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A New 3D Laser Bonding Process for Single Spring Attach on 300mm Probe Cards

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Advantage of Laser Bonding

- **Localized heat –**

  no thermal stress on the areas outside of bonding interface

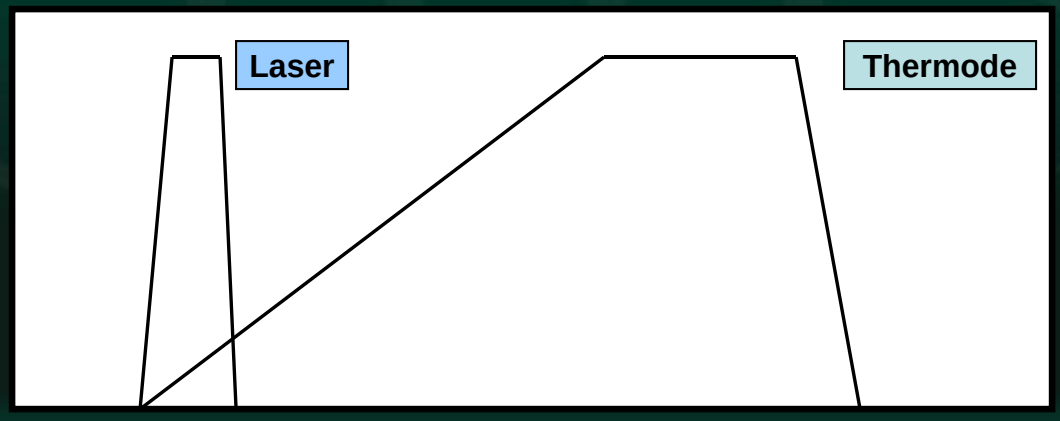
- **Short laser pulse –**

  low thermal stress on chip/ substrate and interconnection

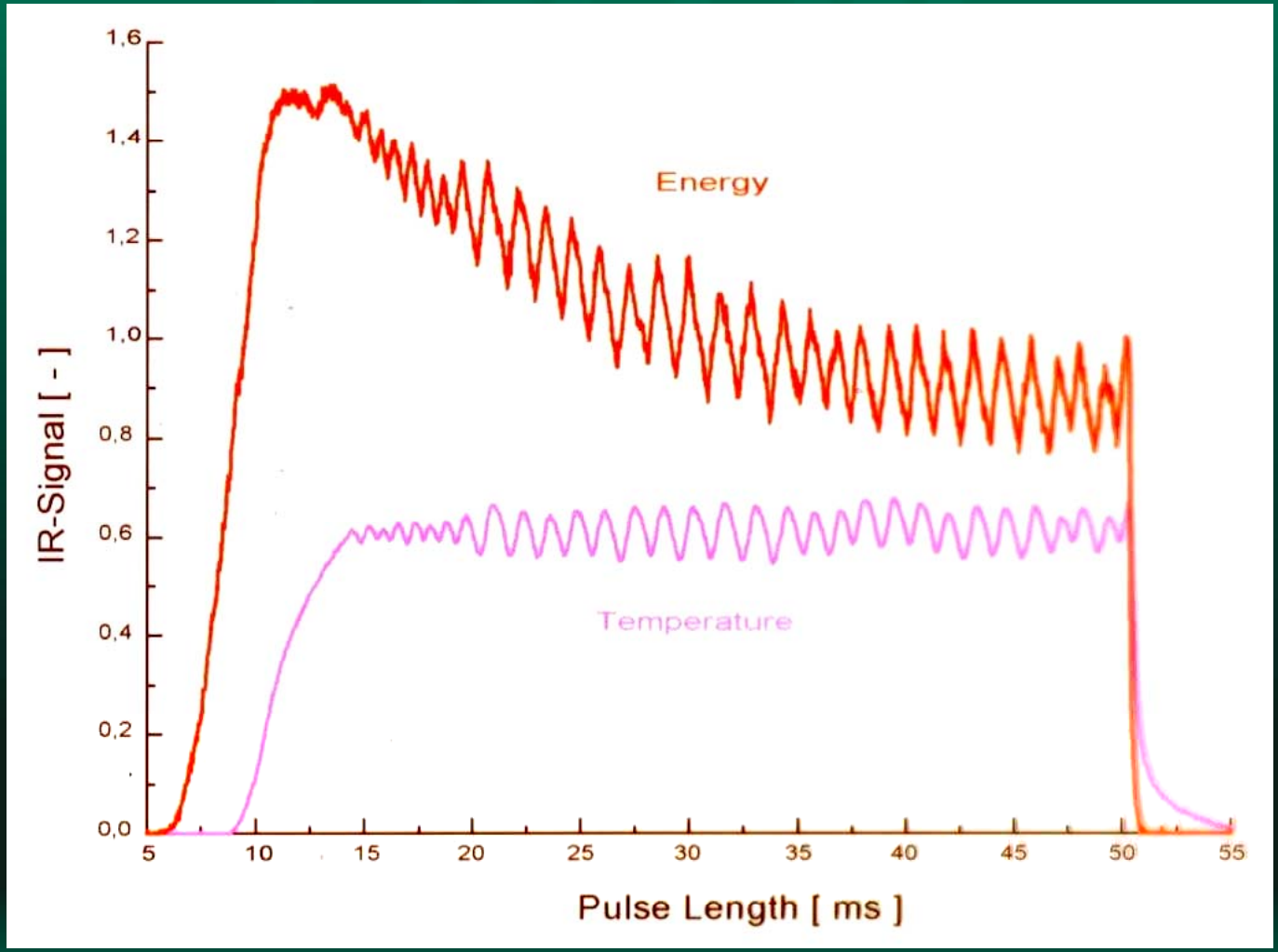
Thermode Bonding vs Laser Bonding

Heating time to bonding temperature:

Laser:	**0.01 - 0.2**	**sec**	**~ msec**
Thermode:	**1 – 10**	**sec**	**~ sec**
Oven Reflow:	**60 – 180**	**sec**	**~ min**



Temperature Control Through In Situ Laser Energy Tuning during Bonding



Compatible Substrate Materials for Laser Soldering

- **Substrate**
  - FR4, BT- Epoxy, Polyimide, Ceramic, Silicon
  - TG above 150 ° C
  - most applications: rigid
- **Pad metallization**
  - Copper coated with NiAu, Sn, Au
  - Thin Film : Cr/Au, NiAu, Au

Advantages of Laser Bonding for Probe Card Assembly

- **Flexibility**
  - layout change by software only
  - multiple spring design
  - independent from substrate material
- **Repair Capability**
  - quick & local
- **Customer Support**
  - quick & local

Cantilever Assembly Process Flow

Cantilever Assembly Line for Probe Cards

Cantilever Sorter

- Input: MEMS substrates
- Inspection of cantilever
- Laser cutting with the Laser
- Placement of cantilever in waffle packs

SB2-Jet: Solder Jetting

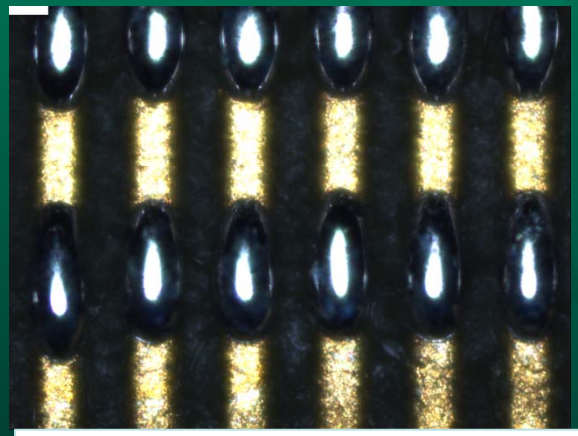
- Solder Jetting on ceramic substrate
- Solder Balls sizes: 30 – 760 µm,
- Solder alloys capability: PbSn, SnAgCu or AuSn

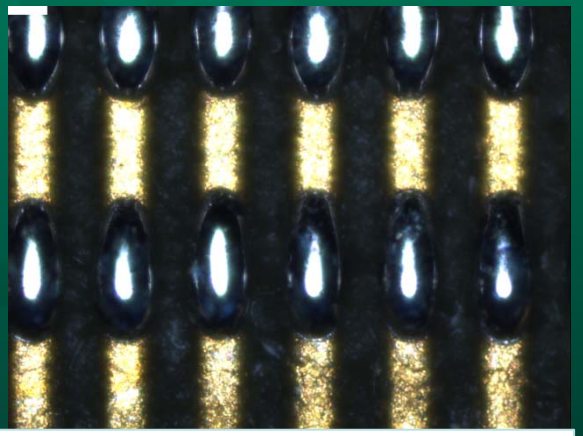
Cantilever Bonder

- 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
- Cantilever rework capability

