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Advanced laser-assisted bonding technology for medical packaging solution

Chemnitzer Seminar: “Sensor Systems for One Health”

Matthias Fettke

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  - Process description
  - Application examples
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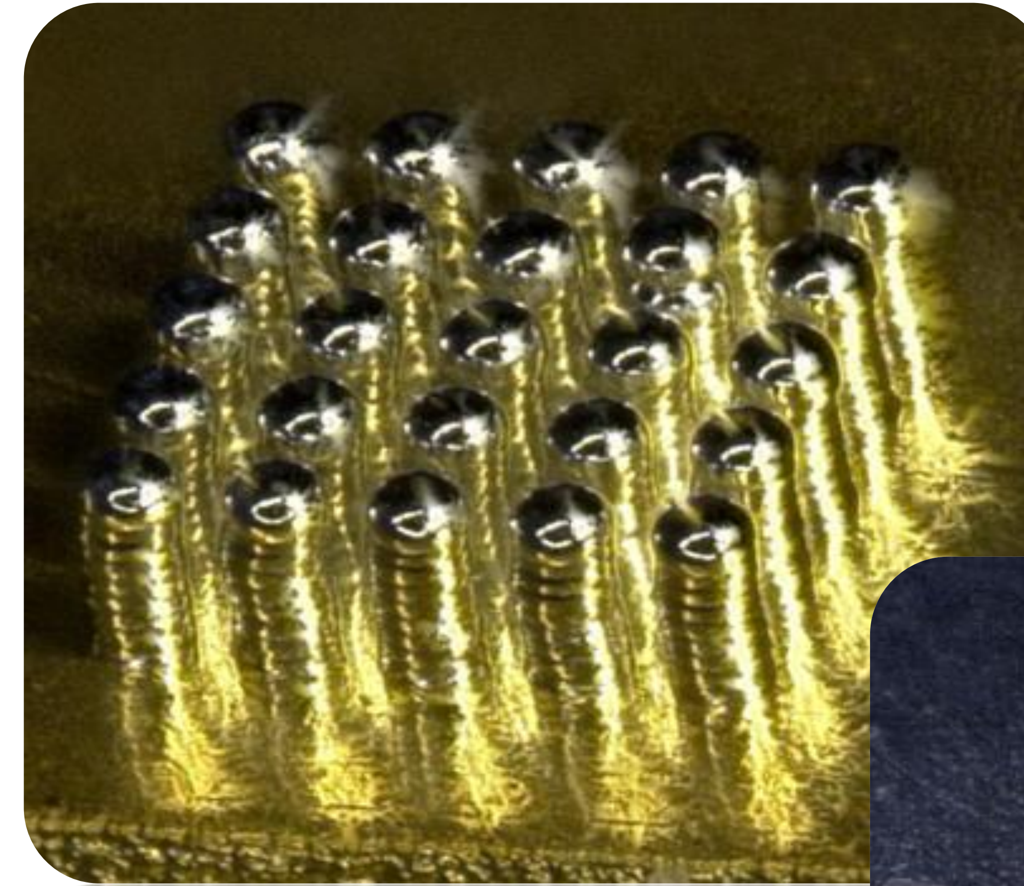

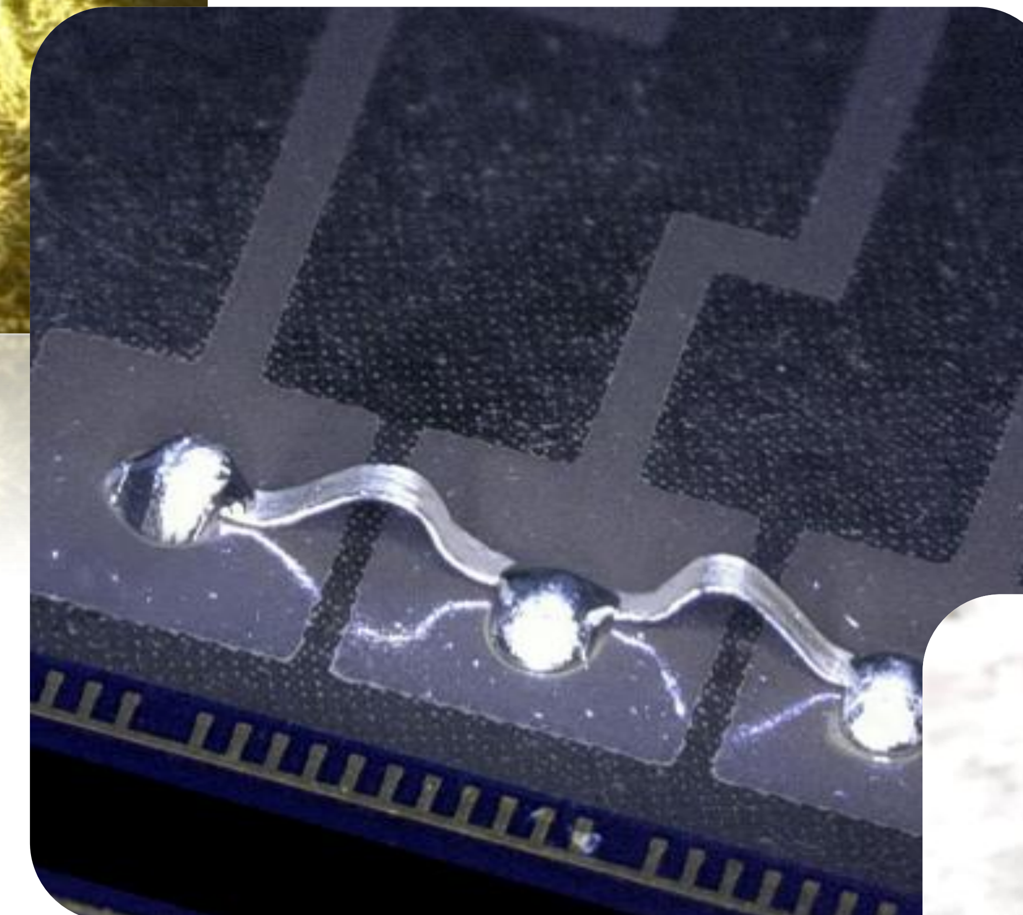

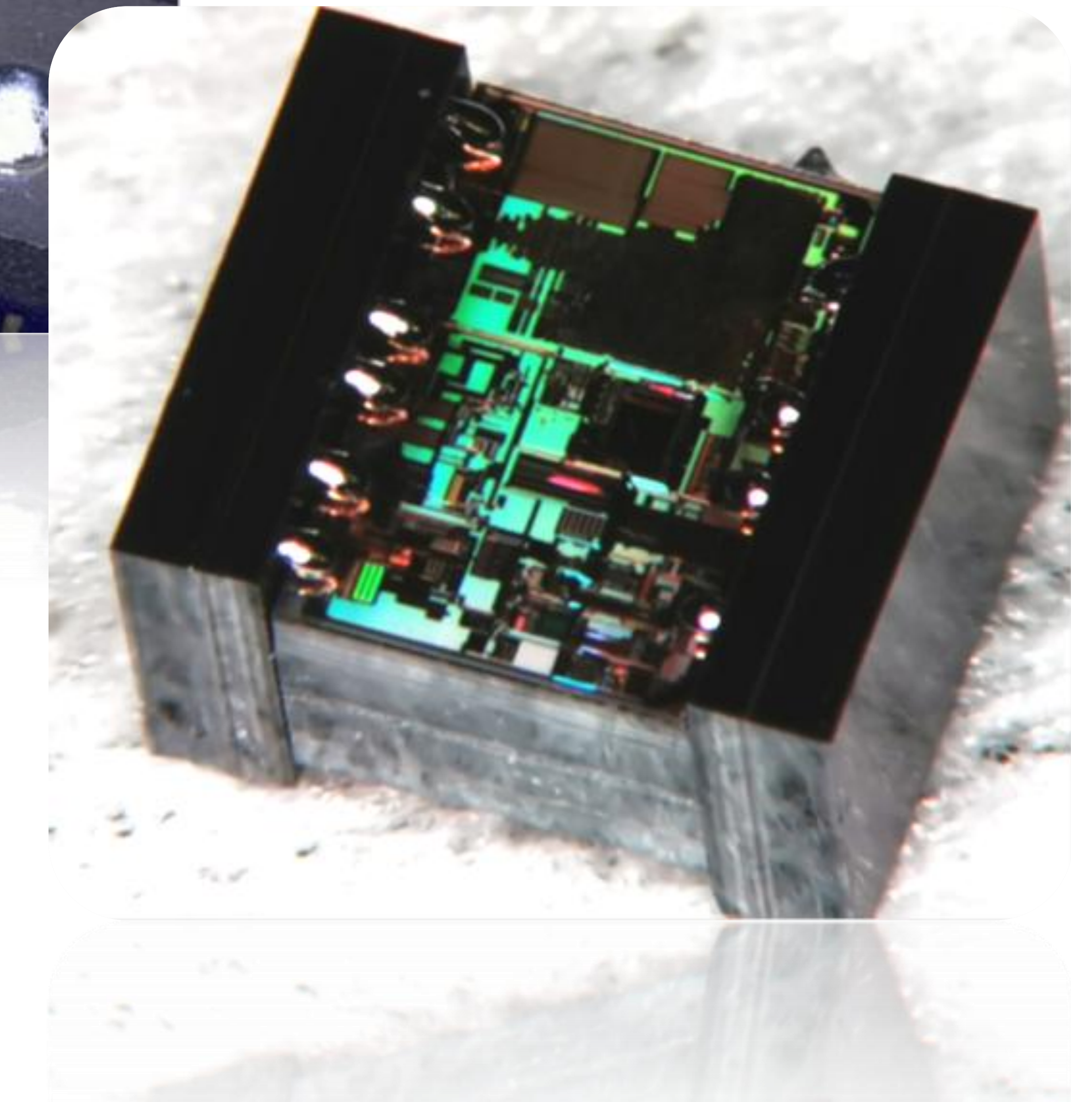

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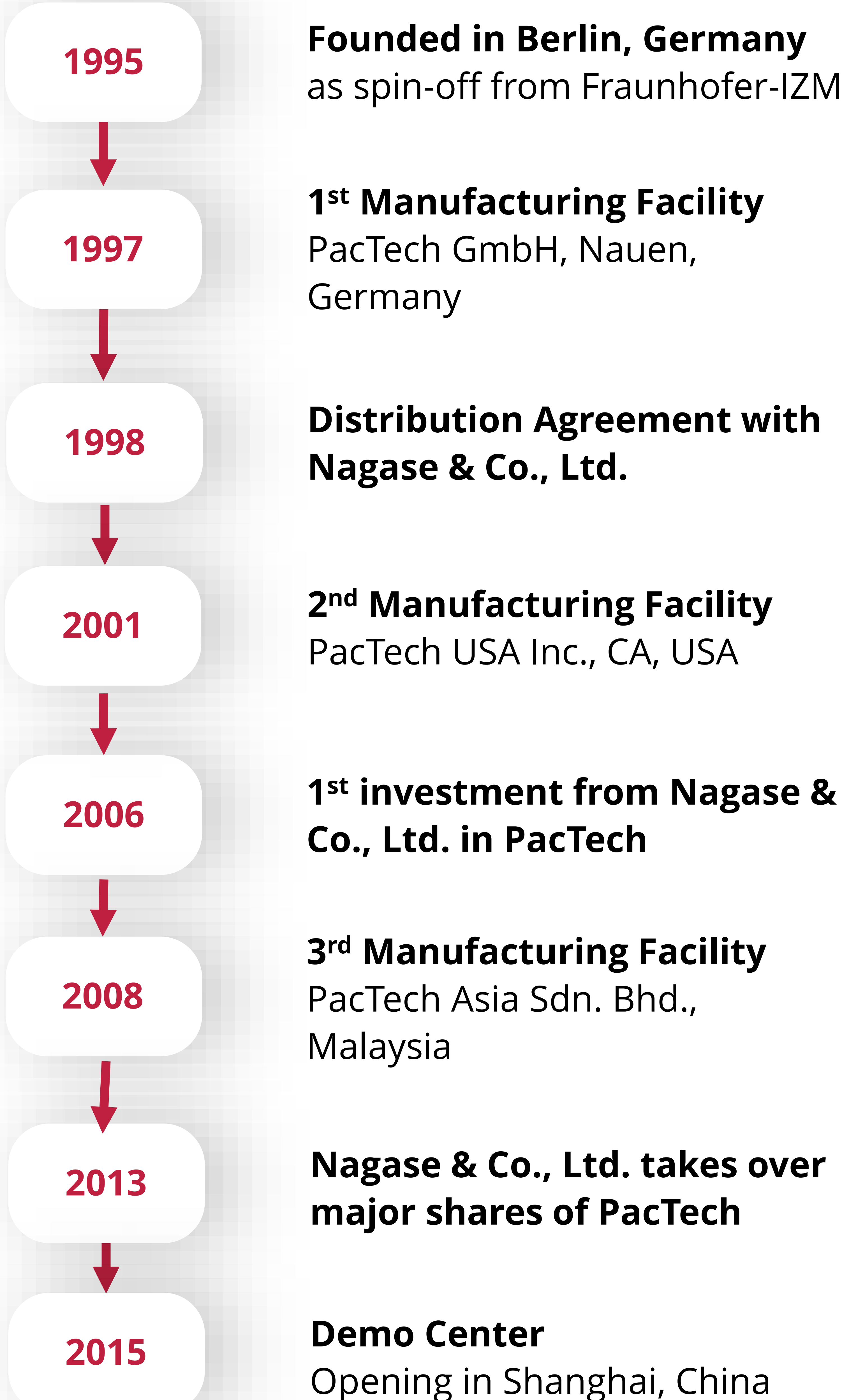
PacTech CorporateProfile



