SWTEST

PROBE TODAY, FOR TOMORROW

New concepts for yield improvements and selective repair of cantilever pins for Flash and DRAM probe cards

PacTech

member of nagase group

Thomas Oppert

PacTech-Packaging Technologies GmbH

June 2-5, 2019

Outline

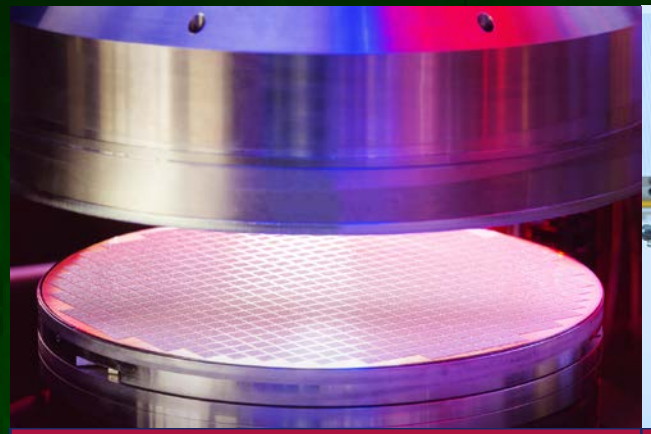
- Short Company Profile
- Introduction in Cantilever Assembly
  - General Process Flow & Specs
  - Improvements during 10 years manufacturing of cantilever bonder
- Temperature Control
- Selective Cantilever Repair/Rework
- Wire Soldering
- Summary/Outlook

Company Profile

- 1995 Founded in Berlin, Germany as spin-off from Fraunhofer-IZM
- 1997 1st Manufacturing facility: PacTech GmbH, Nauen, Germany
- 2001 2nd Manufacturing facility: PacTech USA Inc., CA, USA
- 2005 Equipment Field Service & Support Center, Thailand
- 2008 3rd Manufacturing facility: PacTech Asia Sdn. Bhd., Malaysia
- 2013 > 115 patents granted
- 2014 Demo Center Opening: Hsinchu, Taiwan
- 2015 Demo Center Opening: Shanghai, China
- 2015 100% owned by NAGASE & Co. Ltd.
- 2018 > 1,300 Production Machines shipped

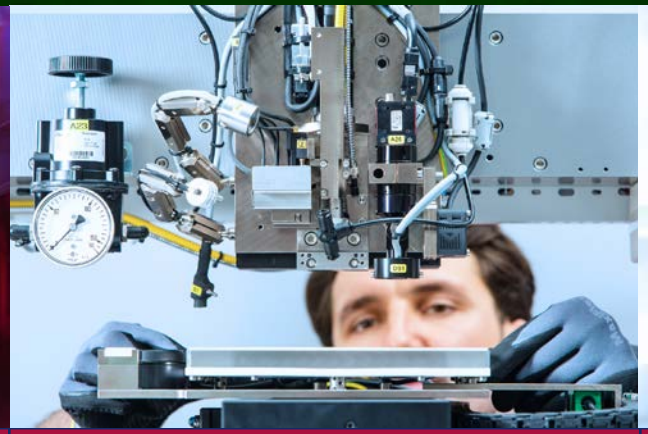
~ 420 employees

Company Profile



Wafer Level Packaging

+ Wafer Front Side Metallization
+ Solder Bumping
+ Wafer Backside Metallization
+ Backend & Die Sort
+ Wafer Inspection



Equipment

+ Wafer Plating & Wet Process
+ Laser Soldering
+ Solder Ball Placement
+ Flip Chip Assembly
+ Cantilever Assembly

Chemicals

+ Electroless Plating
+ Resists
+ Solvents

Certified ISO 9001, IATF 16949, ISO 14001, ISO 50001

Cantilever Assembly

Cantilever Bonding/Assembly

Process Flow:

Cantilever Assembly Line

Cantilever Sorter

Features

- ✓ Input: MEMS substrates
- ✓ Inspection of cantilever
- ✓ Laser cutting
- ✓ Placement of singulated cantilever in waffle packs

Solder Jetting: SB²-Jet

Features

- ✓ Solder Jetting on substrate
- ✓ Solder Balls sizes: 30 µm – 760 µm
- ✓ Solder alloys capability: PbSn, SnAgCu, AuSn

Cantilever Bonder: Laplace-Can

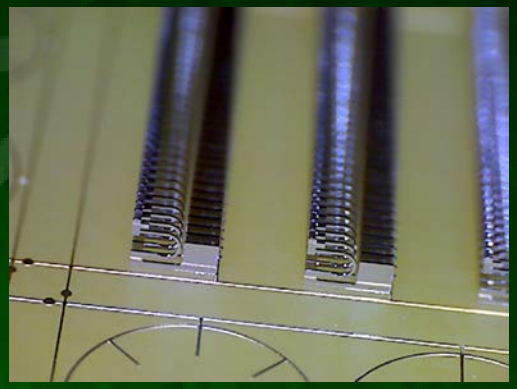
Features

- ✓ Cantilever supplied in waffle packs
- ✓ Cantilever pick & rotation in vertical position
- ✓ Substrate height measurement
- ✓ Dual camera for x, y alignment of cantilever to the substrate
- ✓ Probe tip z alignment
- ✓ Laser bonding of cantilever
- ✓ Post inspection (optional)
- ✓ Cantilever rework capability

Cantilever Bonder Specifications

- Linear axis or gantry system
- Probe card sizes up to 14 inch
- Alignment by precision optical system
- Tip correction (bend)
- IR laser for solder reflow
- Placement Accuracy: +/- 3.5µm
- Z height control: +/- 4.0µm
- Hump tilt: +/- 3.0µm
- Cantilever thickness: min 20µm
- Pitch: min 50µm
- Process suitable for complete card assembly and selective rework
- Post Bond inspection (optional)

Cantilever Assembly (xxµm pitch)



Cantilever Assembly (80µm pitch)

Cantilever Assembly (60µm pitch)

Improvements

Cycle Time Roadmap

2009
process development
first machine
<30 sec

2012
Mass production
<20 sec

2014
Mass production
<15 sec

2016
Mass production
<12 sec

2018
Mass production
<9 sec

2019
Mass production
< 8 sec

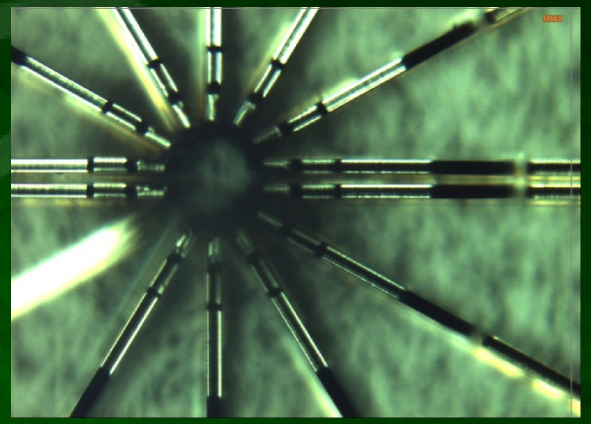
One cycle: Cantilever pick-up, Alignment, Bonding

