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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

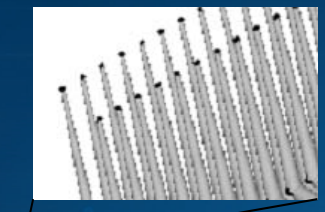
Background

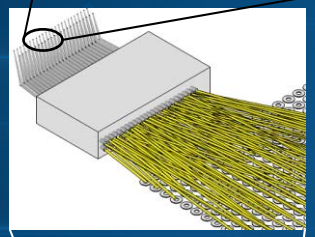
- **Geometrical limitation**
  - Trends towards finer pitch, higher I/O-count and higher speed.
  - Fine-pith<15um, pin-count>2K (LCD driver as a typical model)
  - Fine-pitch area array (TSV array in 3DICs as a typical model)
  - Mechanical and electrical performance must be filled, as well.
- **Manual probe assembly and Dense wiring problems**
  - Manual probe assembly and hand wiring cause degradation and dispersion in quality, and decrease in yield.
  - 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.

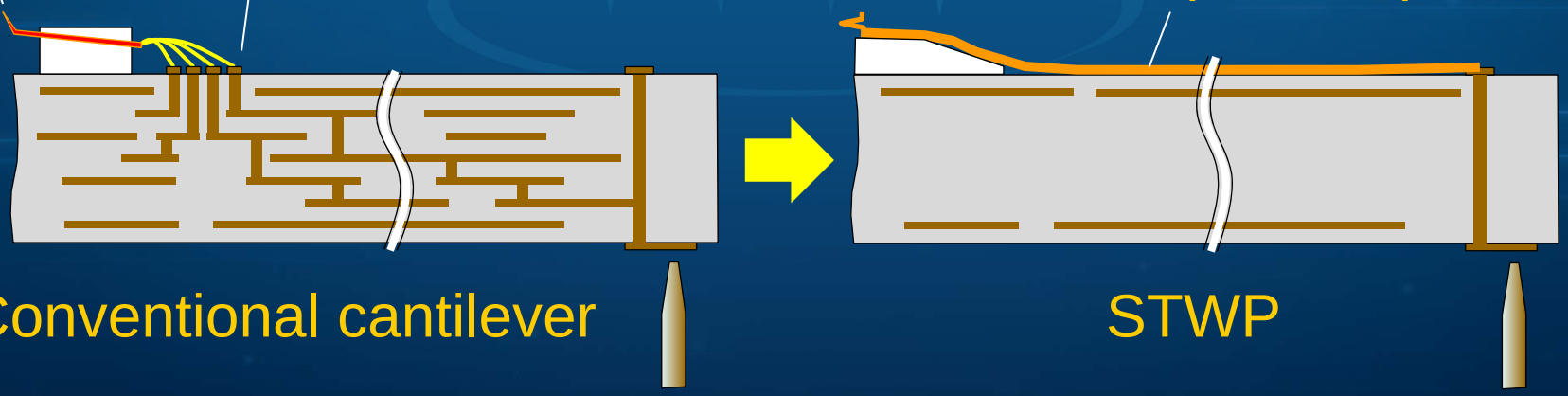
Seamless Tape Wire Probe Architecture: What for?