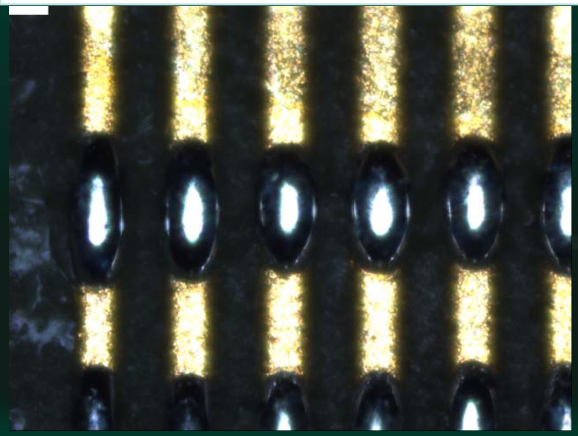
Laser Soldering SB²-Jet

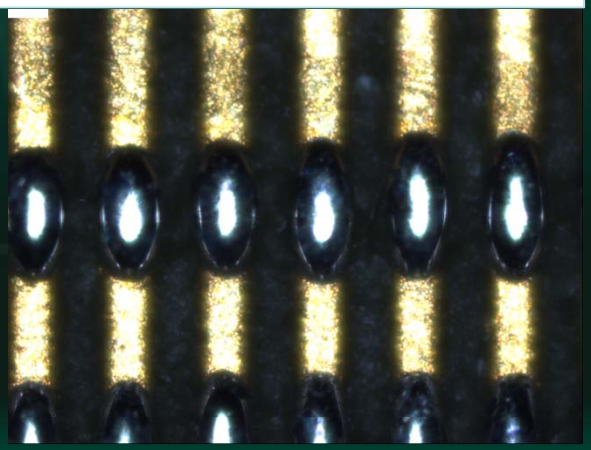
Solder Ball Placement





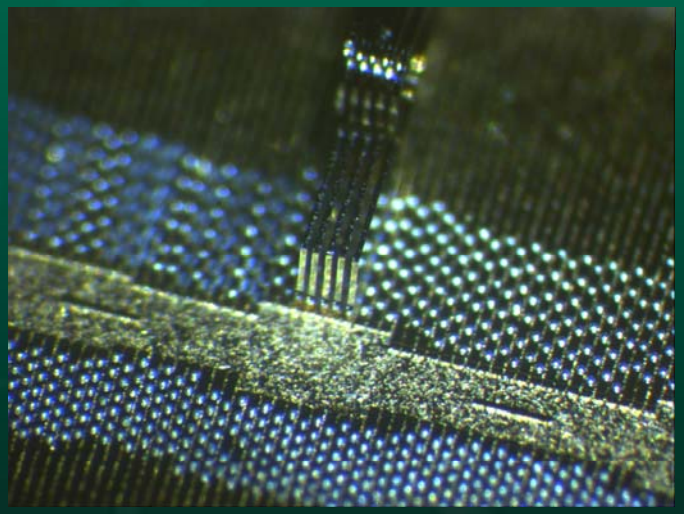
Pictures are showing solder depots placed
by SB²- jet process on substrate pads





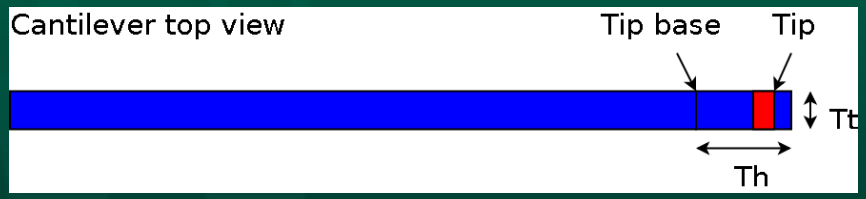
Cantilever Bonder Specification

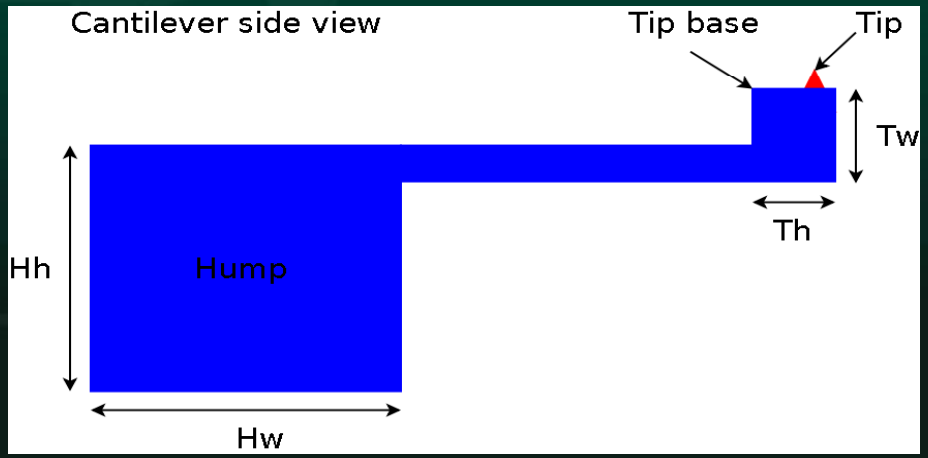
- Linear axis or gantry system
- Probe card sizes up to 13 inch
- Full process control
- Alignment control by position bonding
- Placement Accuracy: down to +/- 3µm
  typ. +/-5µm
- High power laser for bond reflow
- Height control: 1µm accuracy
- Cantilever thickness: 20 – 100µm
- Min. Pitch: 60µm
- High mechanical stability of probes
- Process suitable for rework and complete card assembly



Cantilever Design Rules

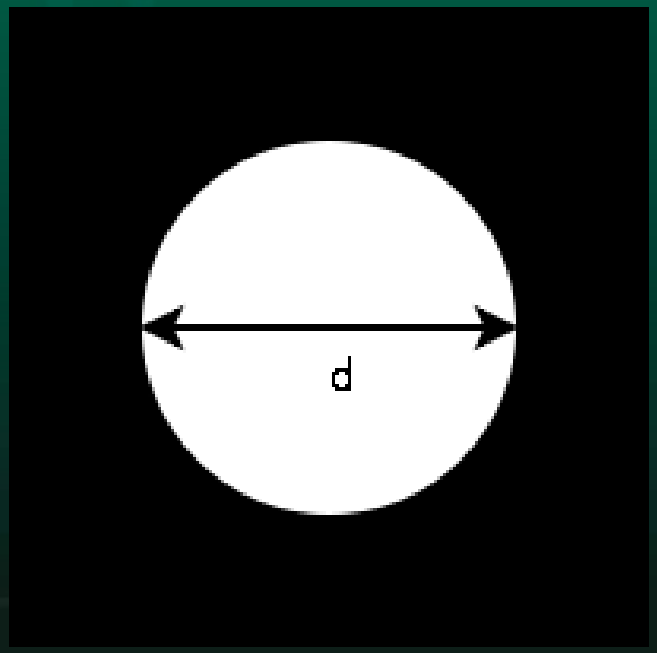
- **Hump needed for handling and laser energy absorption**
  - Hh ≥ 500 µm
  - Hw ≥ 500 µm
- **Tip base needed for alignment.**
  - Th ≥ 200 µm
  - Tw ≥ 200 µm
- **Well defined edges are important for vision system**