Improvements

Machine Performance Data

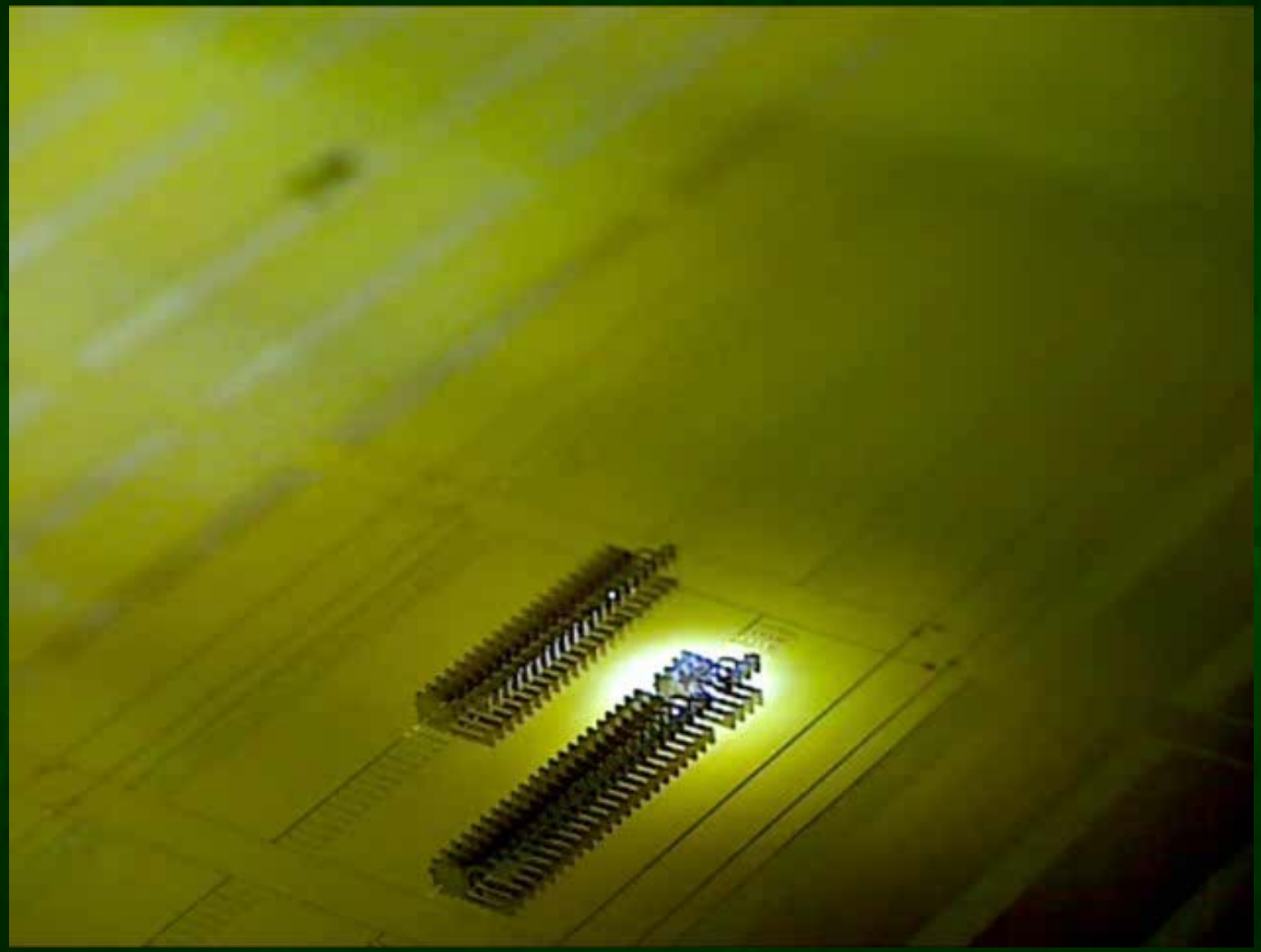
MTTF:	250 hrs for process (pin transfer alignment failure)
MTTF:	400 hrs for machine
MTTA:	Alignment failure < 2h
MTTR:	< 4h
Uptime:	95%
Cycle time:	8 sec for 1pin
Yield:	> 98% @ +/- 4um