1995 — **Founded in Berlin, Germany**
as spin-off from Fraunhofer-IZM

1997 — **1st Manufacturing Facility**
PacTech GmbH, Nauen, Germany

1998 — **Distribution Agreement with Nagase & Co., Ltd.**

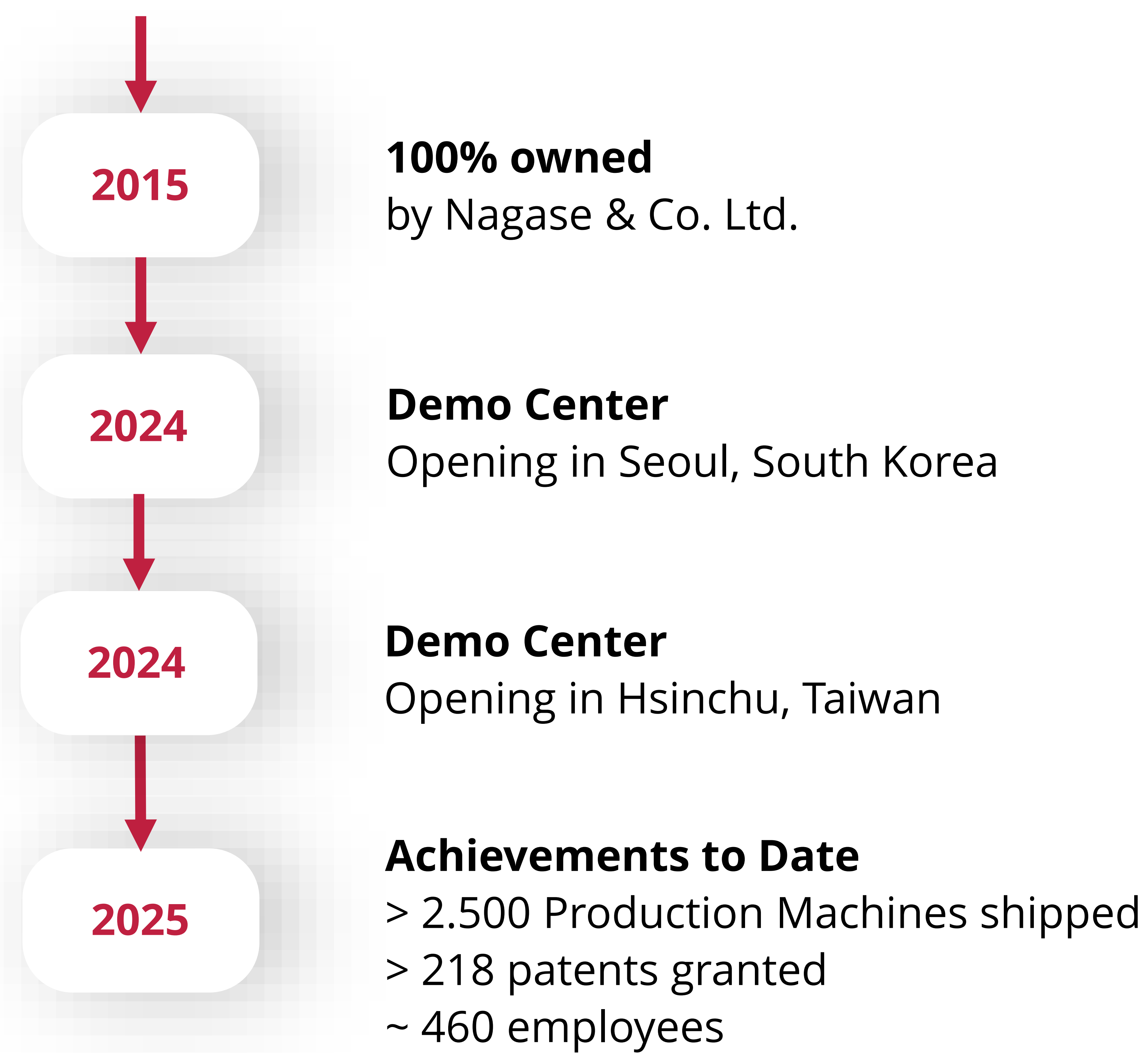
2001 — **2nd Manufacturing Facility**
PacTech USA Inc., CA, USA

2006 — **1st investment from Nagase & Co., Ltd. in PacTech**

2008 — **3rd Manufacturing Facility**
PacTech Asia Sdn. Bhd., Malaysia

2013 — **Nagase & Co., Ltd. takes over major shares of PacTech**

2015 — **Demo Center**
Opening in Shanghai, China



2015 — **100% owned**
by Nagase & Co. Ltd.

2024 — **Demo Center**
Opening in Seoul, South Korea

2024 — **Demo Center**
Opening in Hsinchu, Taiwan

2025 — **Achievements to Date**
> 2.500 Production Machines shipped
> 218 patents granted
~ 460 employees

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Locations

PacTech – Packaging Technologies GmbH

Am Schlangenhorst 7-9
14641 Nauen
Germany

PacTech Asia Sdn. Bhd.

Plot 14, Medan Bayan Lepas Technoplex
Phase 4 Bayan Lepas Industrial Zone
11900 Bayan Lepas, Penang
Malaysia

PacTech USA Inc.

328 Martin Ave
Santa Clara, CA 95050
USA

ISO/ITAR Certification:

- ISO 9001 (blue)
- IATF 16949 (red)
- ISO 14001 (green)
- ISO 50001* (yellow)
- ITAR registered (purple)

PacTech Germany

Finland
Norway
Sweden
Denmark
UK & Ireland
Netherlands
Belgium
Luxembourg
France
Russia
Italy
Malta
Turkey
Israel
Japan
NAGASE
South Korea
China
Taiwan
India
Thailand
Vietnam
Philippines
Singapore

PacTech USA

PacTech Asia

Demo Center Shanghai

Demo Center Korea

Demo Center Taiwan

Demo Center Japan (NTE)

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Our Business Units

Wafer Level Packaging

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

Advanced Packaging Equipment

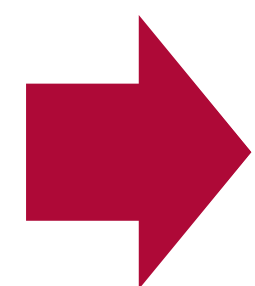
- Wafer Plating & Wet Process
- Laser Soldering
- Solder Ball Placement
- Flip Chip Assembly

Chemicals

- Electroless Plating
- Resists
- Solvents

Introduction & Motovation

- to achieve the goals of current medical technology roadmaps for highly reliable, miniaturized and biocompatible products such as implantable, wearable and diagnostic devices new assembly and interconnection solutions are required
- conventional bonding processes either load high thermal energy and/or mechanical force during the assembly step into the more and more sensitive packages and devices
  - → warpage
  - → contact joint intrinsic stress
  - → flux contamination
  - → massive IMC formation
  - → delamination
  - → high UBM consumption
  - → breakage/micro cracks etc.
- demand for thermally and mechanically minimally interactive bonding principles



introducing of the required energy optically by using a laser

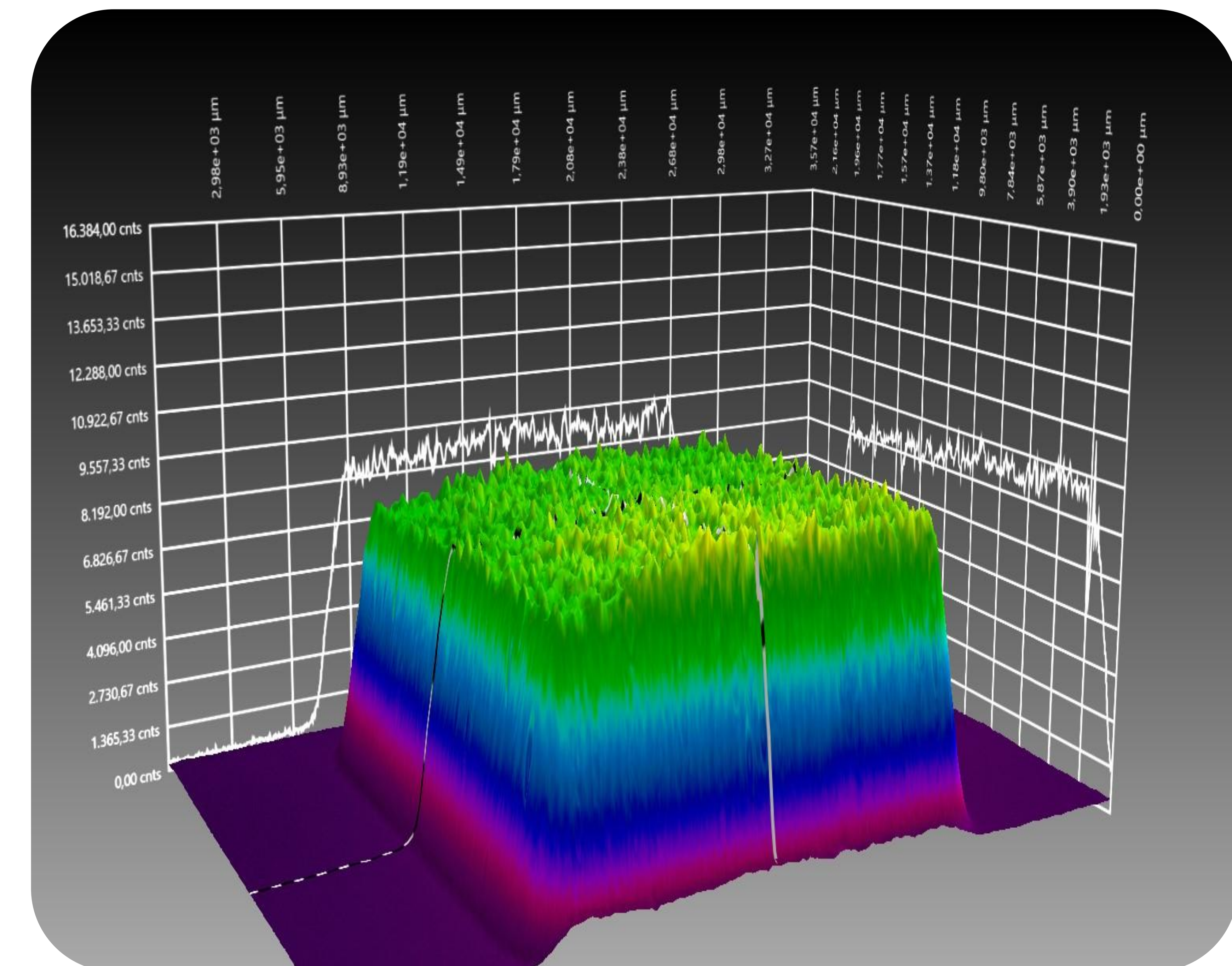


fig. 1: example picture of spatial power distribution for LAB process

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Preamble Laser Based Processes

