Seamless Tape Wire Probe Architecture with Fully-automated Design and Manufacturing Systems for High-end Probe Cards

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Overview

• Introduction and Background
• Objectives
• Seamless Tape Wire Probe Architecture
• Selectable Probe Architecture in the AMMECS®
• Application to LCD driver IC and 3DIC/TSV
• Entire Automatic Design and Manufacturing Systems
• Summary
ProbeAce Work So Far

- Established in 1999, and started researching a new probe card design and manufacturing methodology.
- Proposal of the AMMECS® method (SWTW2013)
  - Geometrical challenges with mechanical solution
    - Multi-probe needle structure in a single sheet as the basic high density probe architecture
    - Precise tip motion controllable structure as the mechanical solution
  - Challenging probe card application:
    - High pin count with ultra fine pitch (>1700pins, 14um-pitches)
    - Fine pitch area array (40um, 1200pins)
  - Achieved the basic automation technologies
    - Automatic probe assembly technology
    - Automatic Cu-wiring technology
Background

- **Geometrical limitation**
  - Trends towards finer pitch, higher I/O-count and higher speed.
  - Fine-pith<15um, pin-count>2K (LCD driver as a typical model)
  - Fine-pitch area array (TSV array in 3DICs as a typical model)
  - Mechanical and electrical performance must be filled, as well.

- **Manual probe assembly and Dense wiring problems**
  - Multilayer PCB and Interposers lead to high cost wiring.
  - Many skilled hands are needed, for both “manufacturing process” and “per-pin maintenance” even in advanced probe cards.(limitation)
Objectives

• Seamless wire probe architecture for HVM
  – Effective technology for dense probe assembly and wiring method

• Probe maintenance technologies
  – Probe-tip correction combined with the probe analyzer
  – Per-pin replaceable in the manufacturing system

• Advancing the AMMECS® for various test application
  – Selectable probe architecture to cover the test requirements

• Accomplishing the entire automation technologies
  – PA’s original automation technologies of design, manufacture, probe card test, and maintenance.
Seamless Tape Wire Probe Architecture: What for?

Solution of
- Probe geometry
- Wiring density
- Hand wiring

Conventional cantilever

Seamless tape wire probe

STWP
What is the Seamless Tape Wire Probe Architecture?

The “seamless” includes two meanings.

1. “Seamless” structure from a probe tip to a terminal pad for tester.
2. “Seamless” on-line manufacture from a probe tip to a terminal pad for tester.
“Seamless” Wire Probe Structure

Fine-pitch Assembly
- Dense staggered array

Tape-feeder / Position controller

Wire-probe

Probe Laser fabrication

Tape wire
- Be-Cu thin tape with Insulation coating

Terminal soldering

Cross wiring

Route-control and fixing machine

Low multilayer PCB

Pogos to tester

Soldering machine
“Seamless” Wire Probe Structure

- “Seamless” structure from a probe tip to a terminal pad for tester, or other assigned point.
  - A long tape Be-Cu with insulation coating as a material
  - The tape thickness is totally 10 um including the insulation coat, and the width is 1.4mm at maximum in this study.
  - The probe shape is laser-fabricated precisely “on-site”.
  - Each wire-probe is arranged and fixed at a prescribed position.
  - Wire-end is soldered on the terminal or other assigned pad.
  - Each wiring route is designed and programmed beforehand.
  - Each wire-probe is fixed with adhesive at key points.
  - Each wire-probe can be replaceable even after completing.
Design and Manufacturing Process

Customer's Spec
- Probe-XY
- Pogo-XY
- Terminal-XY

Wiring route design by Routing Software

Design Process
- CAD data
- Probe shape design with precise tip motion controllable structure

Automatic Manufacturing Machines
- Tape-feeder / Position controller
- Laser fabrication
- Be-Cu thin tape with insulation coating
- Probe assembly
- Wiring and Fixing
- Soldering
“Seamless” On-line Manufacture

• Design process:
  1. Input all probe-tip-XY and terminal-pad-XY coordinates.
  2. Design a probe shape to meet the optimal Fc, OD and Scr.
  3. Design each optimal wiring route and fixing points.
  4. Assign some specific rotational points of the Be-Cu tape, for allowing cross wiring on one surface layer on the PCB, and complete the CAD data.

• Manufacturing process flow:
  1. A Be-Cu tape set and the process started by tape-feeding.
  2. #1-wire-probe shape is laser-fabricated.
  3. The probe part is fed to the assigned position and fixed.
  4. The tape-wire is fed along the assigned route to the assigned position.
  5. The wire-end is fixed with solder on the pad.
     • The soldering can be enforced in the batch process.
     • The tape-wire is fixing by adhesives at key-points en route.
  6. #1-probe process is finished after the tape-wire laser-cut.
  7. Repeated from #1- to #n-probe.
Selectable Probe Architecture in AMMECS®

- **Multi-probe on a single sheet architecture**
  - A combination of the multi-probe structures can be applicable to dense staggered peripheral array or dense area array.
  - Also useful to HF test, and ultra-low leakage current measurement in DC parametric test.