22hr working condition; > 6,000pin bonded



Cantilever Assembly 360°

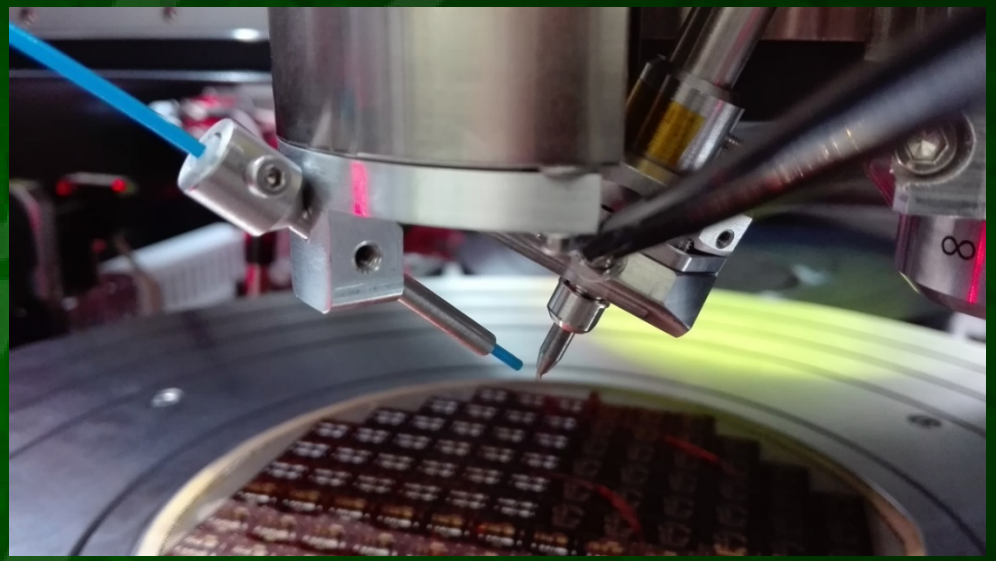
Video Cantilever Assembly



Temperature Control

Temperature Control Overview

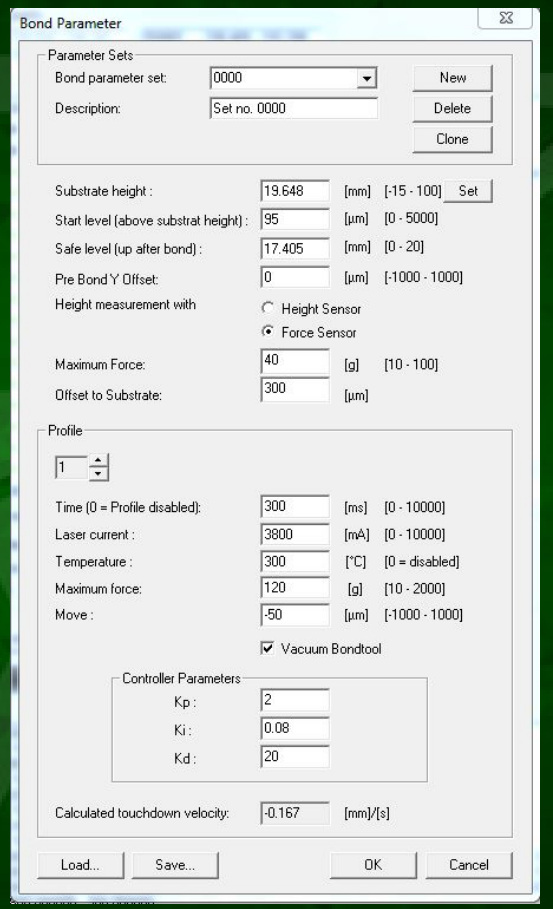
- Temperature is detected by a pyrometer
- Temperature is controlled by a PID software controller
- Temperature values can be set for each single bond profile step, as well as the controller parameters (Kp, Ki, Kd)
- Choice in between temperature control and simple laser value (current version) for each single bond profile step
- First successful tests have been finished (± 2µm accuracy)

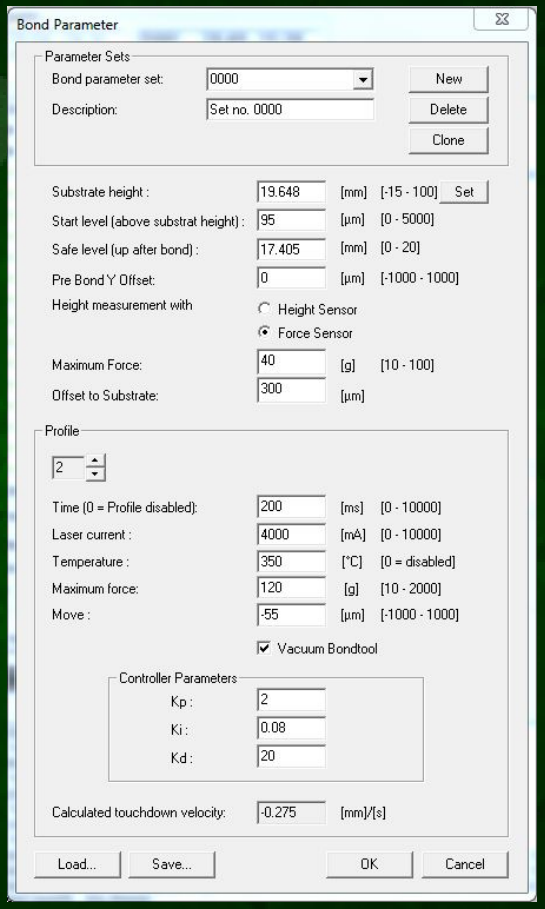


Bond Tool & Temperature Control Unit

Temperature Control Bond Parameter

- Examples of Temperature settings
- if the temperature value is zero, the laser parameter is used for this single step
- Setting of controller parameters (Kp, Ki, Kd) for each single step

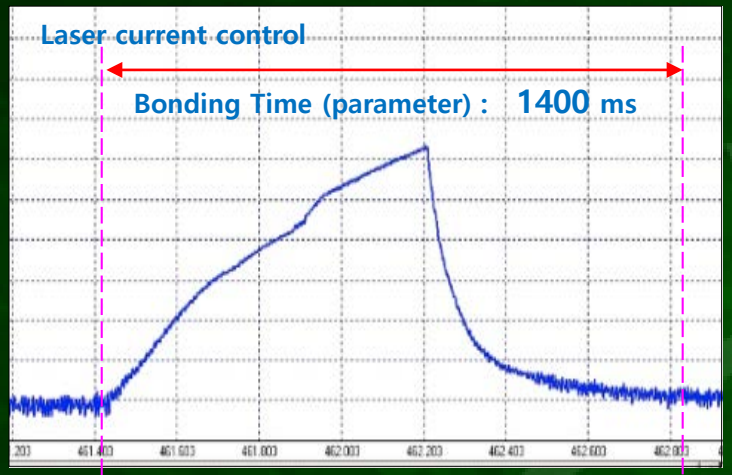


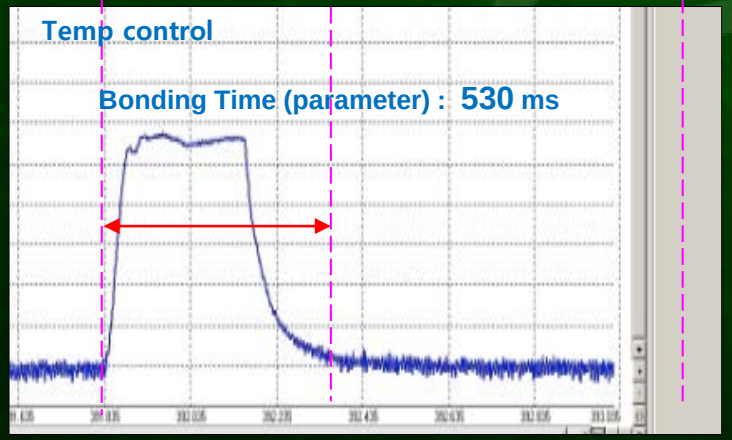


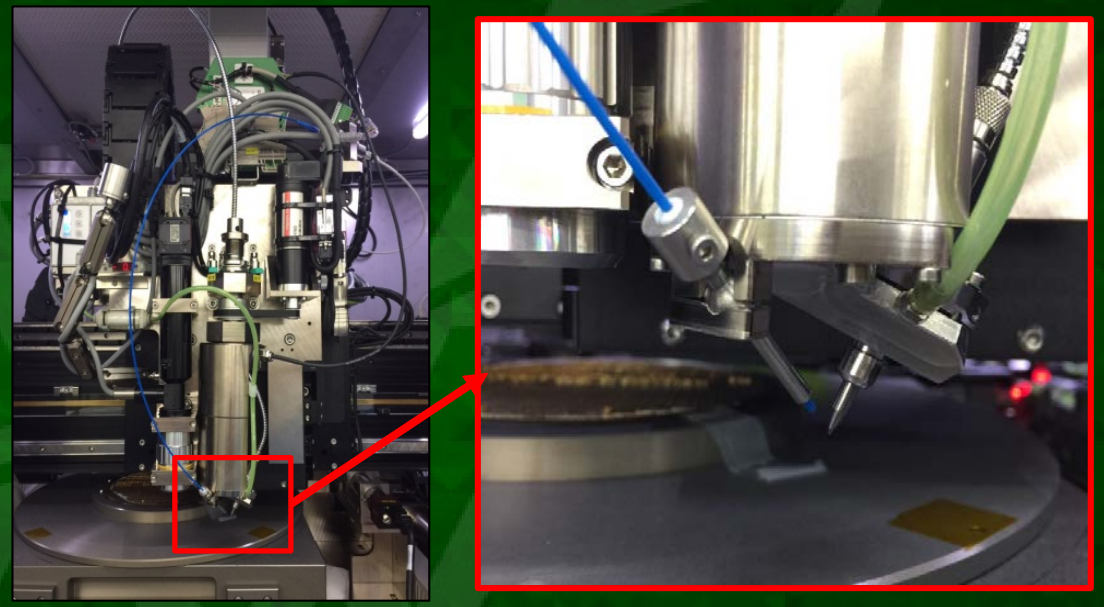
Laplace-Can Temperature Control Test

√ Laplace-Can Temperature Control

- Used temperature control (Original: Laser current control)