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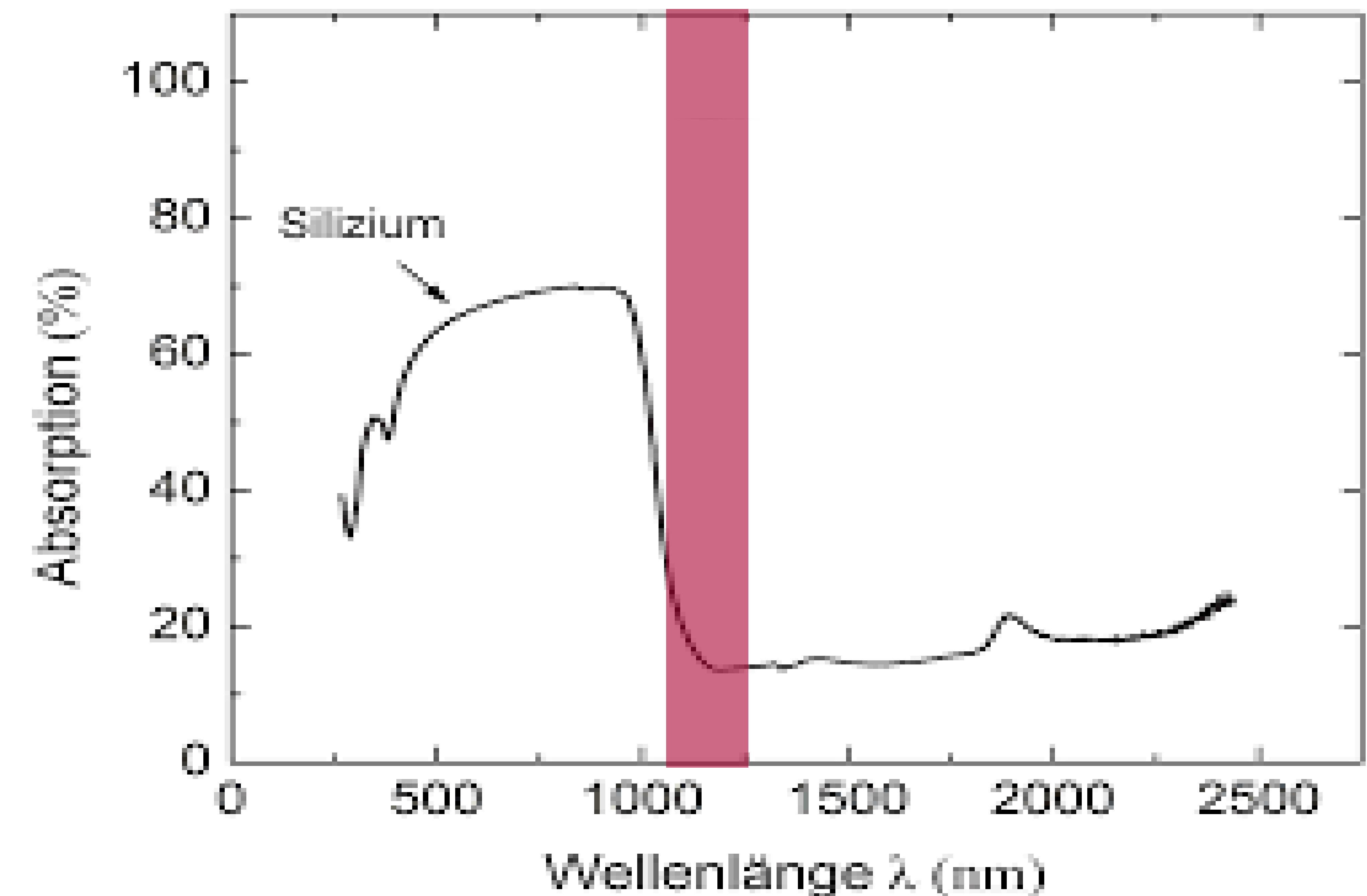
- High speed reflow in ms – s range
- Much shorter reflow time in comparison to conventional processes like thermo-compression bonding, wave sodlering or using a reflow oven
- Utilize semi-transparent effect of IR-radiation for semiconductor materials (organic + inorganic)
- Short laser pulse producing lowest thermal stress at bonded parts and bonding interconnection
- Short optical thermal load lead to smaller IMC and reduced growing characteristic
- Local and selective reflow, no thermal stress on the areas outside of bonding interface
- Bonding of materials with highest CTE mismatch
- Compatible with various metallization layer, such as NiAu, Sn, HASL, Au, Cr/Au, Cu and many more…

Solder Reflow Method	Temperature Range	Reflow Time
Laser	250 - 600 °	~ 0.01 – 10 s
Thermode	250 - 300 °	~ 3 – 40 sec
Oven Reflow	230 - 250 °	≥ 90 s



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SB² → Solder Ball Bumping

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Process Sequence

- Singulation of solder spheres (range 30µm-2000µm) in bond-head
- Solder sphere drops in capillary and blocks in capillary tip
- NIR laser pulse liquifies the solder sphere which is shot out by nitrogen pressure onto the pin contact
- Solder hits pin and contact surface, solidifies and forms a stable and reliable interconnection