Fiducial Mark Recognition

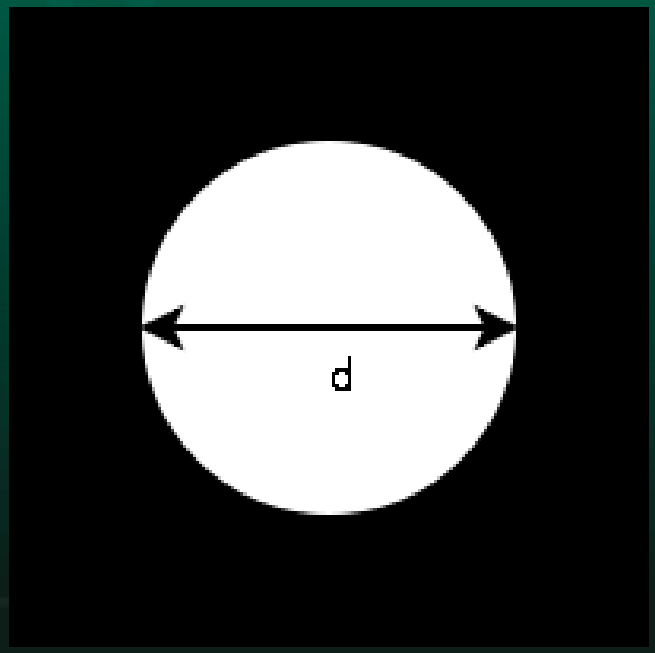
- **Automatic X,Y substrate alignment after loading and bond stage rotation (W-axis)**
- **Pattern recognition with bond head camera**
- **Alignment accuracy: +/- 1µm**
- **High contrast simple mark needed**



d = 100 µm

Substrate Height Measurement

- **Continuous substrate height measurement during bond process**
- **Sensor: Laser scanner (+/- 0.05 µm)**
- **Alignment accuracy: +/- 3µm (Z-axis)**
- **Measurement pad 200 µm with bond pad height used**



d = 200 µm

Alignment Scheme

Cantilever recognition in waffle pack

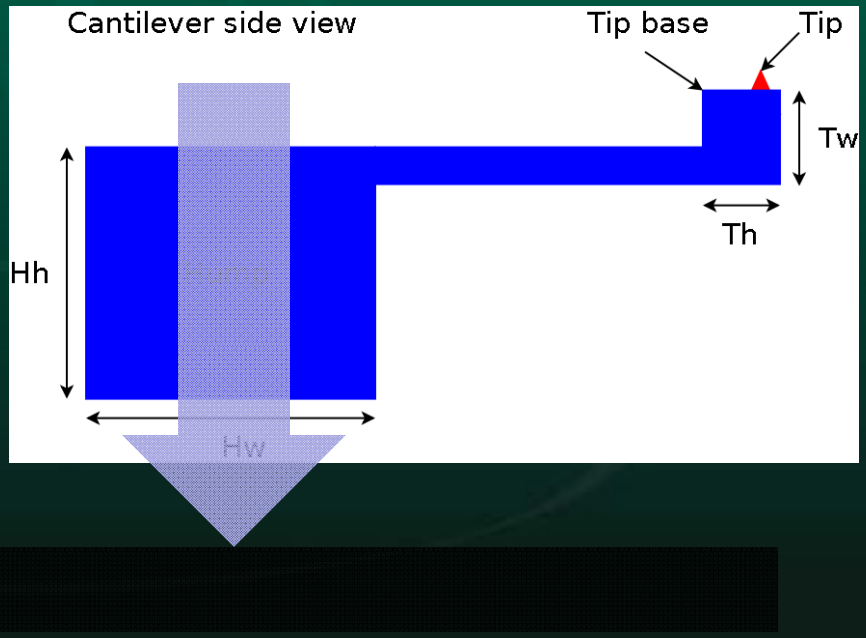
- Pattern recognition of whole cantilever
- Detects position in waffle pack pocket (A,B axis)
- Discards defect cantilevers
- Sensor: Camera 4 on Pick&Flip unit
- Alignment accuracy: +/- 5 µm

Rotation and alignment for tool transfer

- Pattern recognition of whole cantilever
- Detects transfer offsets for bond tool (B,D,Z axis)
- Discards defect cantilevers
- Sensor: Stationary Camera 2
- Alignment accuracy: +/- 5 µm, +/- 0.5°