Solution of

- Probe geometry
- Wiring density
- Hand wiring

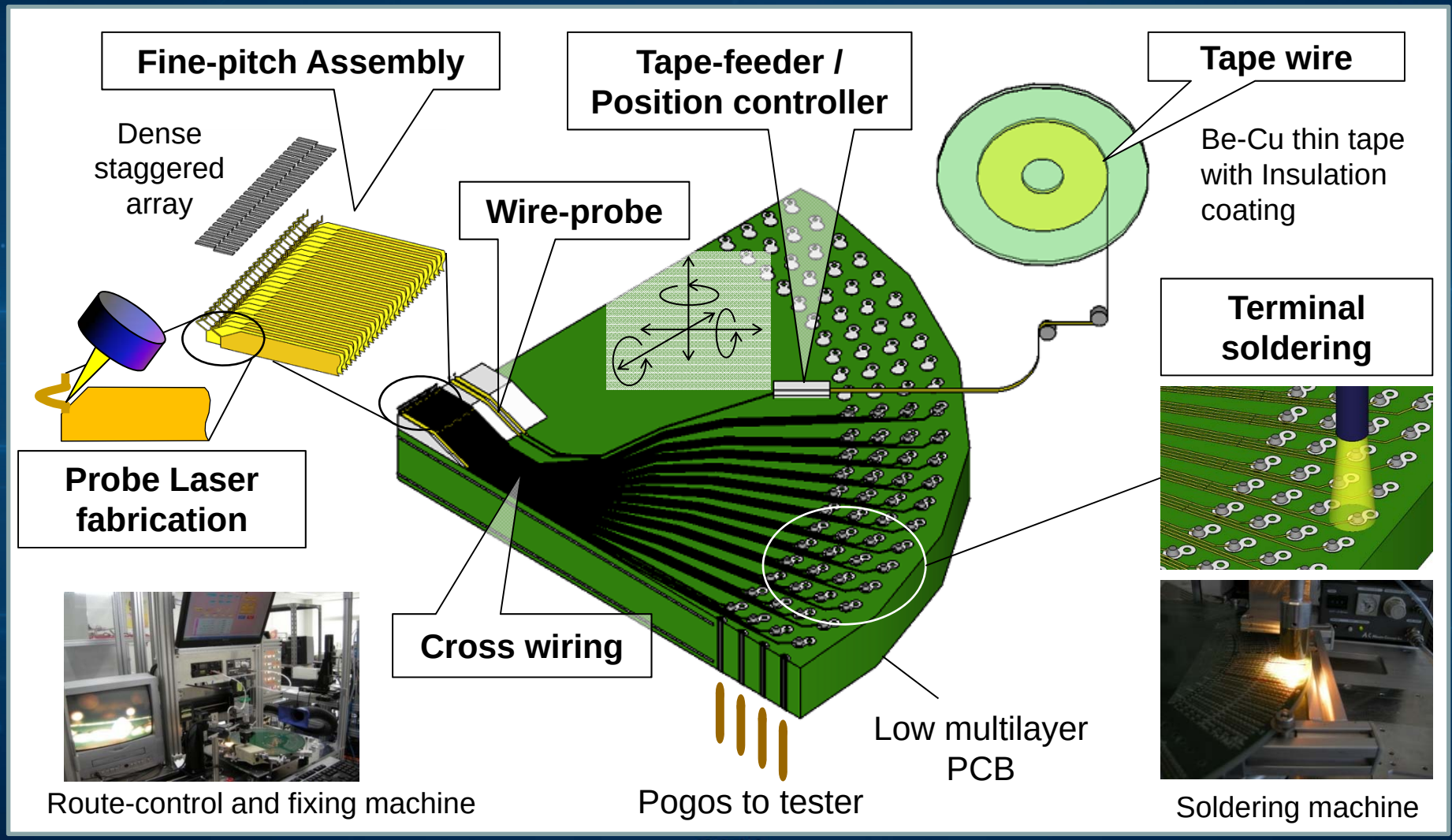


What is the Seamless Tape Wire Probe Architecture?

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



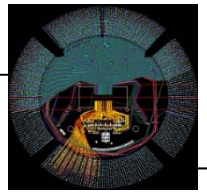
“Seamless” Wire Probe Structure

- **“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

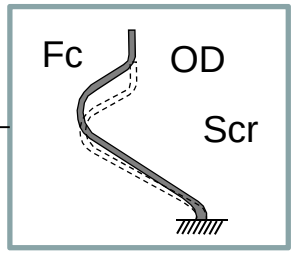
Probe-XY
Pogo-XY
Terminal-XY



Wiring route design
by Routing Software

Design Process

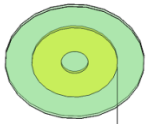
CAD data



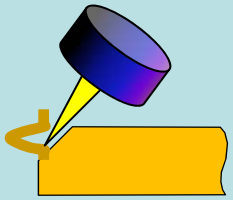
Probe shape design with precise tip motion controllable structure