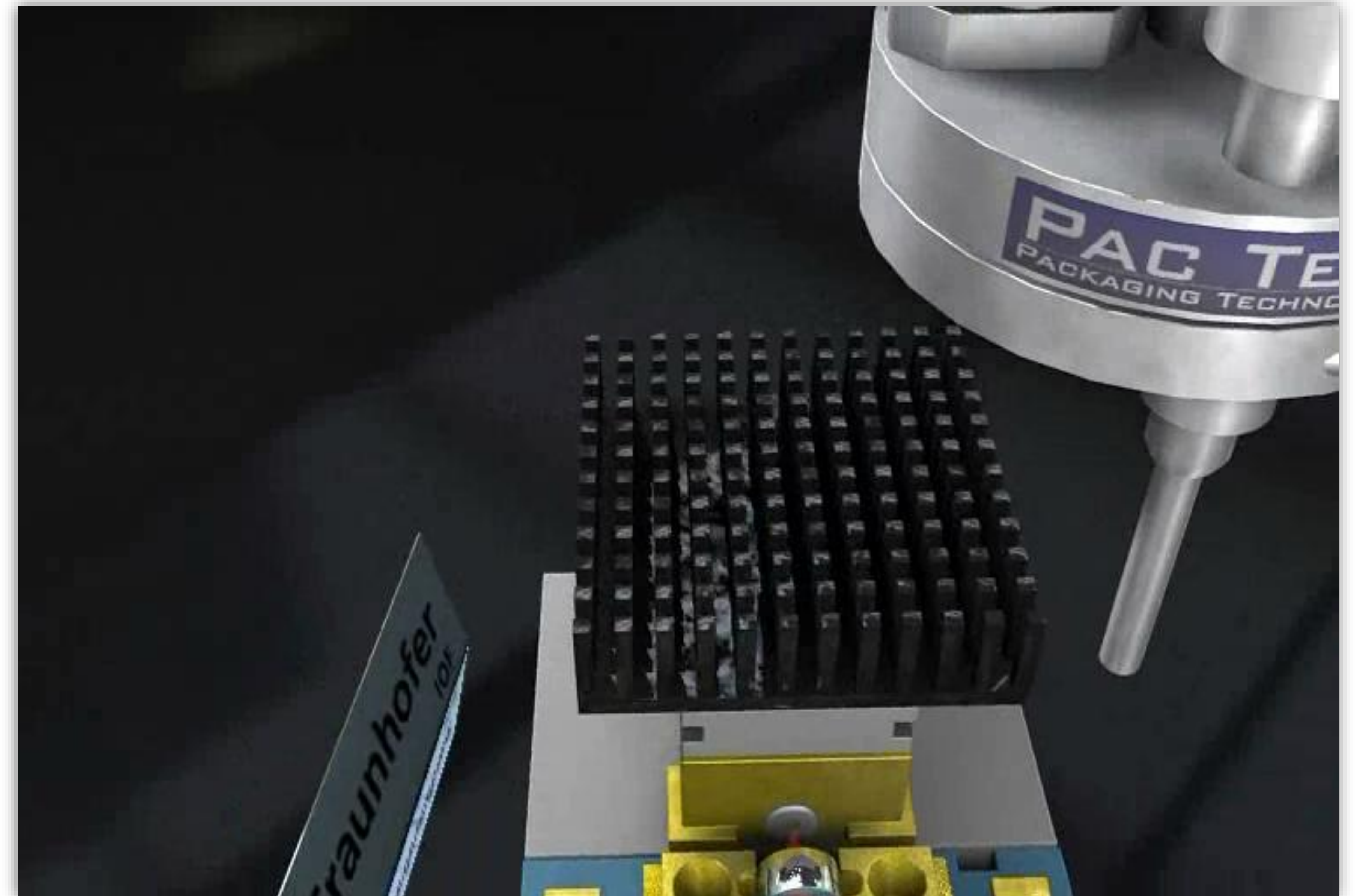

fig. 1: process principle

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SB² → Solder Ball Bumping

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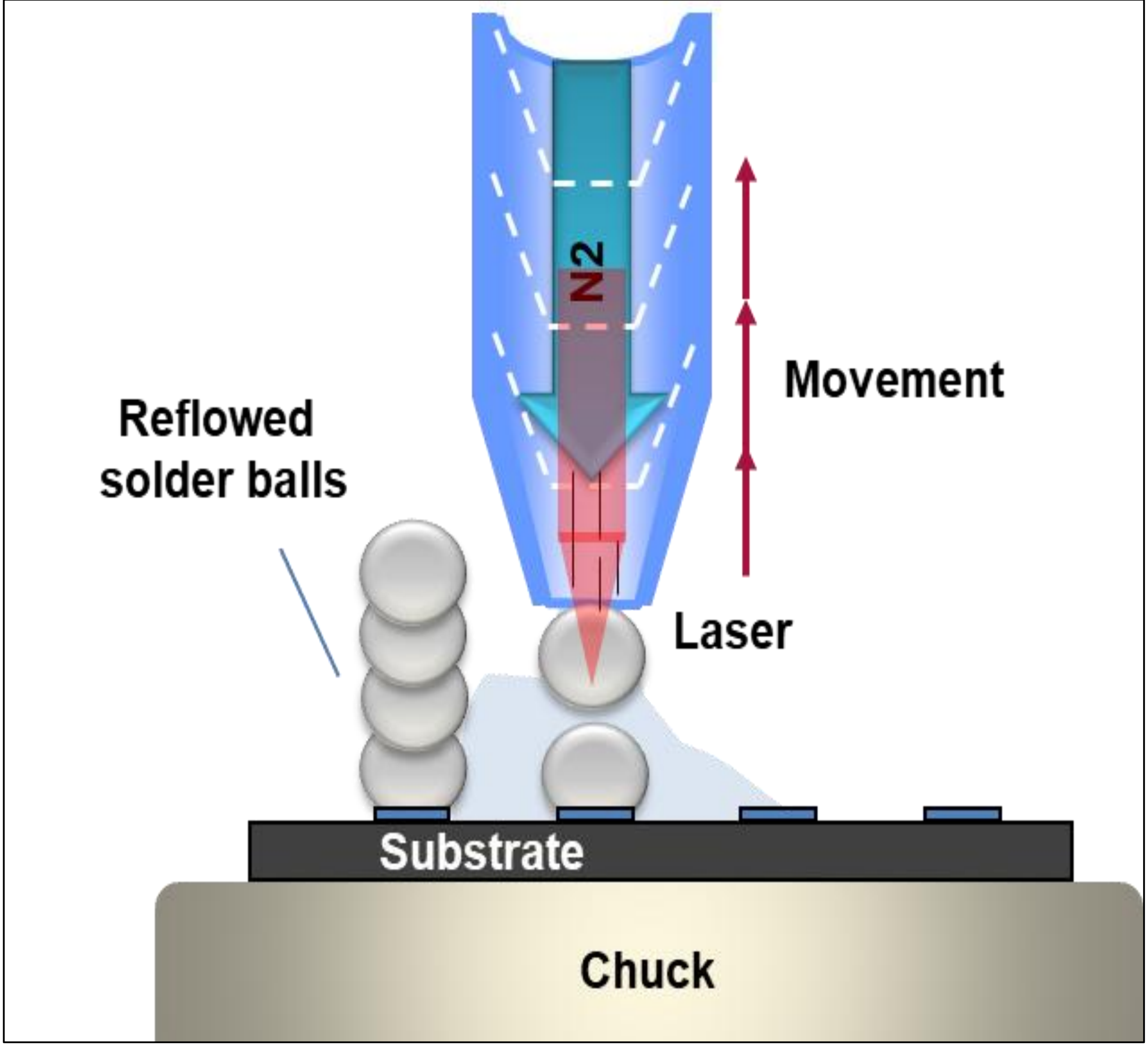
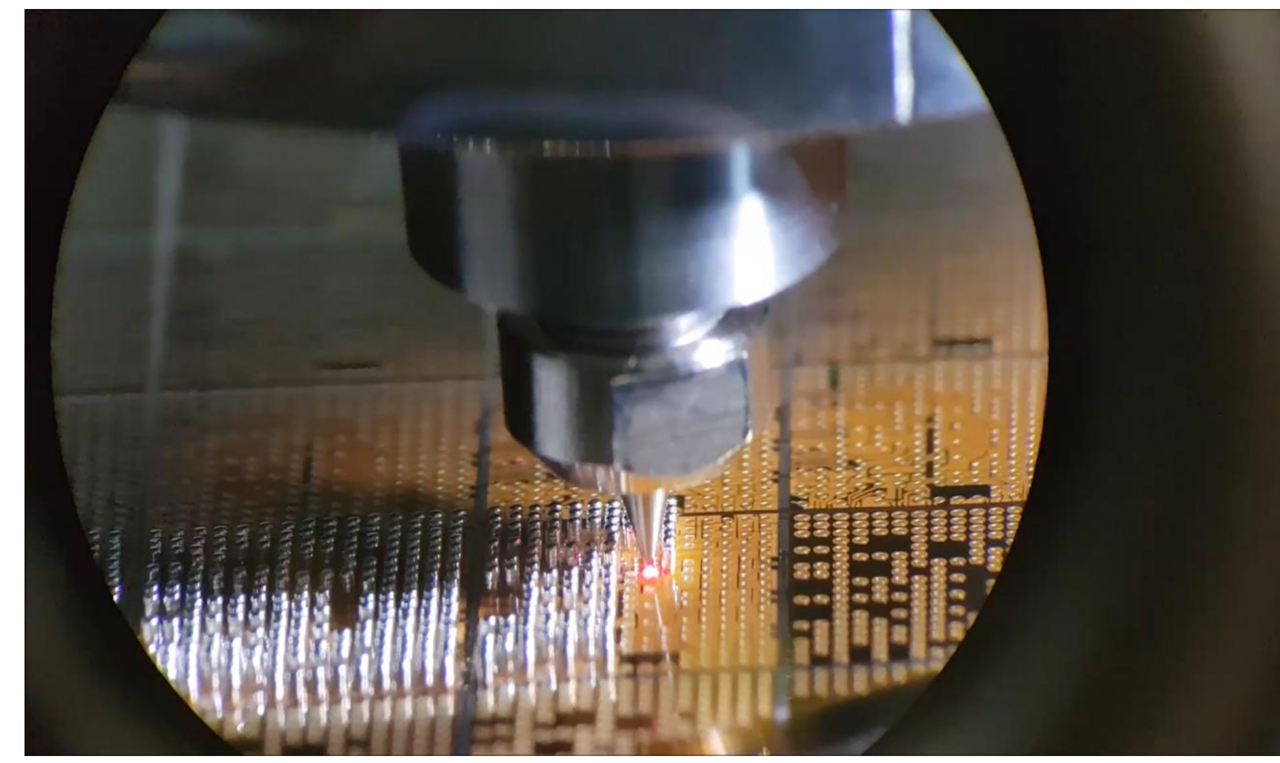
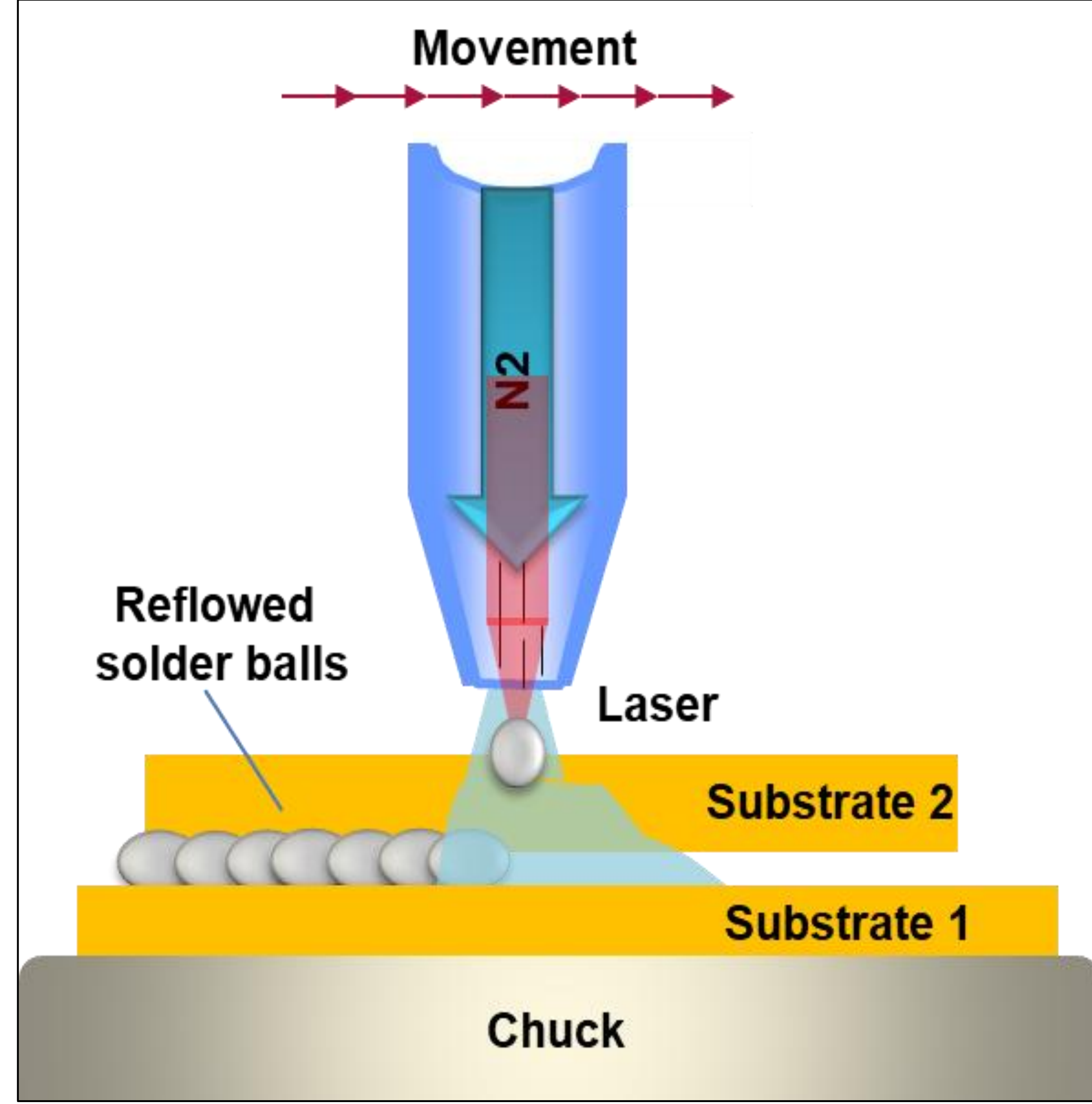
Process Variations