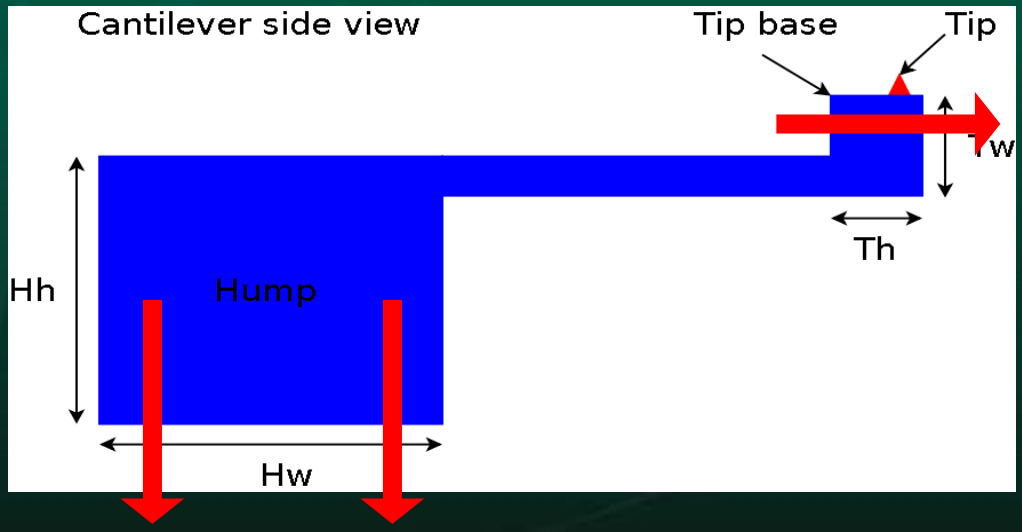
Mechanical Correction

- **Cantilever is fitted into bond tool by touching down on a mechanical spring**



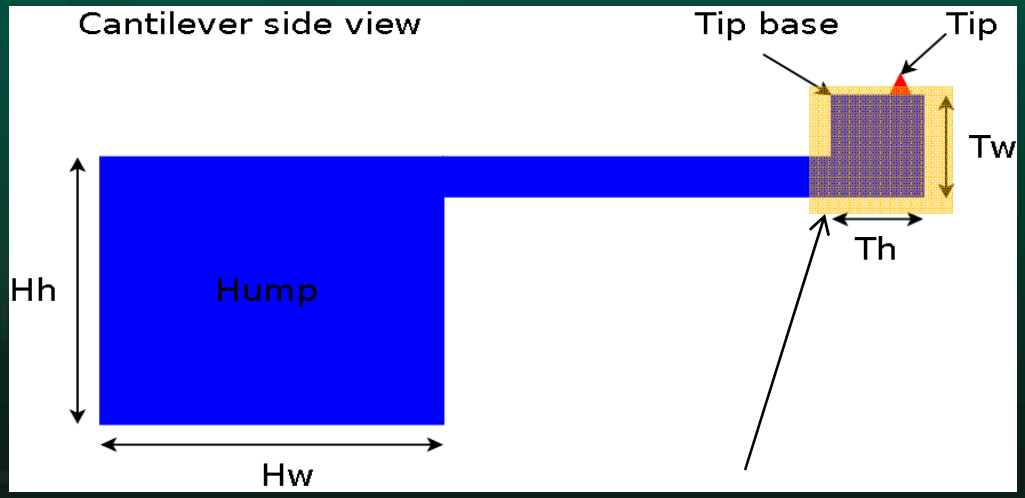
Laser Scan Alignment

- **A laser scanner determines**
  - X offset for bonding
  - U angle correction
  - Tilt (hump bottom <-> tip base)
- **Three scans per measurement**
- **+/- 0.01 µm laser scan repeatability**
- **+/- 1 µm accuracy**



Microscope Tip Recognition

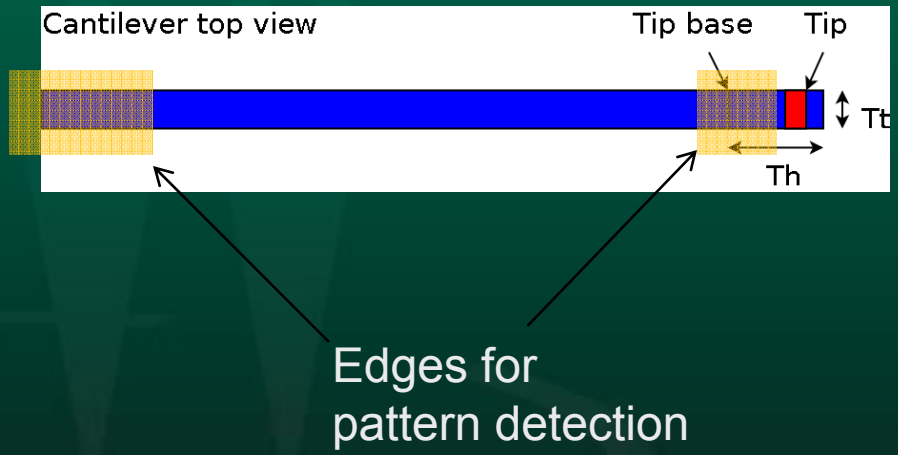
- **Sensor: Side microscope camera 3**
  - Y offset for bonding
  - Z offset for bonding
- **+/- 1 µm accuracy**



Edges for pattern detection

Post Bond Hump/Tip Inspection

- **Sensor: Bond head camera 1**
- **Accuracy +/- 1 µm**
- **Results used for smart correction of next bond process**
- **Well defined edges for repeatable pattern detection needed**