Automatic Manufacturing Machines

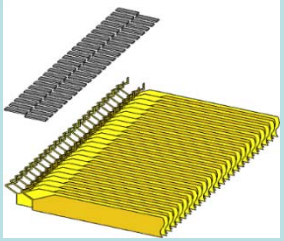
Tape-feeder / Position controller



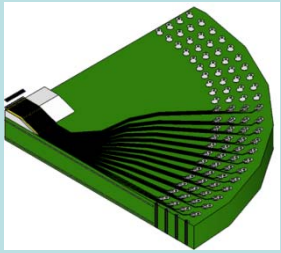
Be-Cu thin tape with insulation coating



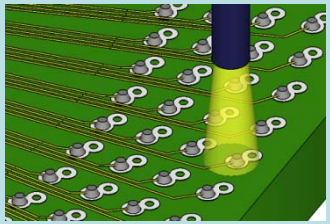
Laser fabrication



Probe assembly



Wiring and Fixing



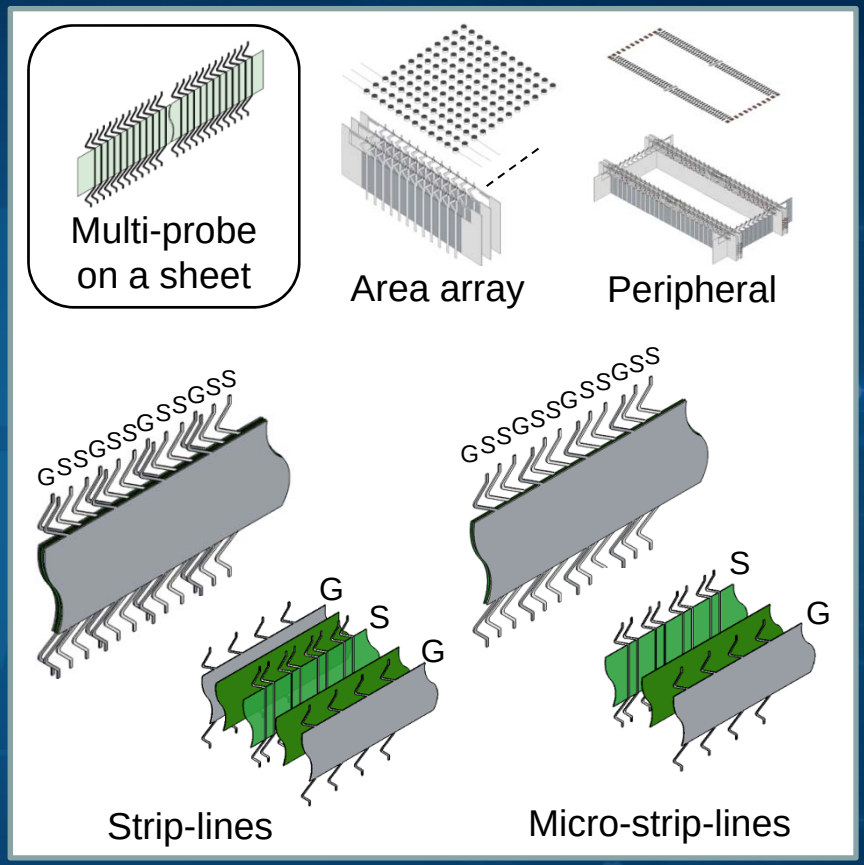
Soldering

“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®

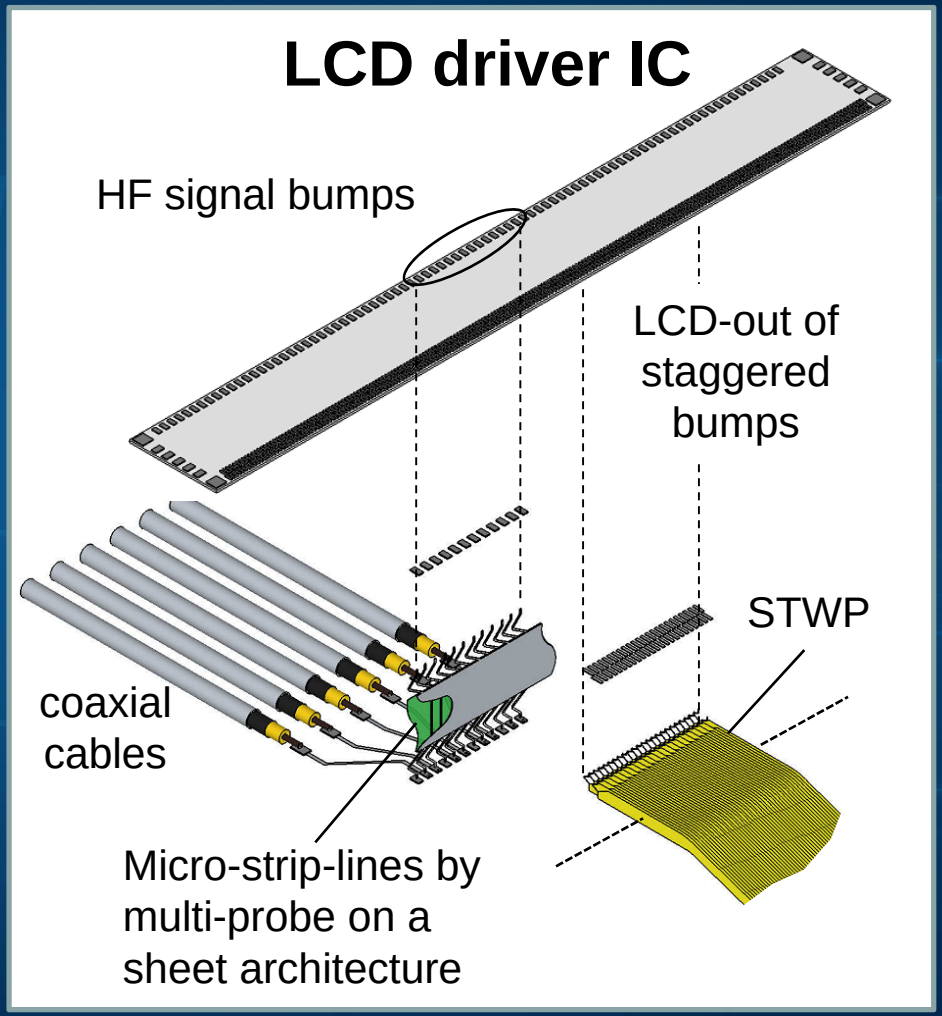
- **Multi-probe on a single sheet architecture**