Stacking

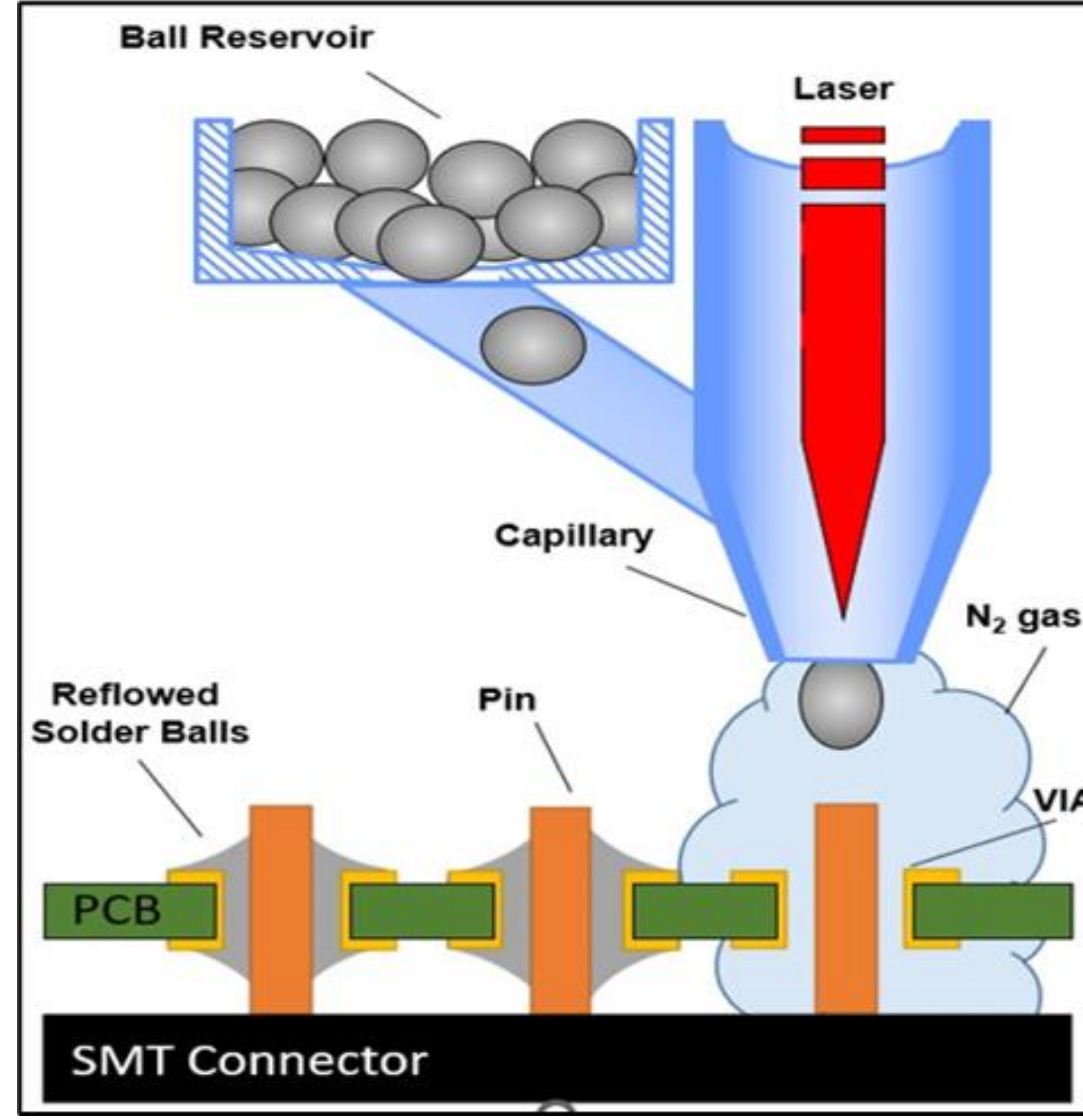


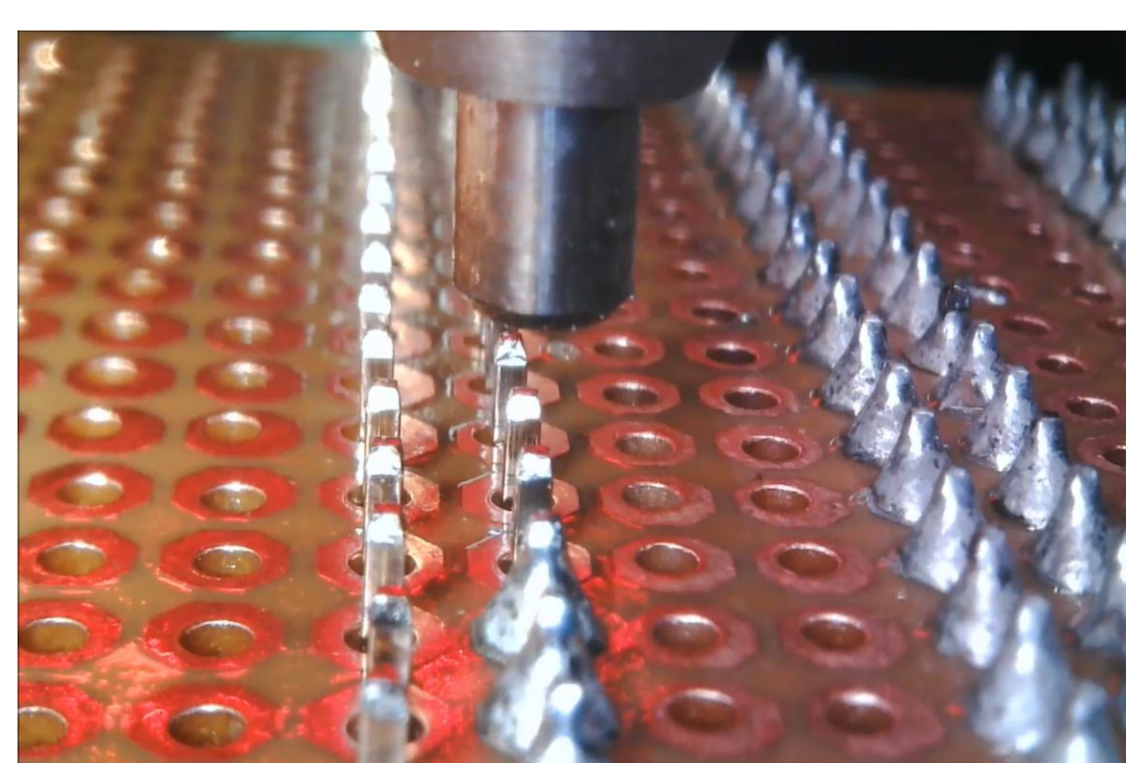


Overlapping

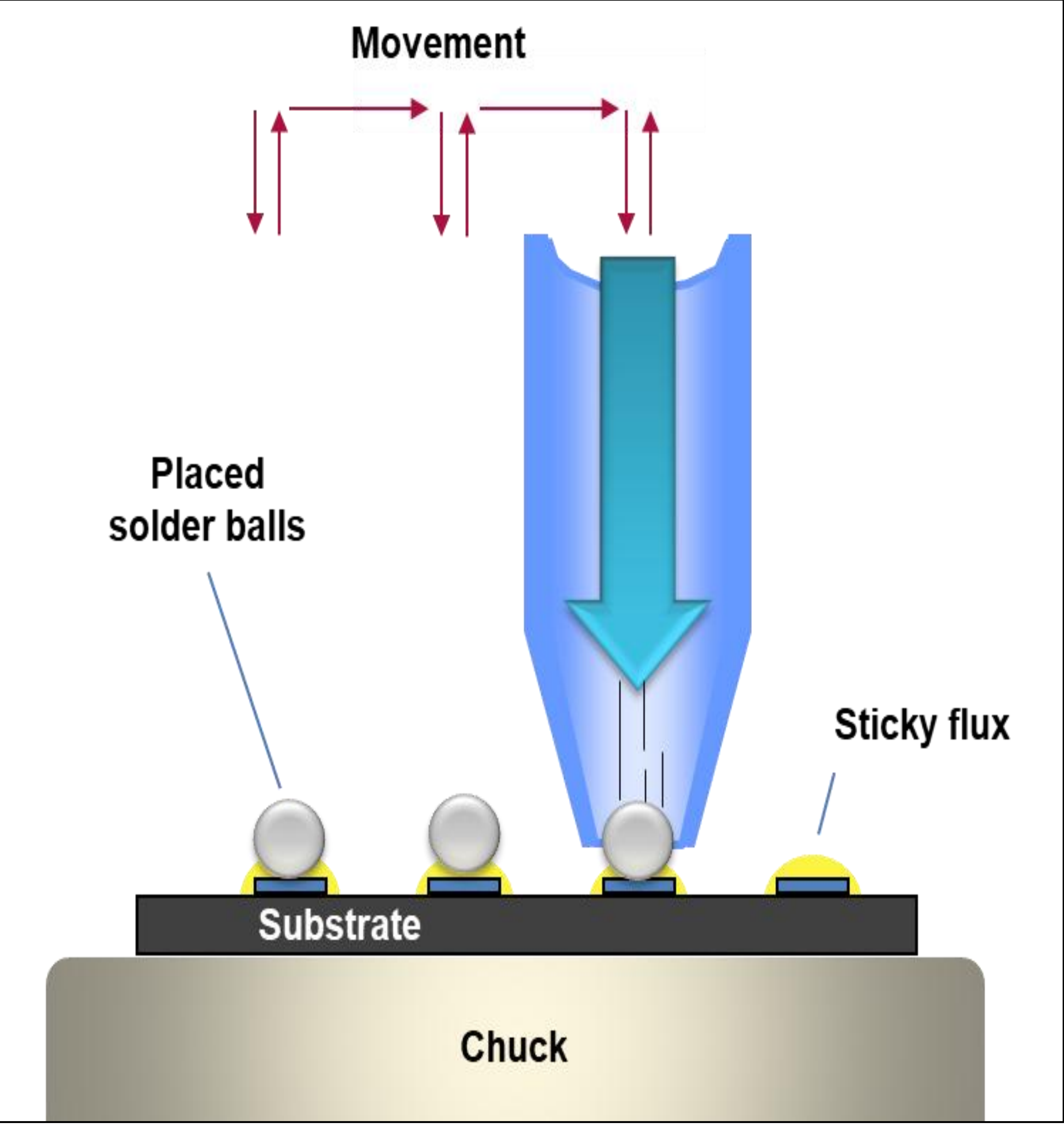


Filling





Tacking



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SB² → Solder Ball Bumping

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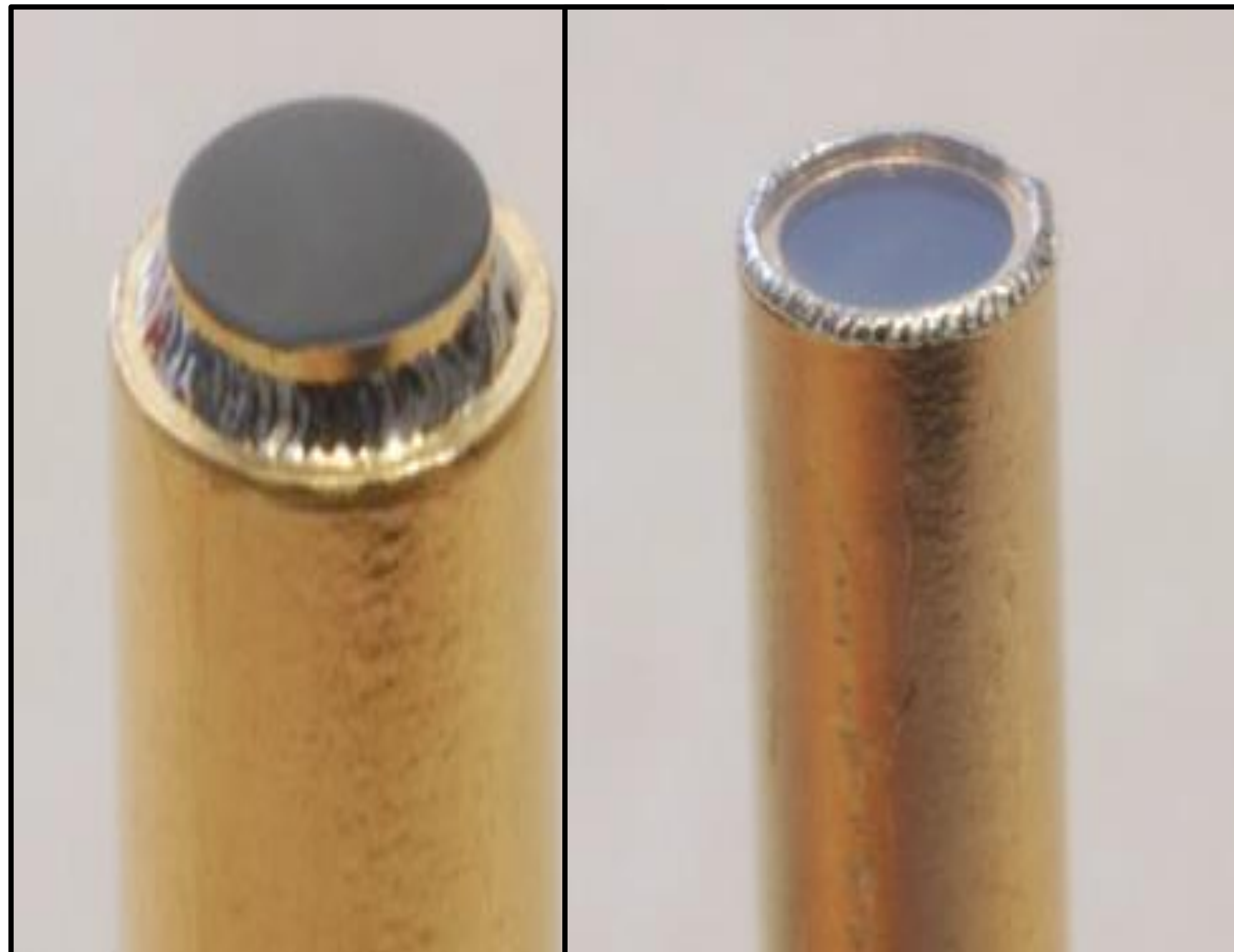
Applications

Endoscope

- Soldering of optical window/lens into tip-mount
- Hermitically sealed
- 500µm balls, Au80Sn20 alloy



Guidewires for Catheters

- Soldering of core and coil partially
- Forming of dome shaped tip
- 300µm balls, SAC_305

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SB²-WB → Laser Soldered Wire Bonding

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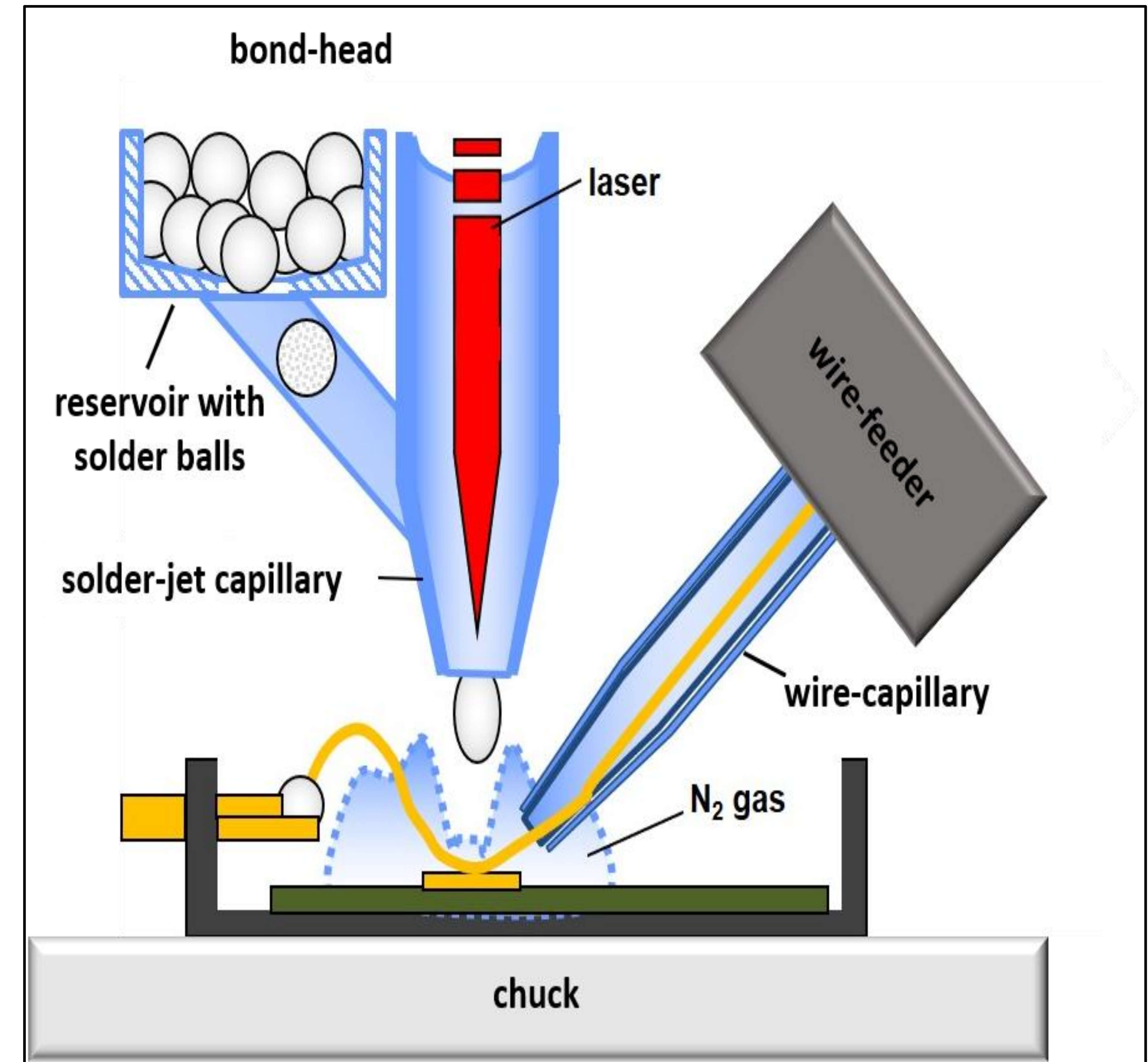
Process Sequence

- Positioning of bond-tools with respect to a solderable target position
- Wire is pushed onto the target while parallel a solder-ball is loaded into the jetting capillary
- Liquid solder droplet is applied by laser and N2- pressure onto the wire located on the target
- Solder solidifies and generates a uniform interconnection between wire, solder and target
- System moves to a subsequent bond location while wire unwinds (loop-forming)
- Previous process steps (1-4) are repeated and the wire either cut or the bonding continued (5)



SB²-WB process principle

SB²-WB → Laser Soldered Wire Bonding

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Advantages compared to common technologies