- **Seamless tape wire probe architecture**
  - Thin tape material enables ultra-fine-pitch probe assembly.
Selectable Probe Architecture in AMMECS®

- **Combination of the multi-probe structures and seamless tape wire probe structures**
  - LCD-driver IC is a typical model of fine-pitch, high-pin-count probe card with high data speed pins.
  - A combination of the multi-probe structures and seamless tape wire probe structures is a practical solution.
  - The multi-probe structures for high frequency signal pins, and the seamless tape wire probe structures for LCD-out pins of ultra-fine-pitch.
## Probe Card for LCD driver IC

<table>
<thead>
<tr>
<th>Probe Card Specifications</th>
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<tbody>
<tr>
<td>Total Pin-count</td>
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<tr>
<td>Min. probe pitch</td>
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<tr>
<td>Overdrive</td>
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<tr>
<td>Scrub</td>
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<tr>
<td>Contact Force</td>
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<tr>
<td>Accuracy</td>
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<tr>
<td>Planarity</td>
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<tr>
<td>Cont. Resistance</td>
</tr>
<tr>
<td>Path Resistance</td>
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<tr>
<td>Max. Current</td>
</tr>
<tr>
<td>Leakage</td>
</tr>
<tr>
<td>Data Speed</td>
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<tr>
<td>Material of wire-probe</td>
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Application Example to 3DIC/TSV

- Example of Wide I/O DRAM which has an area array of 40 x 50 um-pitch and 1200 bumps.
  - The tape wire probe is placed with some proper angle to the XY coordinates of bump.
  - Each probe part is automatically fed to the assigned position, to meet the TSV bump-XY positions.
Available Options in the AMMECS® for Test Application

<table>
<thead>
<tr>
<th>Probe Card Architecture</th>
<th>Test Application</th>
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<tbody>
<tr>
<td></td>
<td>LCD driver</td>
</tr>
<tr>
<td></td>
<td>LCD-out</td>
</tr>
<tr>
<td><strong>Needle(s) on a sheet</strong></td>
<td><strong>Single</strong></td>
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<tr>
<td></td>
<td></td>
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<tr>
<td><strong>Multiple</strong></td>
<td><strong>Single layer</strong></td>
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<td></td>
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<tr>
<td><strong>Multi layers for HF etc.</strong></td>
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(*) Note: Seamless tape multi-wire-probes on a sheet (Future work)
Entire Automatic Design and Manufacturing Systems

- Automatic route design software
- Automatic manufacturing system for multi-probe assembly, and Cu-wiring (in the last year)
- Automatic manufacturing system for STWP, including:
  - wire probe laser fabrication, probe assembly, wiring and fixing and soldering.
- Probe tip polishing machine
  - for easy image recognition of probe-tip and tip-alignment in the existing prober
- Probe card analyzer and tip-position-corrector
Probe Card Analyzer and Corrector

- PA’s original Probe Card Analyzer and Tip-corrector for dense probe array
  - XYZ-tip-position, Contact resistance, and Leak current test
  - Probe-tip positioning correction
Probe-tip Positioning Correction

- Based on PA's original positioning correction process
  - A thin template is embedded beforehand in all probe-tip part.
  - Manipulating the template, to be shifted in the x- or y-direction with adding some plastic deformation to the defect probes
  - The precision is within +/-3um from target positions.
## Advancement of the AMMECS® method

<table>
<thead>
<tr>
<th>AMMECS method</th>
<th>Solution</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Multi-probe needle structure on a sheet</td>
<td>Geometrical, Electrical</td>
<td>Fine-pitch and high-count arrays, HF: strip lines and micro strip lines</td>
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<tr>
<td>2. Seamless Tape Wire Probe Architecture</td>
<td>Geometrical, Dense wiring</td>
<td>Ultra-fine-pitch and high-count arrays, Low cost wiring, Free from high multilayer substrates</td>
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<tr>
<td>3. Precise tip motion controllable structure</td>
<td>Mechanical, Geometrical, Maintenance</td>
<td>Optimization of Fc, OD, and Scr, Small touchdown area, Prevent contamination and pad damage</td>
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Achieved in this study

Achieved in 2013

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Summary

• Seamless wire probe architecture was achieved.
  – Solutions of probe geometrical and wire density problems
  – Seamless structure and manufacture: a series of probe fabrication, probe assembly, and wiring from probe-tip to any prescribed point
  – Free from manual probe assembly and hand wiring

• Probe maintenance technologies can be available.
  – Probe-tip correction method combined with the probe analyzer
  – Per-pin replaceable in the seamless wire probe architecture
Summary

• **Probe Card for high-end LCD driver ICs**
  – Fine-pitch of 14 um, more than 2000 pins probe card, using new STWP architecture

• **Advancement of the AMMECS® method for various test application**
  – Selectable probe architecture to cover the test requirements

• **Accomplished the entire automatic systems**
  – PA’s original automation technologies of design, manufacture, probe card test, and maintenance.
Thank you!

- Please contact us with any questions ...

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