  - A combination of the multi-probe structures can be applicable to dense staggered peripheral array or dense area array.
  - Also useful to HF test, and ultra-low leakage current measurement in DC parametric test.



- **Seamless tape wire probe architecture**
  - Thin tape material enables ultra-fine-pitch probe assembly.

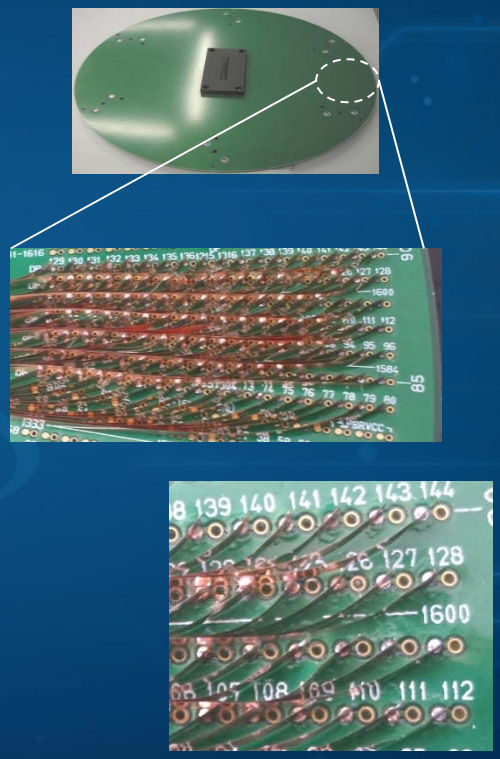
Selectable Probe Architecture in AMMECS®

- **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.