- Contactless formation of wire bond interconnection
- No transformation of wire-diameter or -bulk
- No-loop option enables smaller package size without the wire loop
- Wire soldering on various bondable surface
- Simple repair possibilities of soldered interconnection
- Flexible bond-tool configuration in a hemispherical work-space

	Wire-Bond Technologies		
Parameter	**TS**	**US**	**SB²-WB**
ultrasonic power	yes	yes	no
bonding force	low (30-90cN)	low (25-45cN)	negligible (< 2µN)**
temperature substrate	middle (100°C-220°C)	low (room temperature)	low (room temperature)
bonding time	short (30-100ms)	short (50-100ms)	ultra short (1-10ms)
preferred wire metal	Au, Ag, Cu, Pt, Pd	Al, Au, Cu	Au, Cu, Ag, Pd, Pt
preferred pad material	Al, Au, Cu	Al, Au, Cu	NiAu, Au, Cu
contamination	middle	middle	middle
speed	4-10 wire-bonds/s	2-3 wire-bond/s	3-4 wire-bonds/s*
min. pitch	35µm (15µm wire)	35µm (15µm wire)	40µm (15µm wire)*

current process speed 0,5 wire-bonds/s

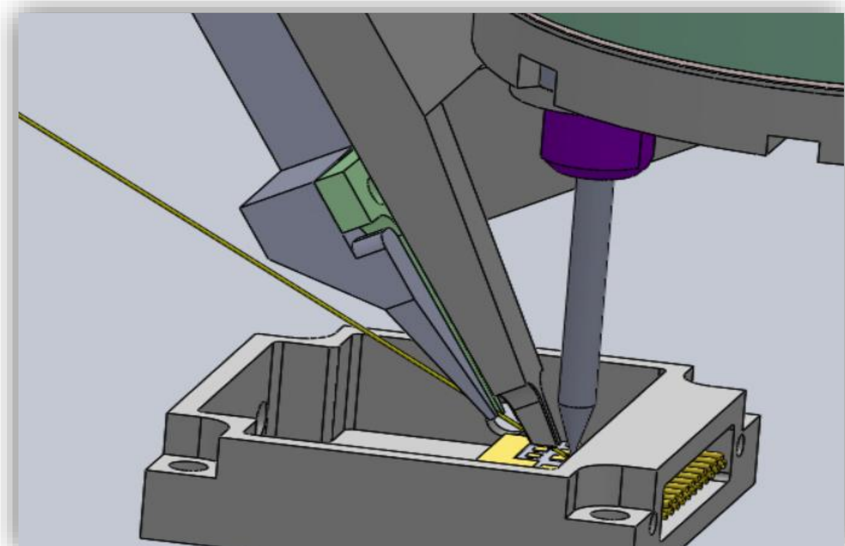

Fig.1 Bond-tool

* therotical calculated value

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Laplace → LAB

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Laser Assisted Bonding

- Daughter substrate fixed against bonding tool by using vacuum
- Optical alignment of daughter substrate with respect to mother substrate
- After substrate placement, reflow is initialized by modulated laser beam
- Daughter substrate kept in position during reflow by tool vacuum
- Parallel optical temperature detection and regulation
- Optional flushing of active or passive process gases

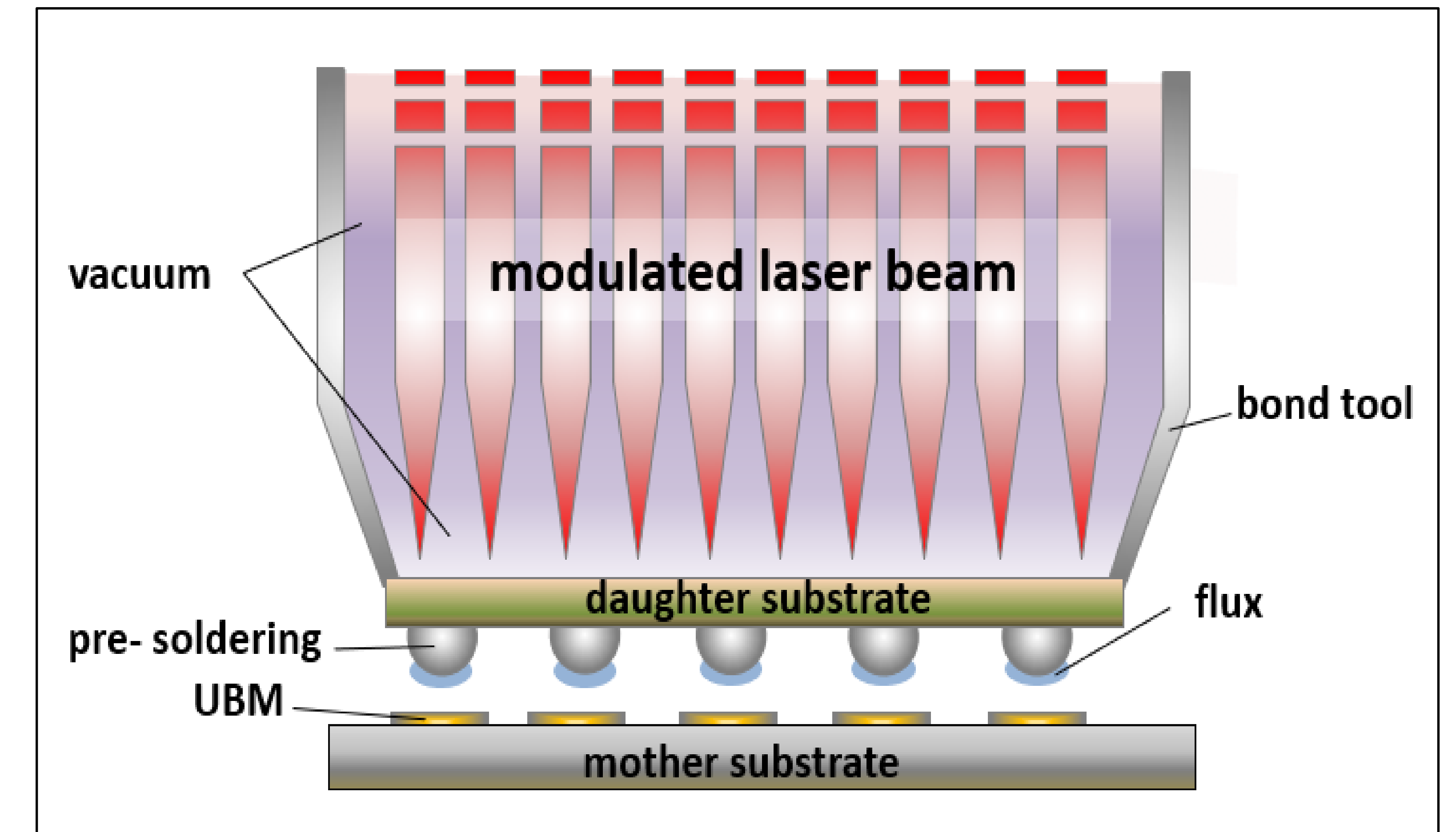

fig. 1: process principle

- Universal for CoC, CoW, CoG, CoB, SOP, SIP etc.
- Die sizes 60µm x 60µm – 50mm x 50mm
- Accuracy ≤ 1µm @3 sigma
- Beam size 50mm x 50mm
- Supports 600mm x 600mm panel size
- Cycle time 5s/chip @ 5µm accuracy
- Rework process capability

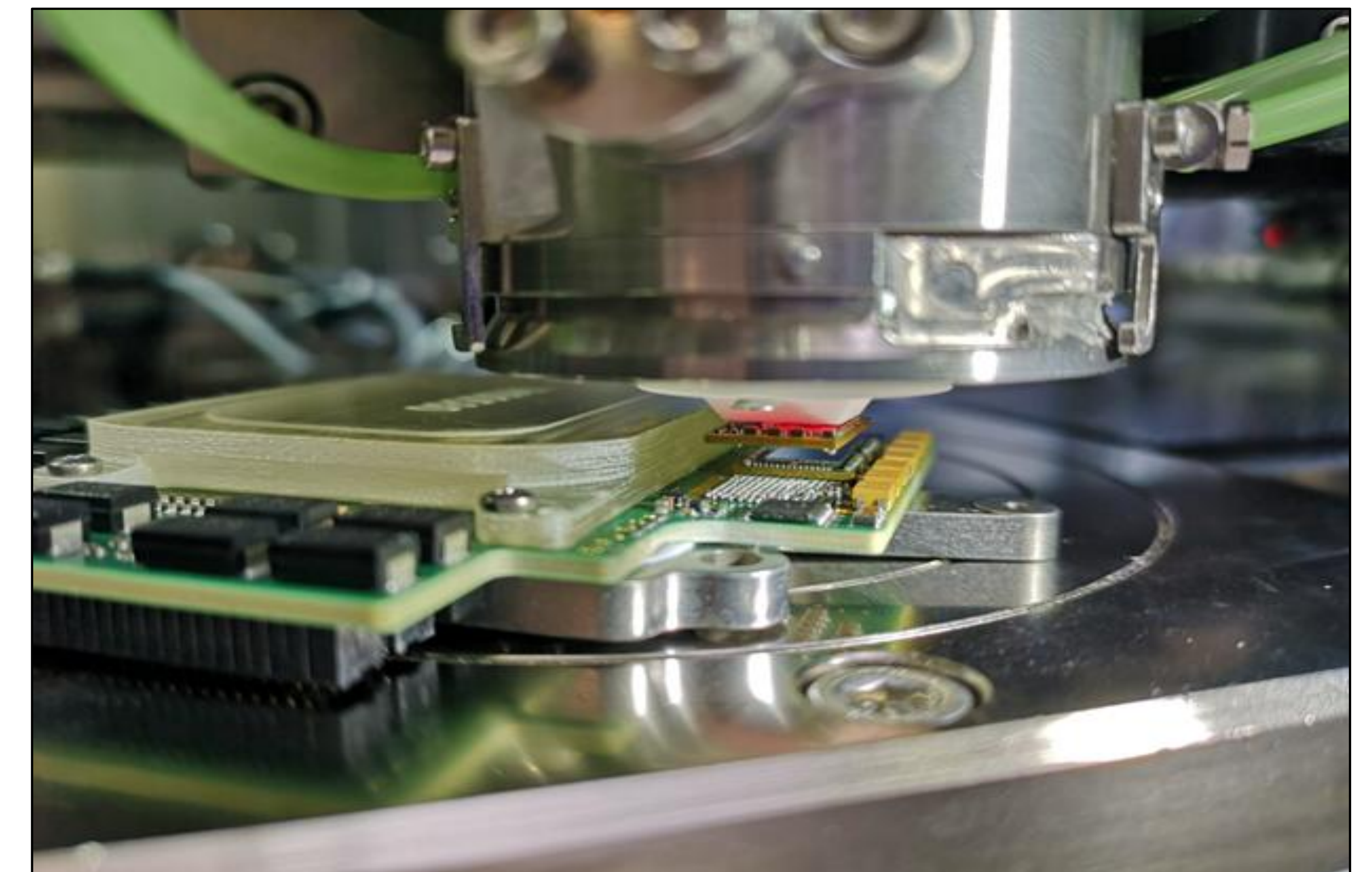

fig. 2: laser assited bonding example

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Laplace → Laser Assisted Bonding