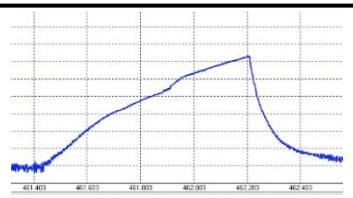
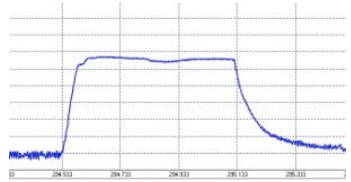
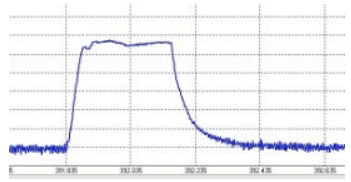
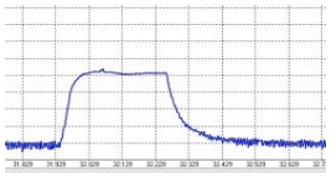
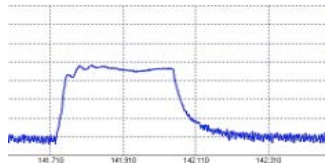


✓ Compare with Laser current control, the temp control show 0.8 sec less cycle time.

✓ New type bonder: EQ859
Expectation to reduce the bonding cycle time down to 6.8 sec in max case.

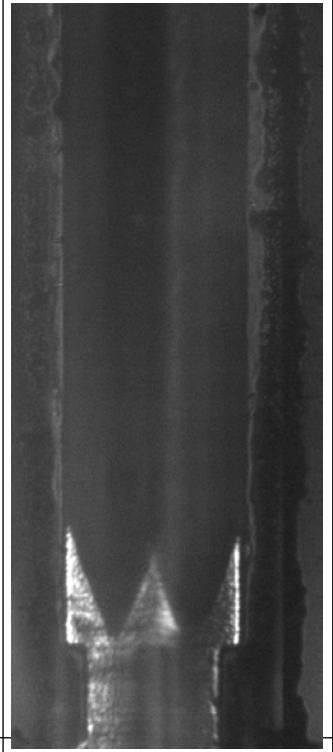
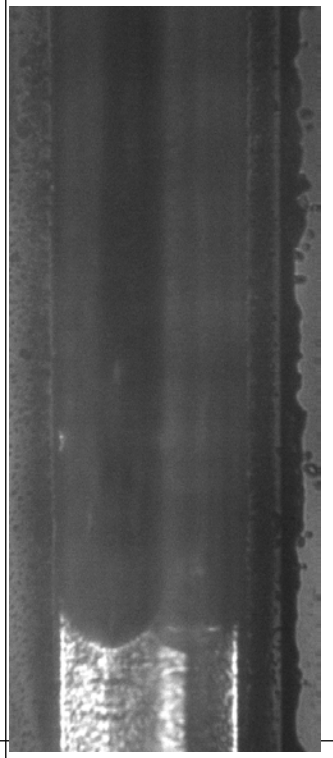
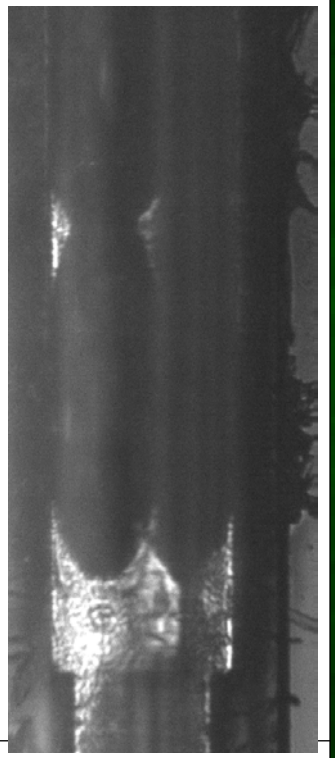
Laplace-Can Temperature Control Test

√ Temperature Control

	Profile	Temperature (℃)	Diagram
Laser current control	1	0 (=disabled)	
	2	0 (=disabled)	
	3	0 (=disabled)	
	4	0 (=disabled)	
Temp control 1	1	230	
	2	230	
	3	230	
	4	0	
Temp control 2	1	230	
	2	230	
	3	230	
	4	0	
Temp control 3	1	200	
	2	200	
	3	200	
	4	0	
Temp control 4	1	190	
	2	190	
	3	190	
	4	0	