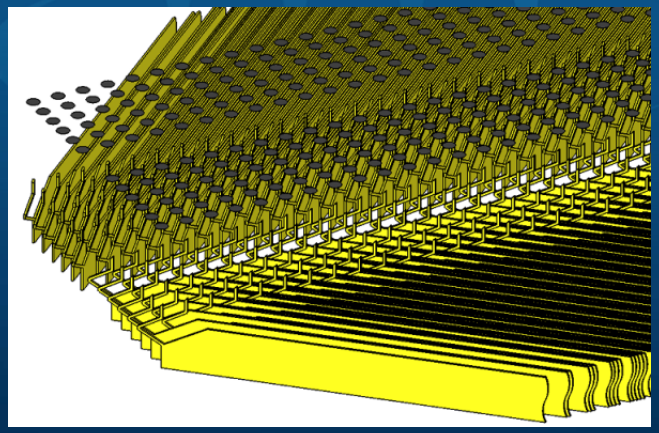
Probe Card for LCD driver IC

Probe Card Specifications	
Total Pin-count	2030 pins
Min. probe pitch	14um/1800pins
Overdrive	30um/RV, 45um/max
Scrub	< 3um
Contact Force	8mN/30umOD
Accuracy	+/-3um
Planarity	< 5um
Cont. Resistance	< 0.5 ohm
Path Resistance	< 2.5 ohm
Max. Current	350mA
Leakage	< 20nA/10V
Data Speed	2Gbps
Material of wire-probe	Be-Cu



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

Probe Card Architecture			Test Application							
Needle(s) on a sheet	Probe layer structure	Wiring and connection method	LCD driver		3D/ TSV	Memory wafer	Logic	CIS	DC Para-metric
			LCD-out	HF					
Single	Single layer	Direct to PCB		*		*	*	*	
		STWP	*		*	*	*	*	*
Multiple	Single layer	Direct to PCB		*		*	*	*	
		Probe to Cu-wire	*		*	*	*	*	
		Multi-STWP(*)			*	*	*	*	
	Multi layers for HF etc.	To HF patterns or wires		*	*		*		
		To Guard patterns							*
		Multi-STWP(*)			*		*		*

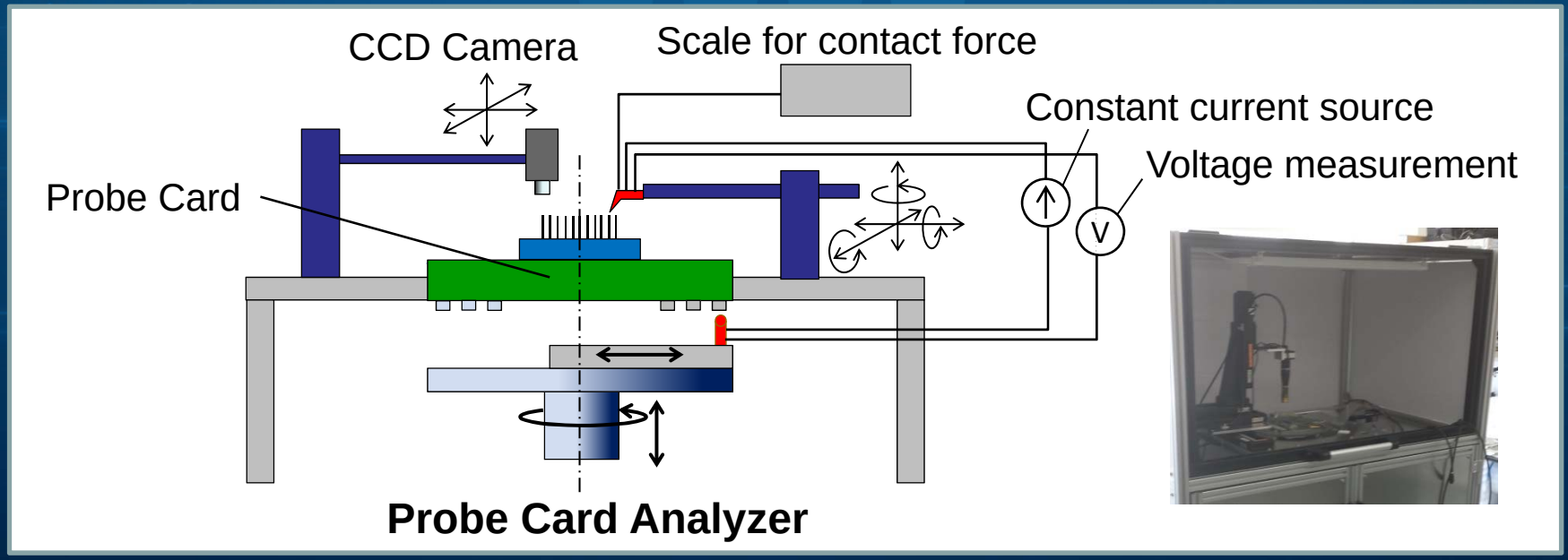
(*) Note: Seamless tape multi-wire-probes on a sheet (Future work)