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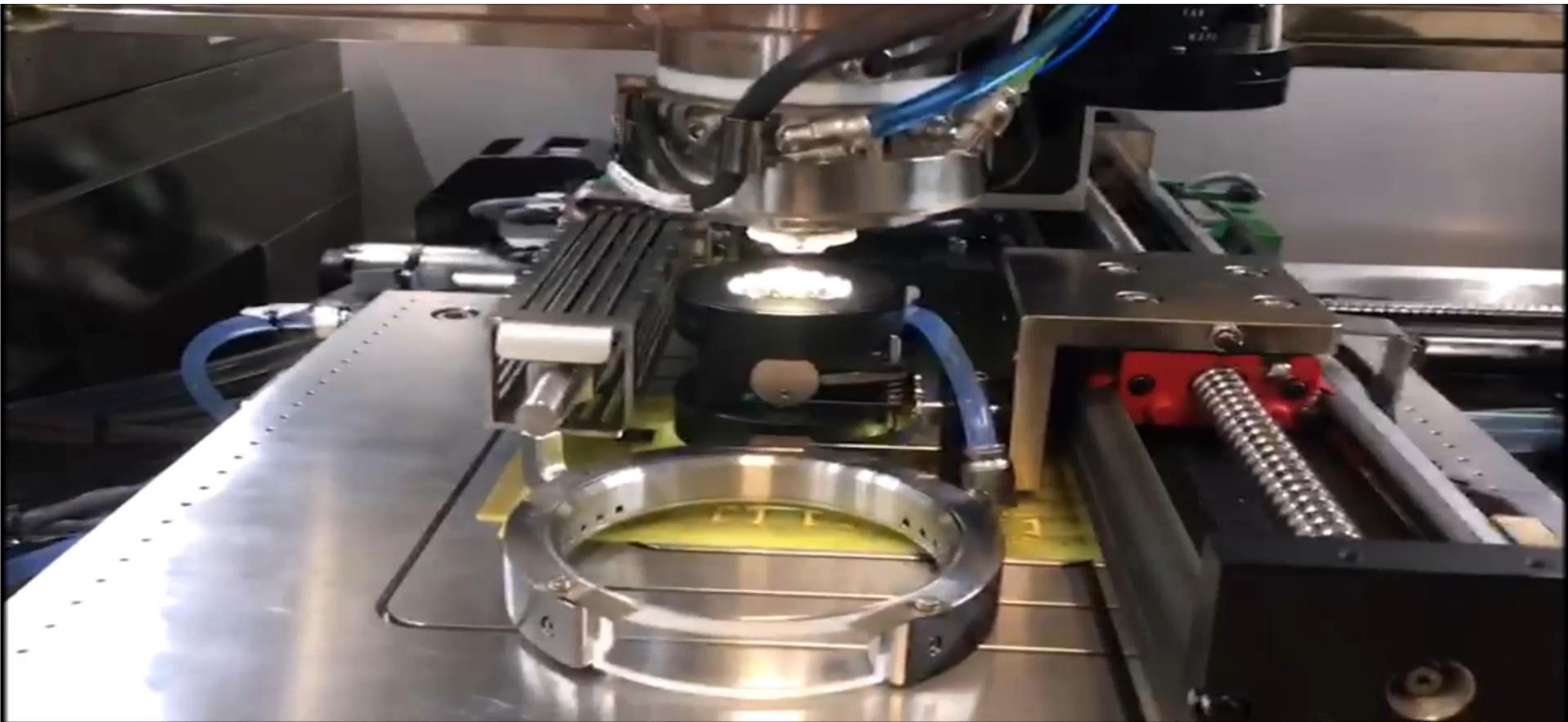
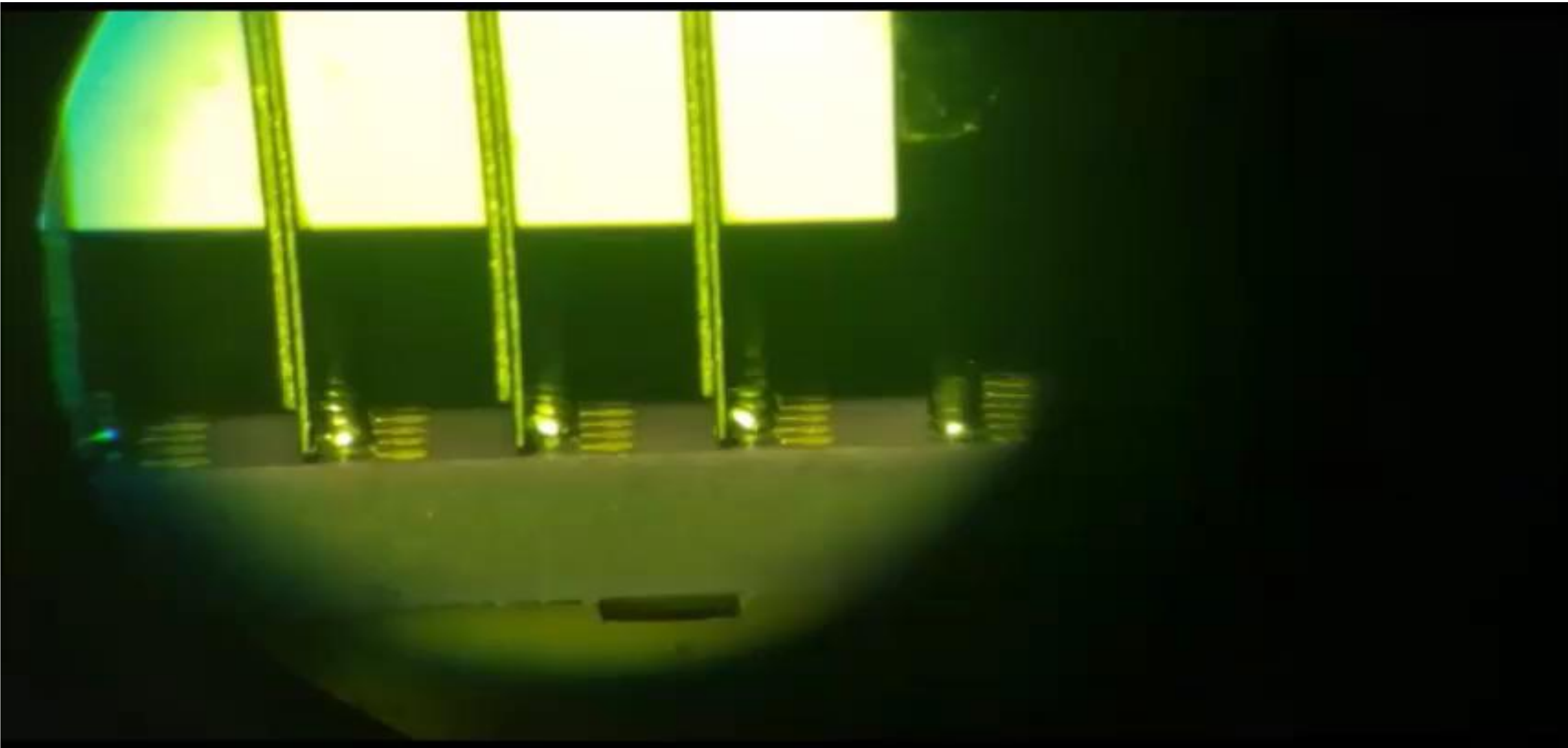
LAB → Process Video