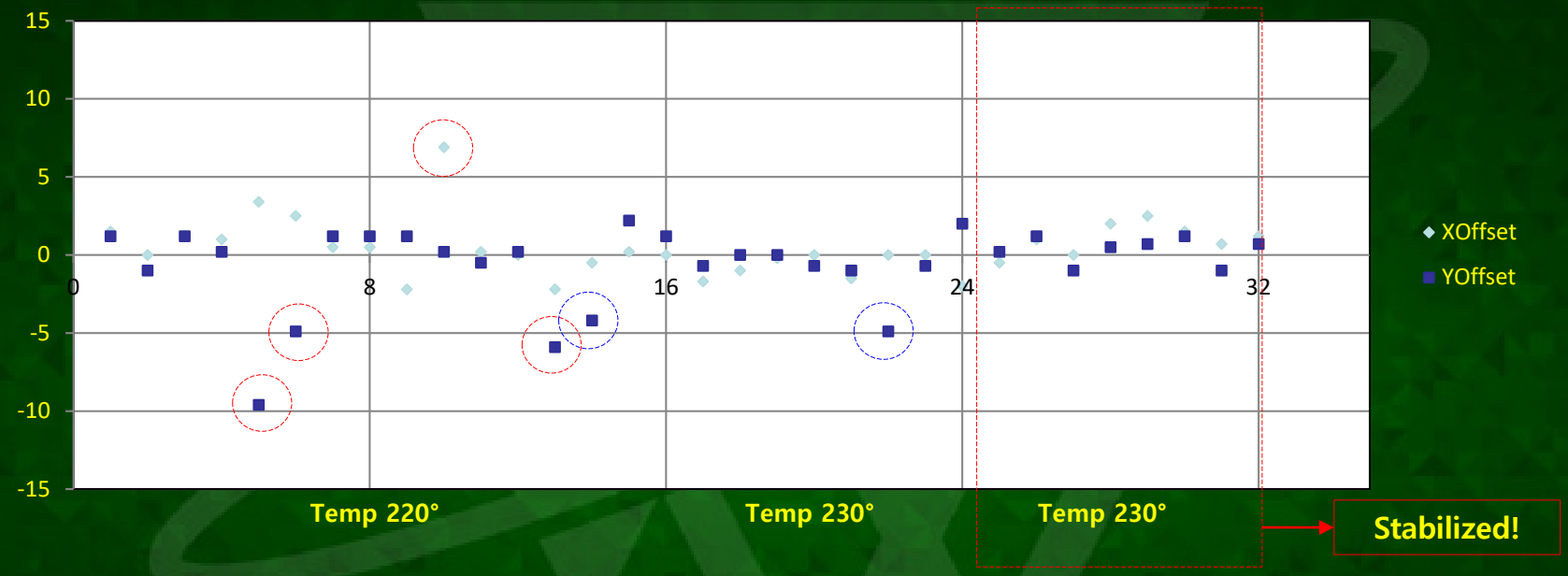
Laplace-Can Temperature Control Test

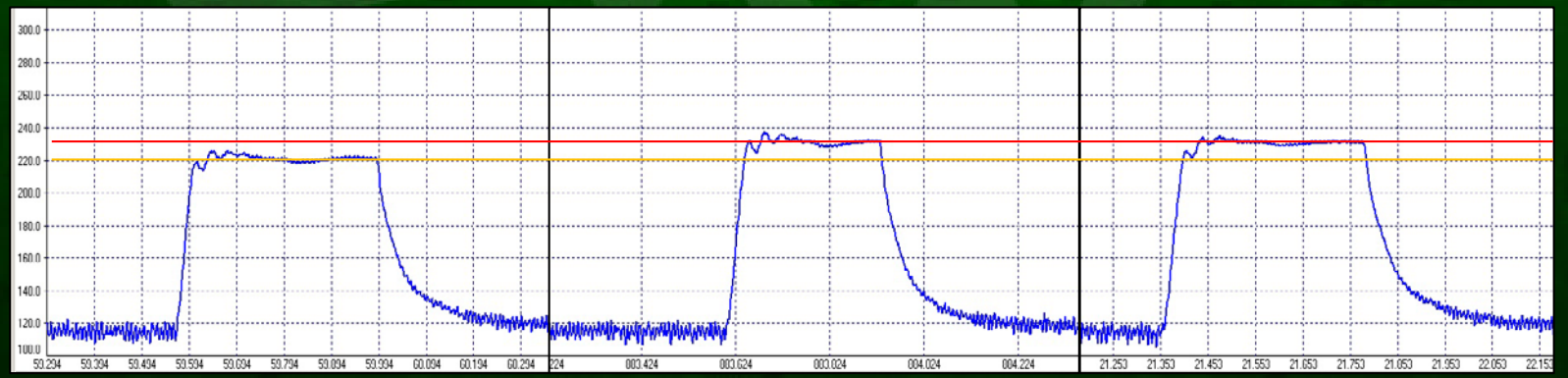
√ Solder melting

	Temp control 1	Temp control 2	Temp control 3	Temp control 4
Solder melting Image	No image			
Condition	Good	Good	Good	Not bad

Laplace-Can Temperature Control Test

√ Bonding Test (Align)
- bond parameter tuning for stabilization still ongoing





Laplace-Can Temperature Control Test

√ Shear force test

- All cantilever off

- Shear force : 45~60g

- Good status

Temp 220°

Test Detail

	Test	Force	Type	Grade	Description
*	1	54.52 g	Pass	5	Cantilever off
*	2	49.96 g	Pass	5	Cantilever off
*	3	49.65 g	Pass	5	Cantilever off
*	4	46.61 g	Pass	5	Cantilever off
	5	43.07 g	Pass	5	Cantilever off
*	6	45.23 g	Pass	5	Cantilever off
	7	43.37 g	Pass	5	Cantilever off
	8	41.96 g	Pass	5	Cantilever off
*	9	51.48 g	Pass	5	Cantilever off
	10	44.71 g	Pass	5	Cantilever off
*	11	46.02 g	Pass	5	Cantilever off
*	12	45.25 g	Pass	5	Cantilever off
*	13	57.04 g	Pass	5	Cantilever off
*	14	57.60 g	Pass	5	Cantilever off
	15	38.06 g	Pass	5	Cantilever off
*	16	49.23 g	Pass	5	Cantilever off

Temp 230°

Test Detail

	Test	Force	Type	Grade	Description
*	1	51.57 g	Pass	5	Cantilever off
*	2	54.75 g	Pass	5	Cantilever off
*	3	54.09 g	Pass	5	Cantilever off
*	4	49.24 g	Pass	5	Cantilever off
*	5	45.89 g	Pass	5	Cantilever off
	6	37.97 g	Pass	5	Cantilever off
*	7	53.41 g	Pass	5	Cantilever off
*	8	59.07 g	Pass	5	Cantilever off

Temp 230°

Test Detail

	Test	Force	Type	Grade	Description
*	1	56.15 g	Pass	5	Cantilever off
*	2	55.01 g	Pass	5	Cantilever off
*	3	51.41 g	Pass	5	Cantilever off
*	4	56.78 g	Pass	5	Cantilever off
*	5	52.66 g	Pass	5	Cantilever off
*	6	46.64 g	Pass	5	Cantilever off
	7	37.39 g	Pass	5	Cantilever off
*	8	48.69 g	Pass	5	Cantilever off

Selective Cantilever Repair/Rework

Gripper Repair System (GRS)

Major functions and rework possibilities

Following single functions are implemented and tested successfully:

- X-,Y- and Z-shifting and angle correction
- Detaching & gripper cleaning
- Spring correction
- Pre-bond tip inspection
- Bonding

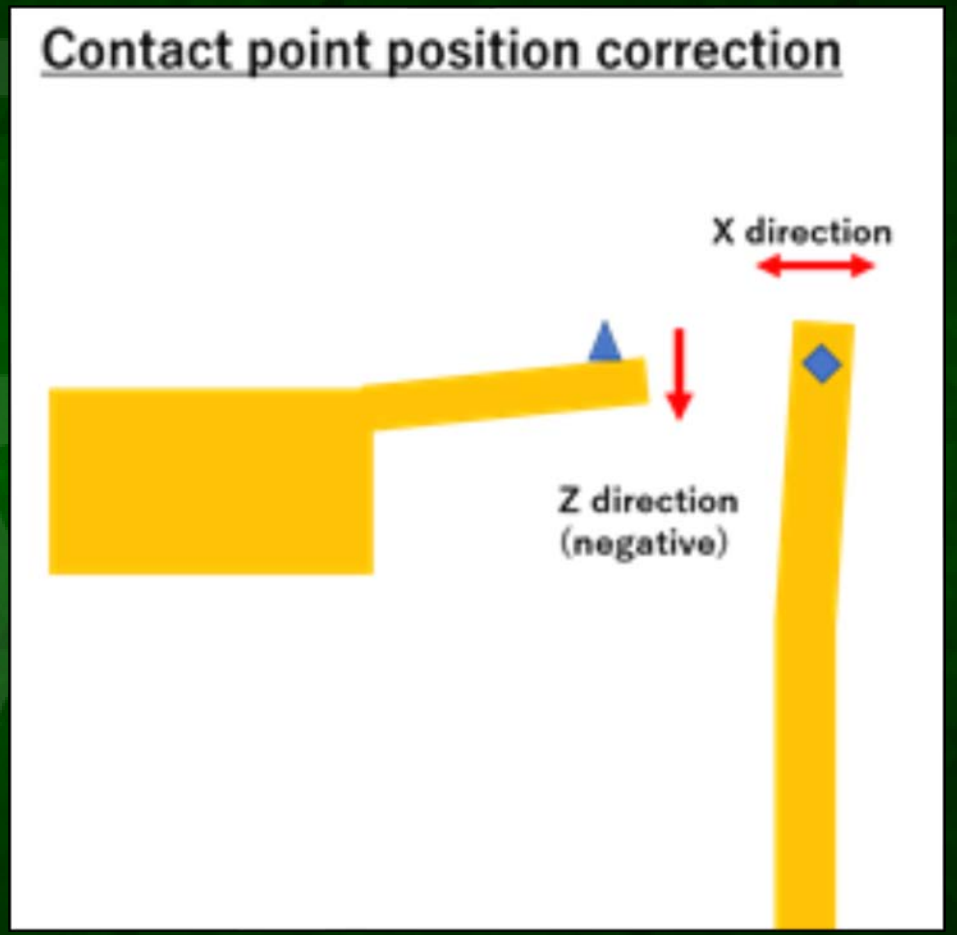
The automatic process is under development and testing. Currently planned is the implementation of a selection of following automatic process functions:

- Pin shifting and angle correction of good but misaligned pins
- Detaching of bad pins
- Automatic repair including detaching and re-bonding

Gripper Repair System (GRS)

Failure mode: Bended Pin/Cantilever

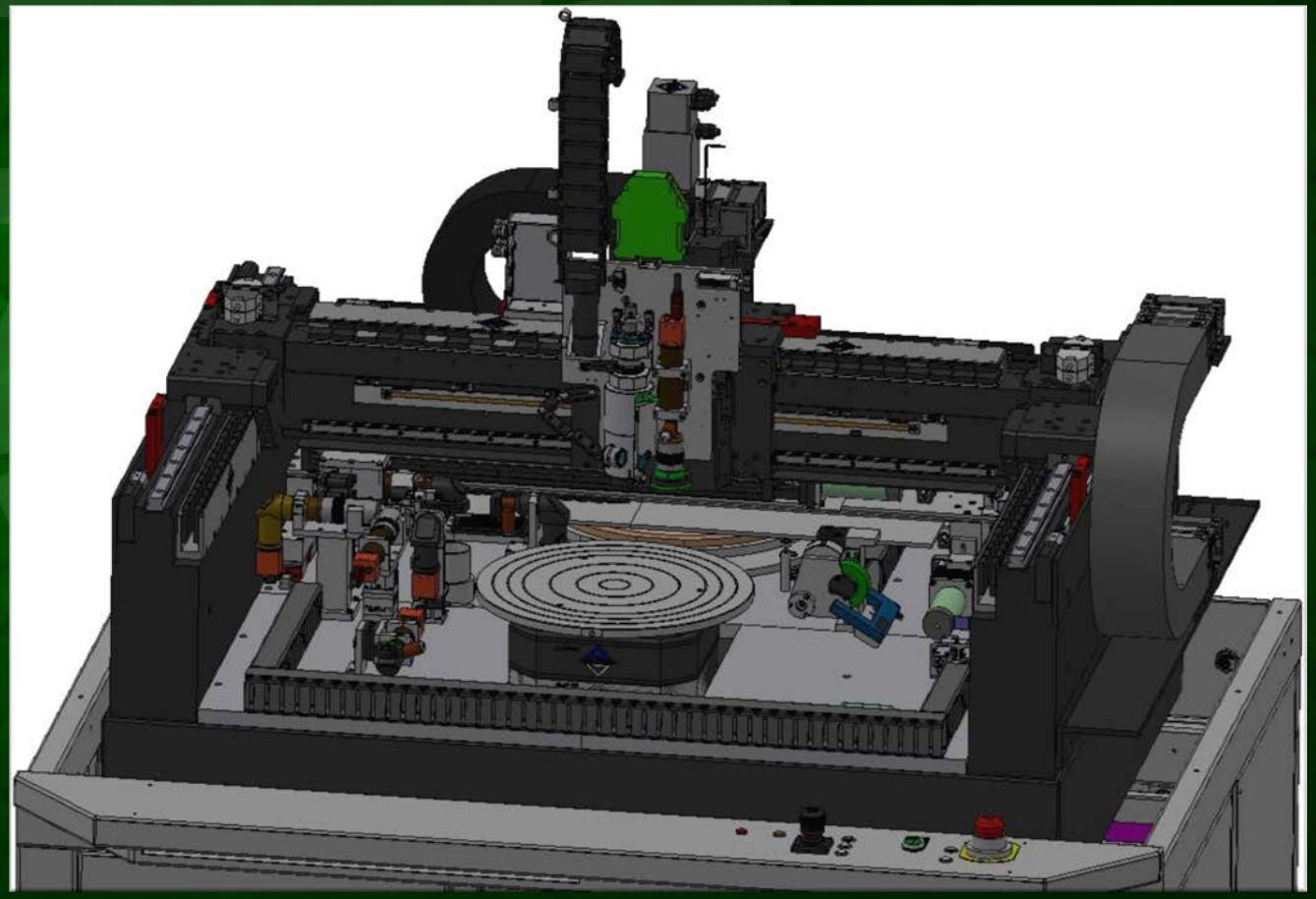
- If the pin is bent at front side (tip) there's most likely not enough space for the gripper tool to move between other pins (pitch).
- The gripper tool length is designed to match to the hump length and is always aligned parallel to that one for gripping purpose.



Gripper Repair System (GRS)

The base for the gripper development was the latest standard Laplace-Can machine used for Cantilever bonding