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**

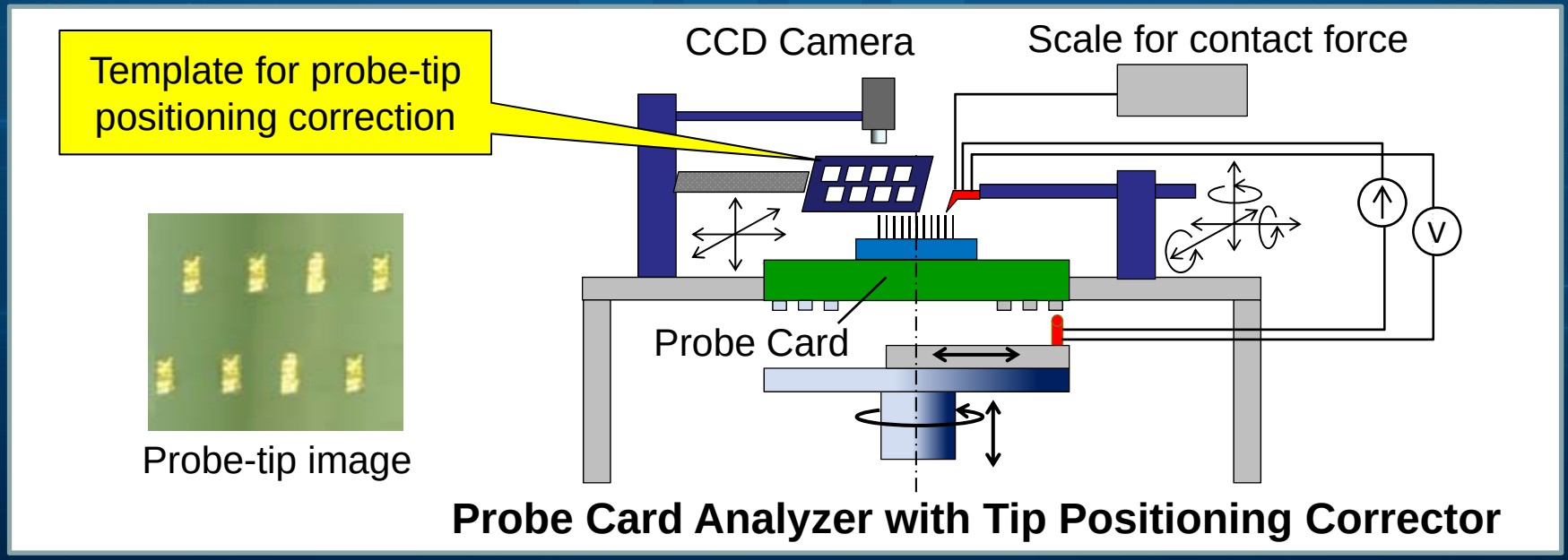
Probe Card Analyzer and Corrector

- **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

AMMECS method	Solution	Description
1. Multi-probe needle structure on a sheet	● Geometrical ● Electrical	● Fine-pitch and high-count arrays ● HF: strip lines and micro strip lines
2. Seamless Tape Wire Probe Architecture	● Geometrical ● Dense wiring	● Ultra-fine-pitch and high-count arrays ● Low cost wiring ● Free from high multilayer substrates
3. Precise tip motion controllable structure	● Mechanical ● Geometrical ● Maintenance	● Optimization of Fc, OD, and Scr ● Small touchdown area ● Prevent contamination and pad damage
4. Entire automatic design and manufacturing systems	● Geometrical ● High yield ● Maintenance ● Cost-effective ● Time-to-Market	● Free from manual probe assembly ● Free from hand-wiring ● Per-pin/wire replaceable ● Common material of Be-Cu thin sheet ● Common design and manufacture method

Achieved in this study Achieved in 2013

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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