copy Exact on EVERY Tool**
- Fastest set up of Panel Automation
- Overall enhanced system for most efficient operation
ContourSP HDI PCB Substrate Metrology
Interface Display Key Features
ContourSP Performance
Critical Panel Metrology Specifications – Features + Uptime

<table>
<thead>
<tr>
<th>Performance Metric</th>
<th>ContourSP Spec</th>
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<tbody>
<tr>
<td>E-MCBF Availability (supplier dependent uptime) [Per SEMI E10]</td>
<td>3000 &gt; 98%</td>
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<tr>
<td>P/T Repeatability</td>
<td>&lt;20%</td>
</tr>
<tr>
<td>P/T Reproducibility</td>
<td>&lt;30%</td>
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<tr>
<td>Min Trace Width</td>
<td>5 µm +/- 2 µm</td>
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<tr>
<td>Min Trace Height</td>
<td>10 µm +/- 3 µm</td>
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<tr>
<td>Min Trace Spacing</td>
<td>5 µm +/- 2 µm</td>
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<tr>
<td>Cu Roughness</td>
<td>200 nm +/- 50 nm</td>
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<tr>
<td>ABF Roughness</td>
<td>300 nm +/- 50 nm</td>
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<tr>
<td>Solder Roughness</td>
<td>60 nm +/- 20 nm</td>
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<td>Min Alignment &lt;dX, dY&gt;</td>
<td>&lt; 20 µm</td>
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<tr>
<td>Min Via Top Diameter</td>
<td>30 µm +/- 5 µm</td>
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<tr>
<td>Min Via Depth</td>
<td>20 µm +/- 6 µm</td>
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<tr>
<td>Max Via Recess</td>
<td>10 µm</td>
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ContourSP Performance
Critical Panel Metrology Specifications – Throughput

Committed Performance
(82 Total Scans)

Default Recipe
Measure 13 Unit per Side:
A. Five features per unit
   1. Trace
   2. Cu Roughness
   3. Solder Resist Openings
   4. Via Recess
   5. Via Depth
B. Sixteen (16) Alignment Coupons
C. One notch ID vision measurement

ContourSP Spec
TPT < 30 minutes (2 Panel Sides Per Hour Runrate for Default Recipe)
200% faster than previous generations!
ContourSP Performance
Further Feature and Differential Capabilities

- Able to Measure Panels with Warp up to 6 mm

- Automated Notch ID read for Panel Identification (Option)

- Advanced custom fixture designs
  - Over 20 years experience developing optimized fixture solutions for customer’s specific requirements
  - Latest custom design delivers >5X improvement on feature GR&R

- Integrated ESD protection
Value to Business

ContourSP and Applications

ContourSP Applications

- Measurement of HDI / MCM PCB substrates for features and surface characterization

<table>
<thead>
<tr>
<th>High pin count DSP’s, Network Processors and Micro Processors</th>
<th>Packaging / Assy Houses</th>
<th>Substrate Providers</th>
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<tr>
<td>Intel</td>
<td>Renessas</td>
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<td>Nvidia, Broadcom</td>
<td>Samsung</td>
<td>TSMC</td>
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Bruker BNS – SOM BU
Worldwide Presence - World Class Support
ContourSP Summary + Q&A
Comprehensive Metrology for HVM HDI/MCM PCB Substrates

- Moore’s law + advanced packaging enabling higher density / higher functionality System On Chip (SoC) IC’s

- In-line HDI/MCM PCB substrate metrology critical to ensure functionality and performance of high-value products

- Bruker’s 5th generation ContourSP provides...
  - Comprehensive portfolio of HDI/MCM PCB substrate measurement and analysis capability in Vision software
  - Highly accurate, gage-capable measurement performance with new vibration tolerant design
  - Bruker’s global sales, service and support network as a key value to users offered in this market
Questions?

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Thank You