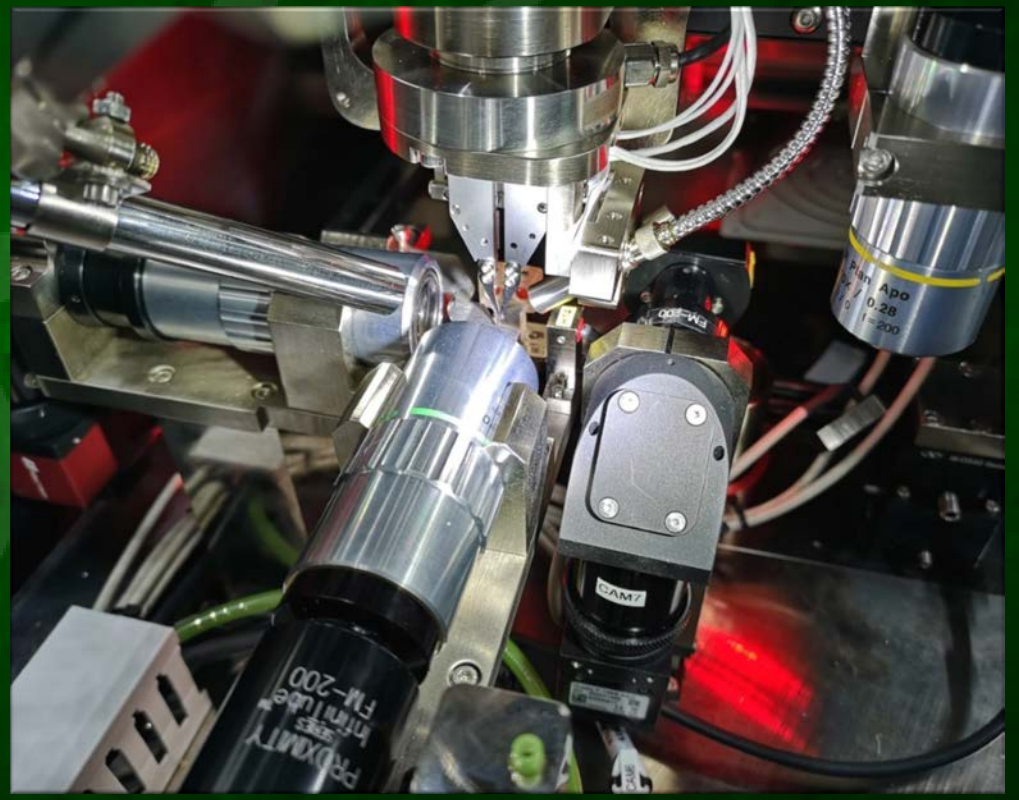
- The Laplace-Can machine platform is used to have the capability of loading a fully assembled wafer probe card and to guarantee the same axis performance and accuracy



Gripper Repair System (GRS)

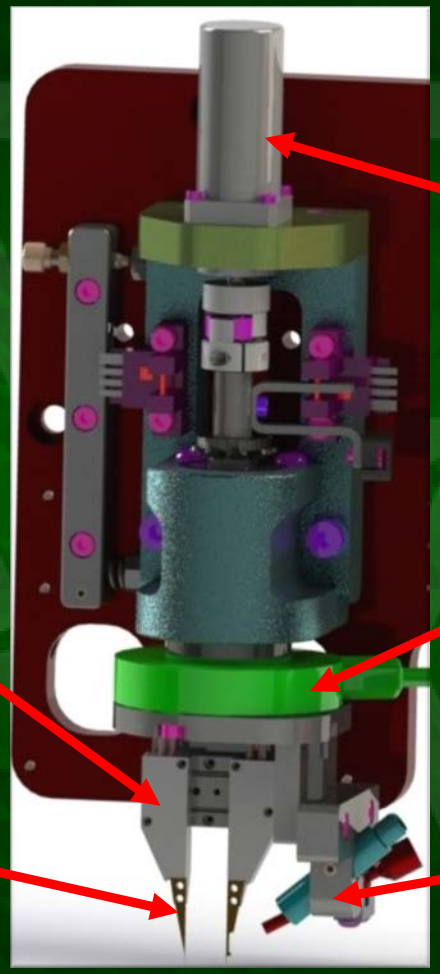
Main components of the existing machine like camera alignment terminal, vacuum cleaning station and spring correction position can still be used.

- The picture shows the gripper at the tip inspection position. The orientation of the tip is always to front side of the machine
- Necessary angle correction moves are performed by rotating the bonding table



Gripper Repair System (GRS)

This picture shows the changed main components located at the Gantry Z-axis.



Direct drive motor with backlash free gear drive

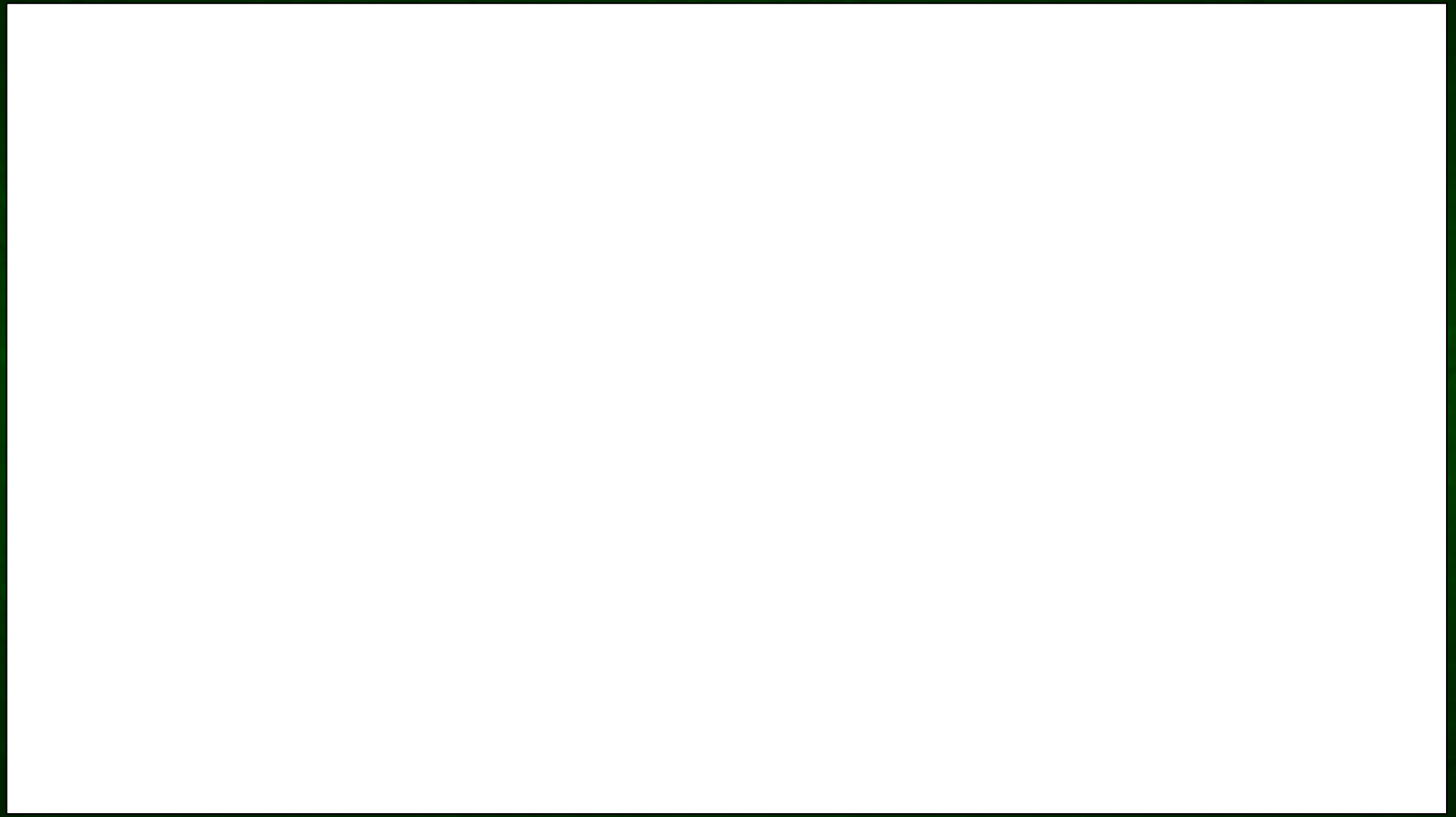
Gripper axis system with integrated force sensors