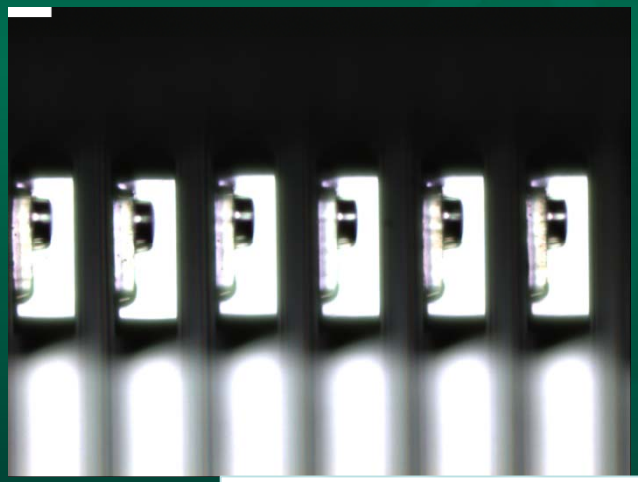
Alignment Summary

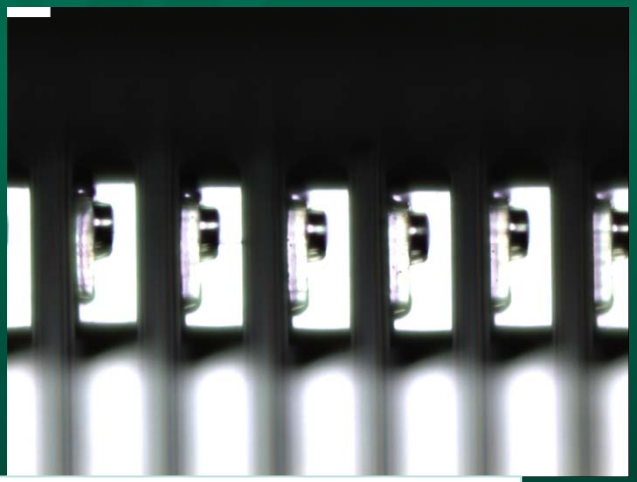
Step	Alignment procedure	Corrected axis	Sensor	Measured feature	Alignment Accuracy
1	Fiducial marks on substrate	X,Y,W	Bond head – Camera 1	100 µm high contrast circle	+/- 1 µm
2	Substrate height	Z	Laser Scanner - Top	200 µm diameter height measurement mark	+/- 0.05 µm (laser) +/- 3 µm (Z-axis)
3	Detect cantilever in waffle pack	A,B	Pick&Flip Unit - Camera 4	Cantilever	+/- 5 µm
4	Rotation and alignment for tool transfer	Z,B,D	Stationary Camera 2	Cantilever	+/- 5 µm +/- 2°
5	Mechanical spring correction	Z	Mechanical spring	-	-
6	Laser scan alignment	X,U,Tilt	Laser Scanner - Side	Hump bottom and tip	+/- 0.01 µm(laser), +/-1 µm(axis), +/- 0.015°
7	Microscope tip recognition	Y,Z	Microscope side cam - Camera 3	Cantilever Tip	+/- 1 µm
8	Post bond hump/tip inspection	X,Y	Bond head – Camera 1	Hump or tip	+/- 1 µm

Alignment Summary

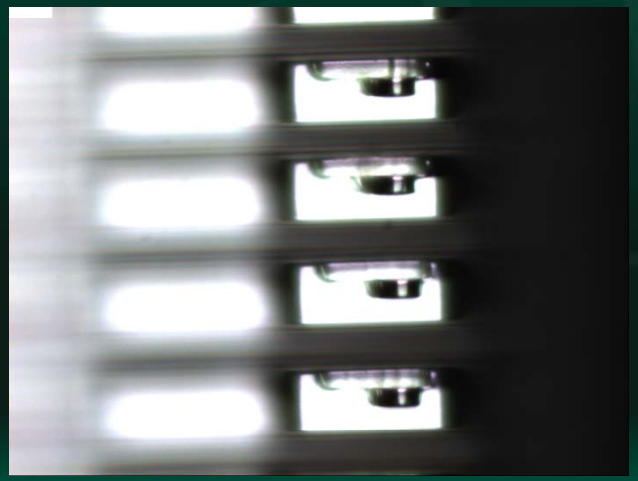
- **Tip accuracy (machine capability):**
  - in X +/- 2 µm
  - in Y +/- 2 µm
  - in Z +/- 4 µm