Already existing force measurement (Z-direction)

Gripper tools

Laser beam supply with prepared IR temperature measurement

Video Cantilever Rework



Wire Soldering

SB²-WB for probe card wire soldering

SB²-WB* is a combination of PacTech´s SB²-Jet (solder ball jetting) process and a wire feeding mechanism

Principle process flow

1. Positioning of bond tool with respect to a solderable target position
2. Wire is pushed onto the target while parallel a solder ball is loaded into the jetting capillary
3. Liquid solder droplet is applied by laser and N_2-pressure onto the wire located on the pad
4. Solder solidifies and generates a uniform interconnection between wire, solder and pad
5. System moves to a subsequent bond location while wire unwinds (loop-forming)
6. Previous process steps are repeated and the wire is cut

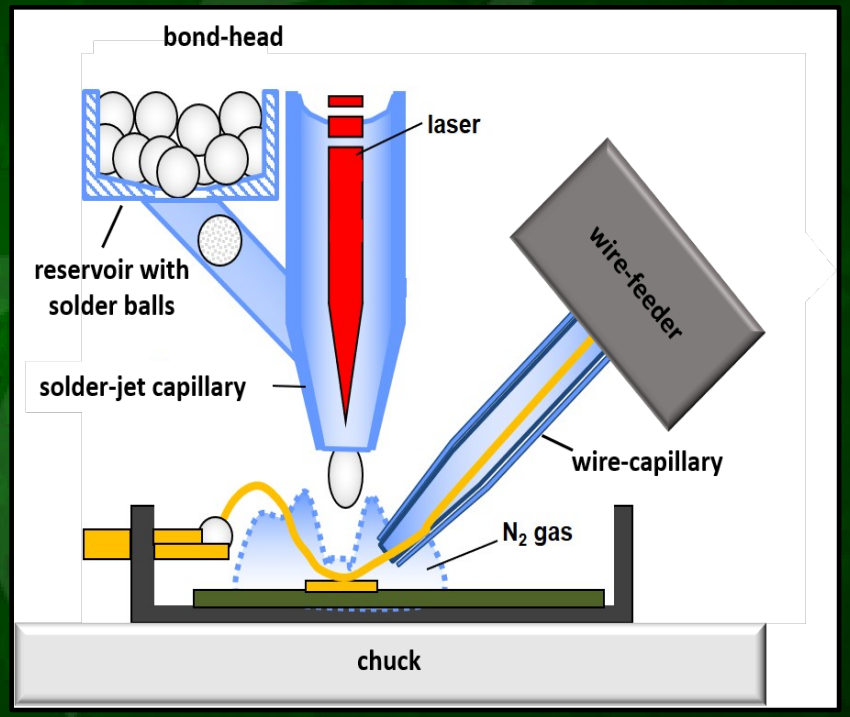


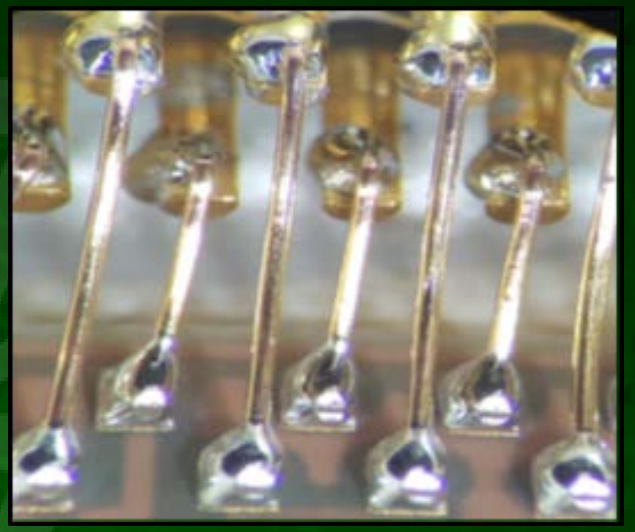
Fig.1: SB²-WB process principle

*protected by PCTWO2019/001783A1

SB²-WB for probe card wire soldering

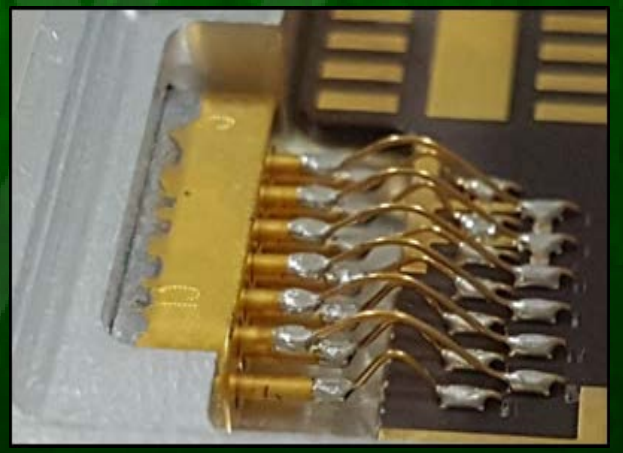
Advantages

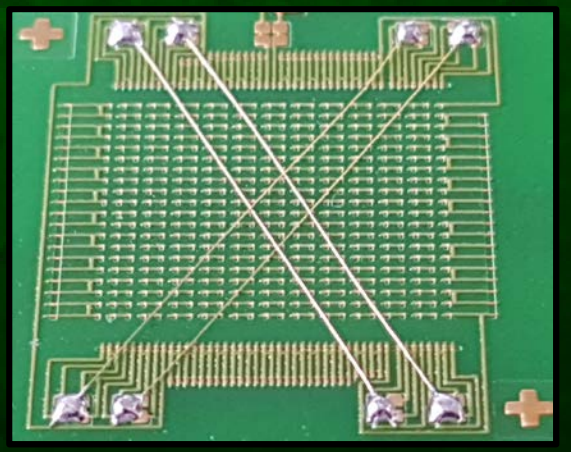
- Neither pressure, vibration nor high temperatures required
- No transformation of wire diameter or change of bulk properties
- No loop option
- Flexible bond tool configuration in a hemispherical workspace
- Bonding of thick and fine wires, even with insulation coating
- Wide range of wire materials: Au, Ag, Cu, Pd, Pt etc.
- Conventional loop forming or no loop options



SB²-WB wire-bonds

- Full automatic process solution for soldering of wires in the peripheric area of probe cards
- Automated contact of pin to board via wire





SB²-WB loop formation

Video Wire Soldering

Summary

The following was shown:

- Improvements on Cycle Time and Machine Performance for an established Cantilever Assembly Process
- Implementation of Temperature Control as important feature for laser bonding stability
- Introduction of a new process as a possibility for for selective Cantilever rework either inline or as stand-alone equipment
- Introduction of Laser Wire Soldering for the electrical connection of passive components, connectors and other components

Thank You!

sales@pactech.com