Cantilever Placement Results

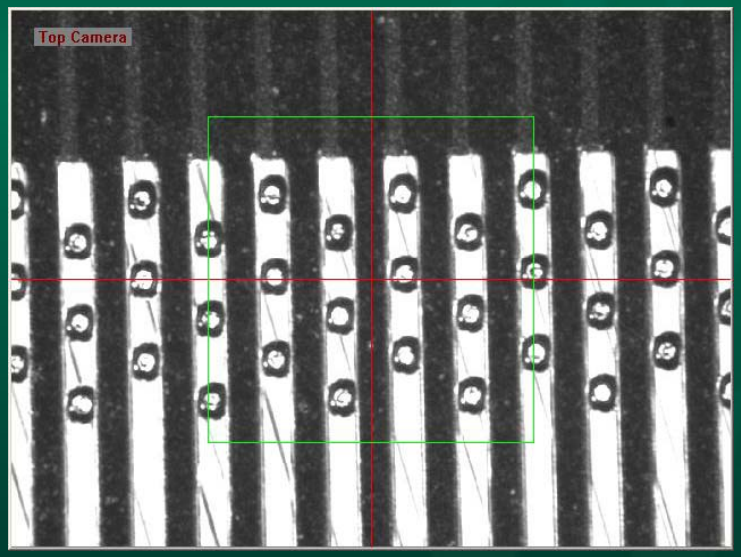




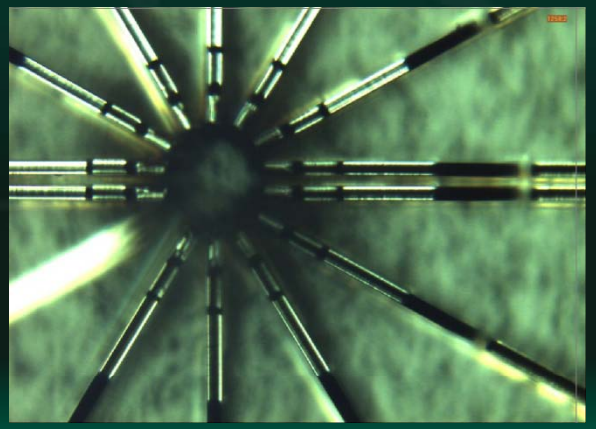
Picture showing Cantilever tip, placed by Laplace-3D process (80µm pitch)



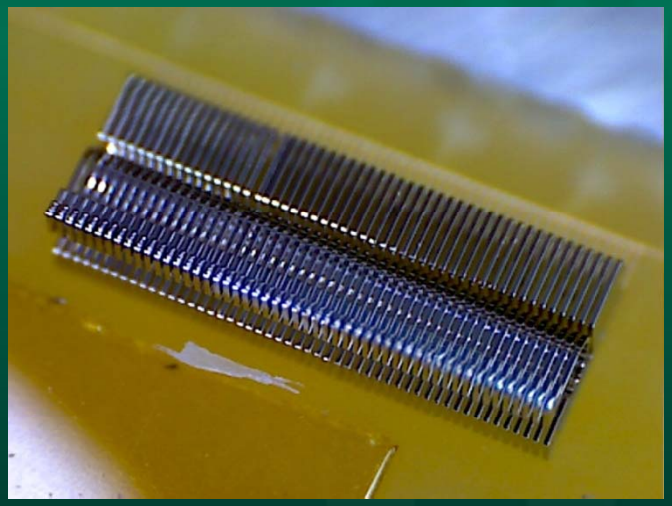
Cantilever Bonding at 60µm pitch

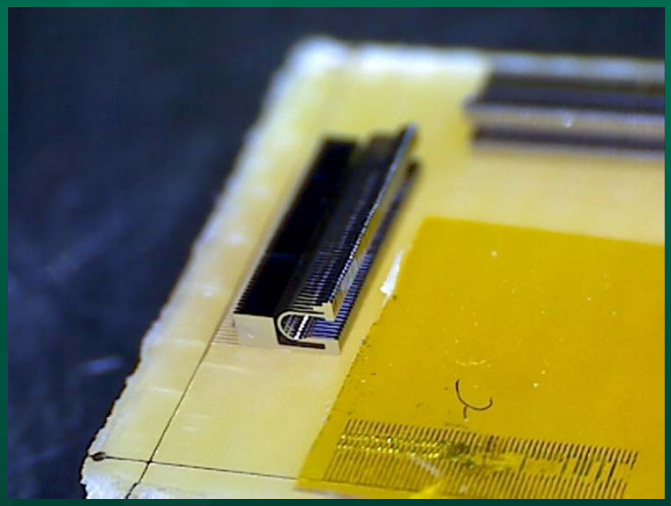


Cantilever Bonding at 360 deg

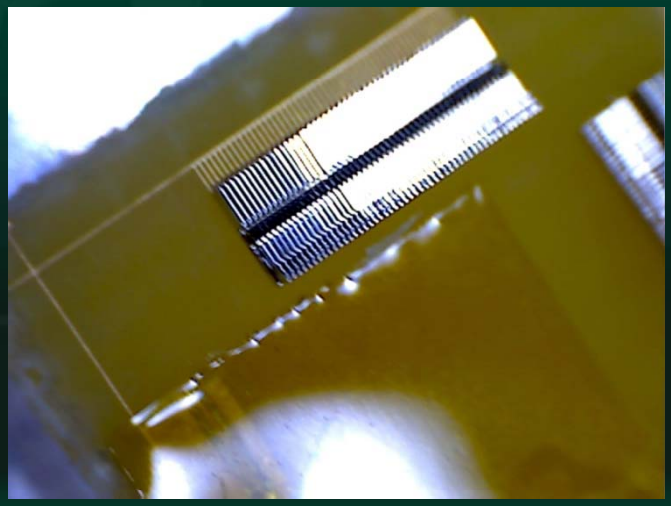


Cantilever Placement Results





Picture showing Cantilever overview, placed by Laplace-3D process (80µm pitch)



Process Data

X,Y Placement Accuracy

Summary		
Min Value [mm]	-0.0035	-0.0033
Max Value [mm]	0.0013	0.0021
Range [mm]	-0.0048	-0.0054
StDiv [mm]	0.00101357	0.00126077

Placement Speed
30µm cantilever width,
80µm pitch

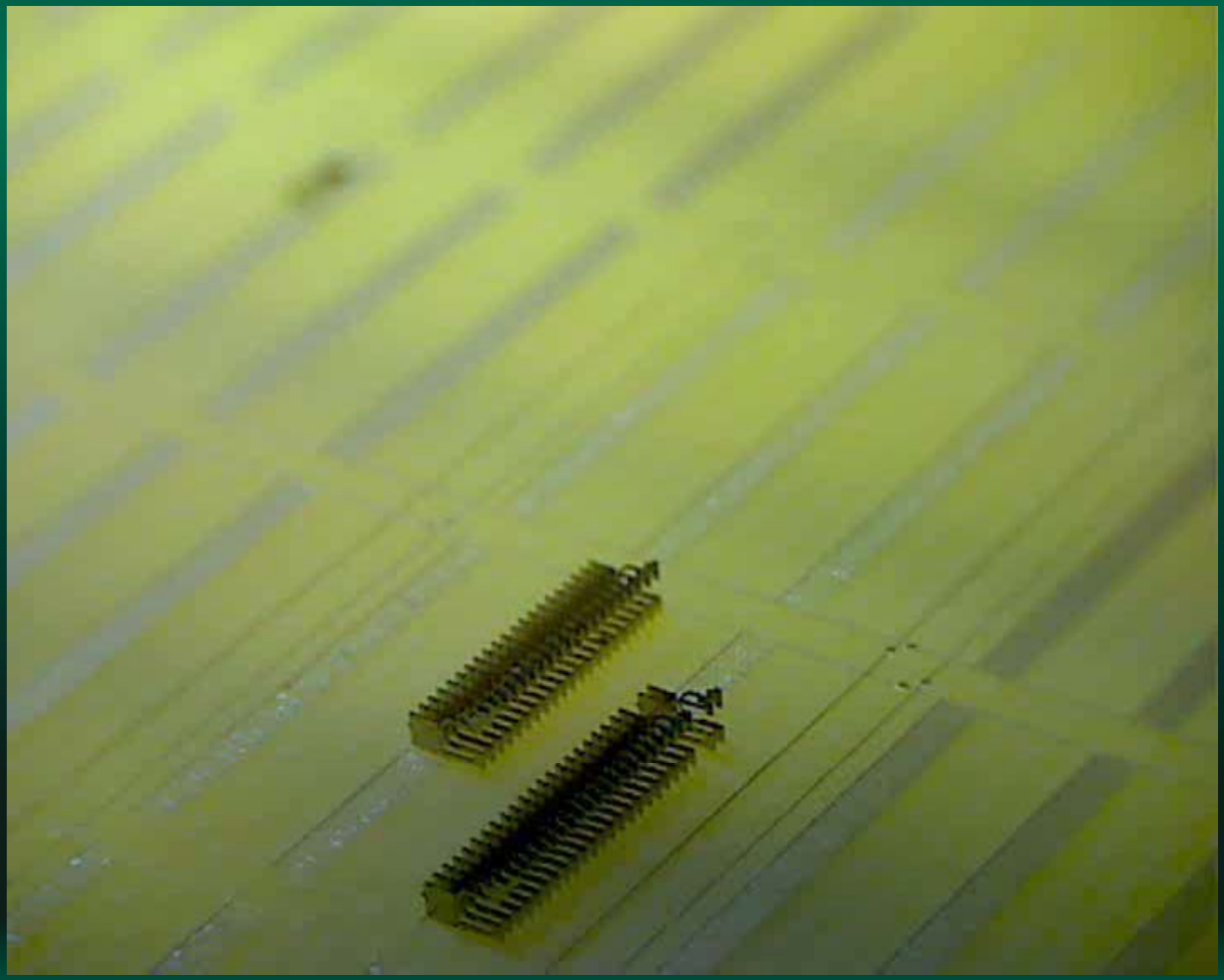
10 sec per cantilever (w/o post inspection)
< 15 sec per cantilever (with post inspection)

Laplace-Can Test Run: Cantilever Positioning Accuracy

Positioning Accuracy	Tip X Error [mm]	Tip Y Error [mm]
Average	0,0002	0,0000
Min Value	-0,0033	-0,0021
Max Value	0,0033	0,0026
Range	-0,0066	-0,0047
StDiv	0,001819	0,000970

Sample: 1000 cantilever, Pitch: 100µm

Cantilever Bonding Video



Cantilever Rework Video - Removal

Cantilever Rework Video - Soldering

Summary

- A new laser assisted sequential cantilever attach process has been presented
- Placement accuracies down to +/-3µm in X,Y have been demonstrated
- Assembly throughput of 10 sec per spring has been observed
- Probe springs can be assembled with free 360 deg orientation
- A fine pitch capability down to 60µm has been accomplished
- The assembly process is capable of single spring rework

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