- Example video horizontal LAB process with local process-gas chamber



- Example video vertical LAB configuration



Application Examples

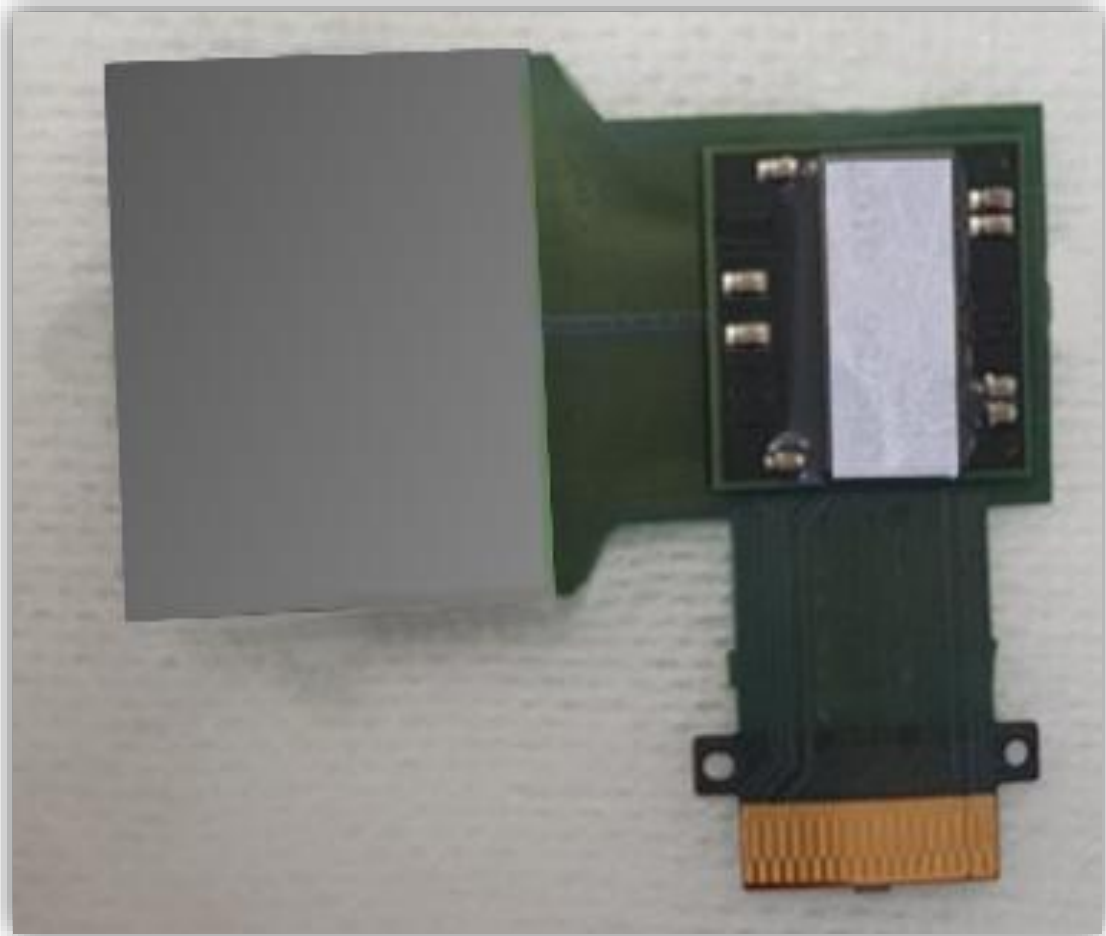


fig. 1: x-ray CT-semsor

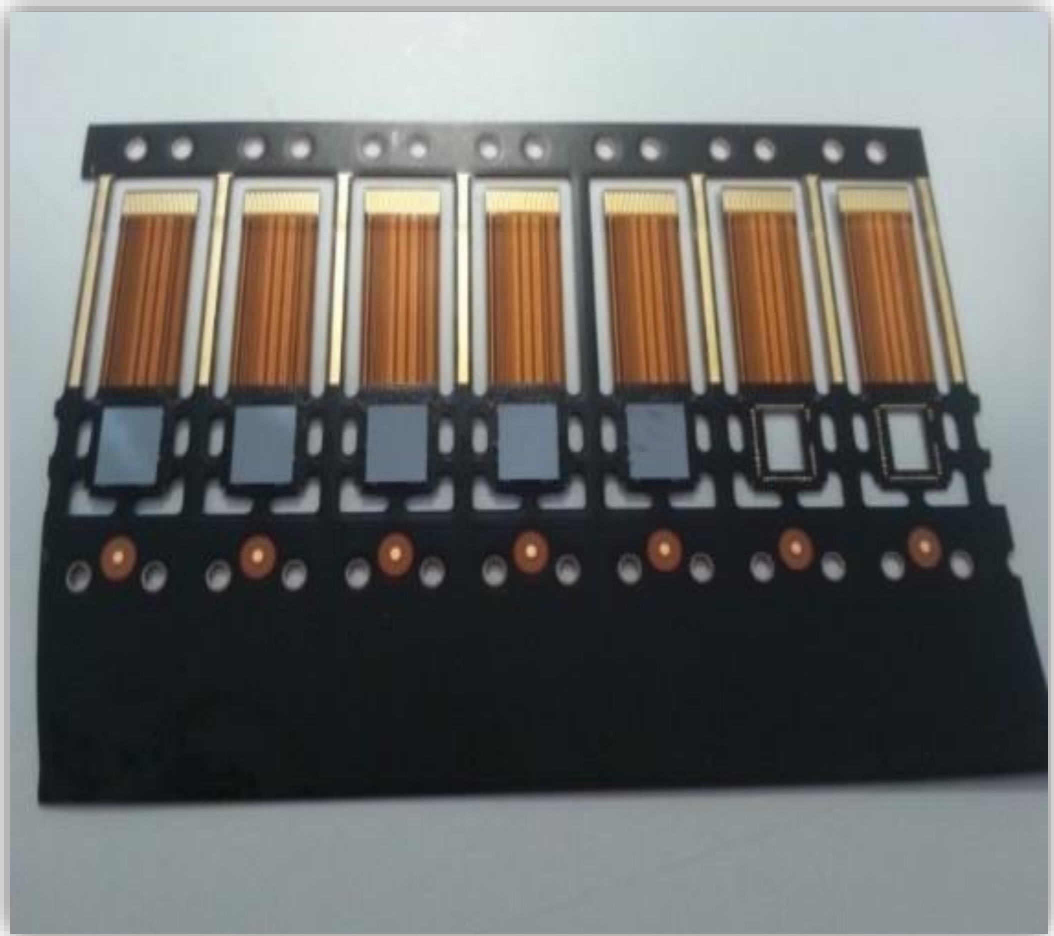


fig. 2: image-sensor

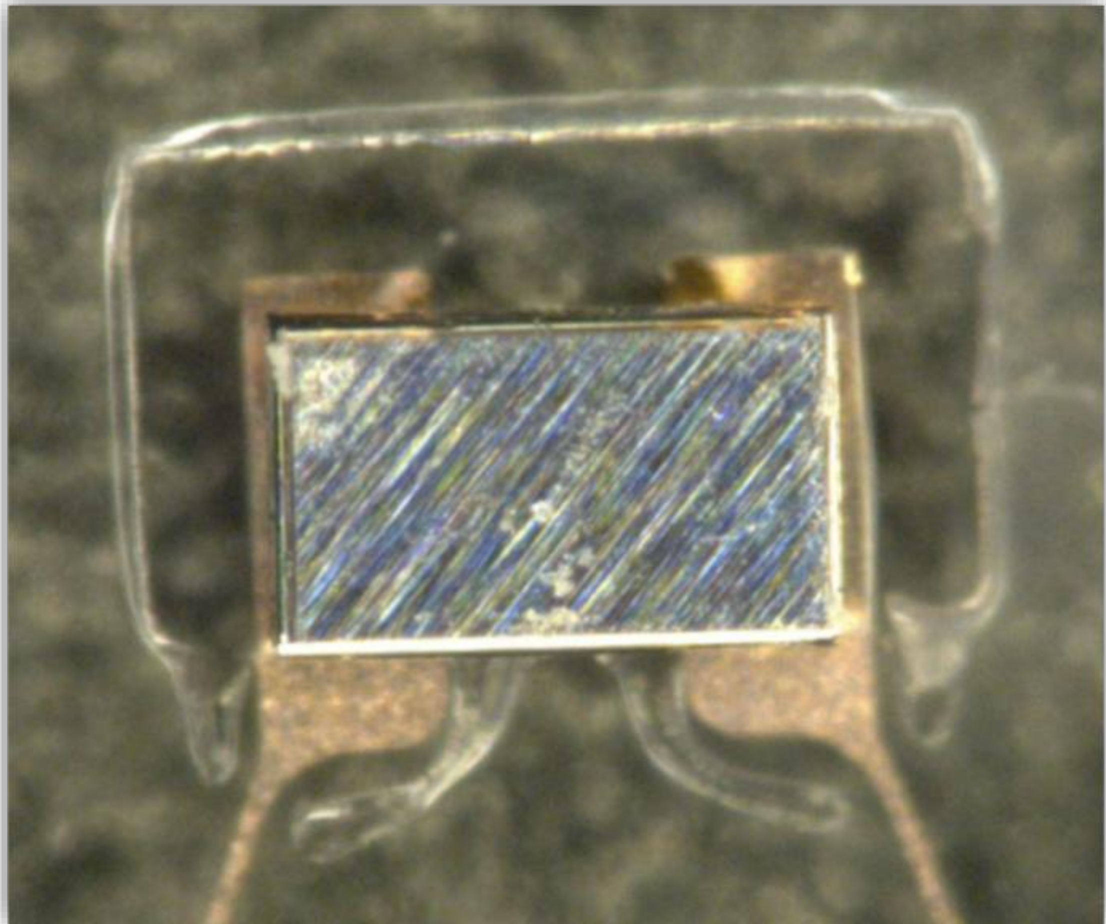


fig. 3: Eye Tracking Laser Diode

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Laplace → LAR

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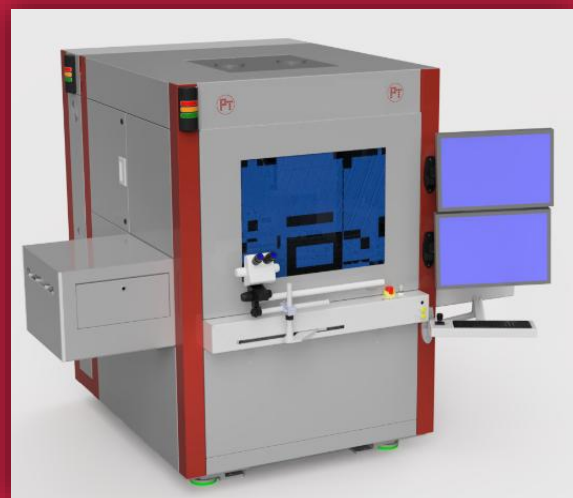
LAR → Laser Assisted Reflow

- Dies are already placed on contact pads on the substrate
- As bond material solder paste, solder preforms, sinter-pastes/inks or conductive adhesive is applied
- Homogenized IR laser beam iridates the whole area and reflow all components in one step
- Self alignment effect by gravity and adhesion forces during the liquid phase of the bond material
- Optical monitoring of temperature and instantaneous control of laser power
- Optional flushing of active or passive process gases



- Substitution of conventional multi zone ovens (8-12m, 10-15kW/h, 20m³/h)
- Reduced power consumption by min. factor 2
- Reduced N2 consumption by min. factor 10
- Reduced footprint by min. factor 2

- Multi component reflow
- Beam size 50mm x 50mm
- Supports 600mm x 600mm panel size

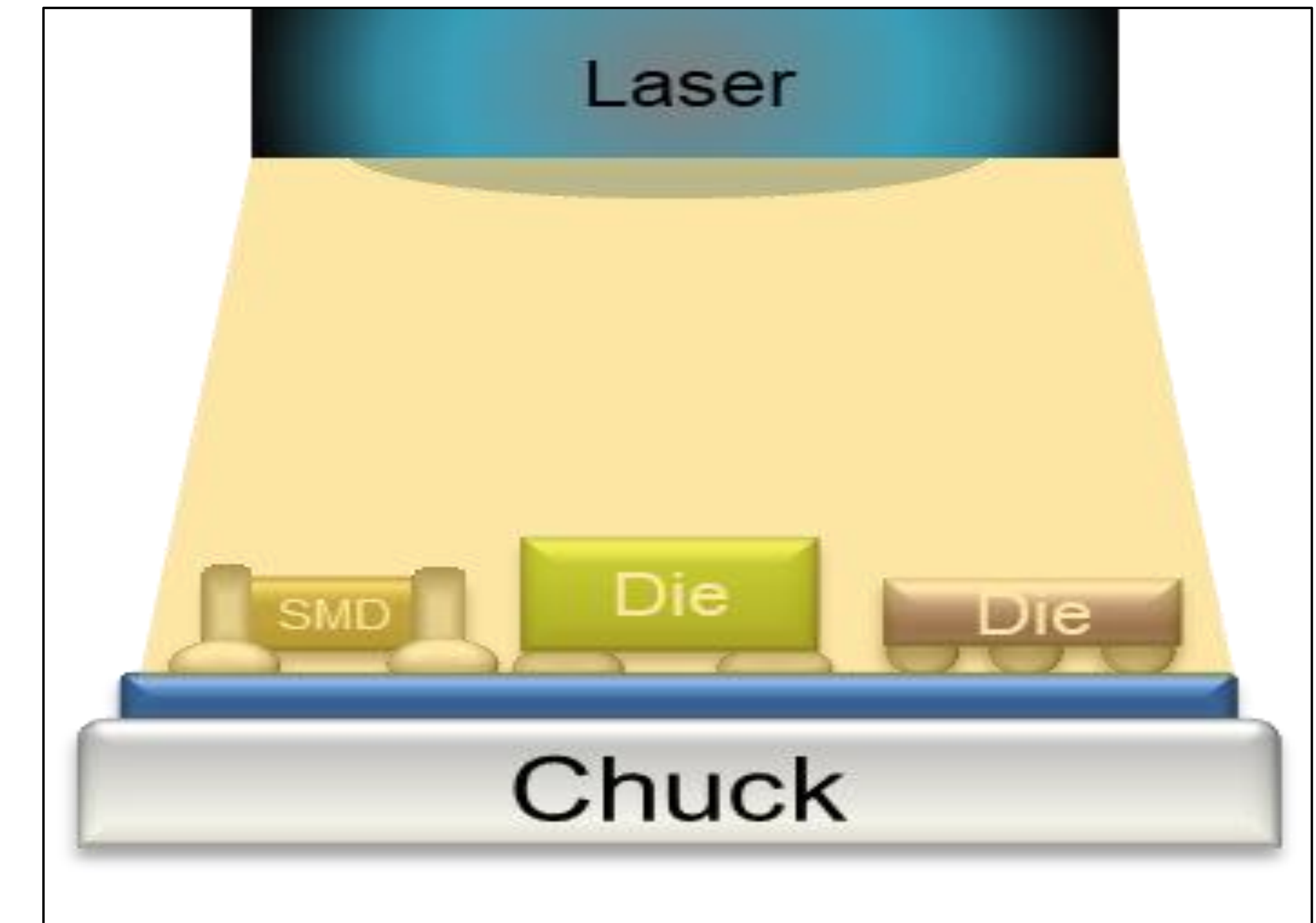


fig. 1: process principle

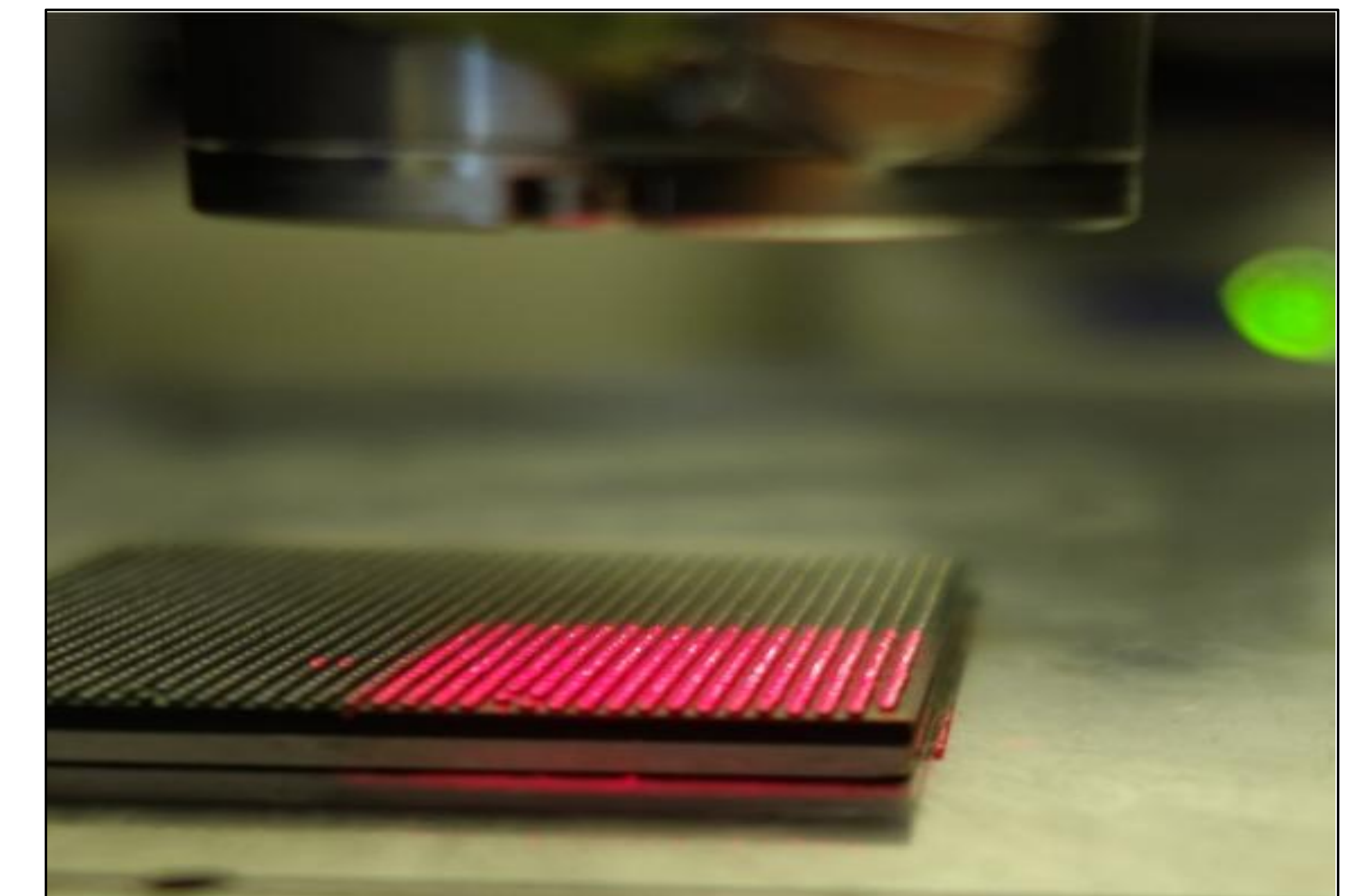


fig. 2: laser reflow example

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Laplace → Laser Assisted Reflow

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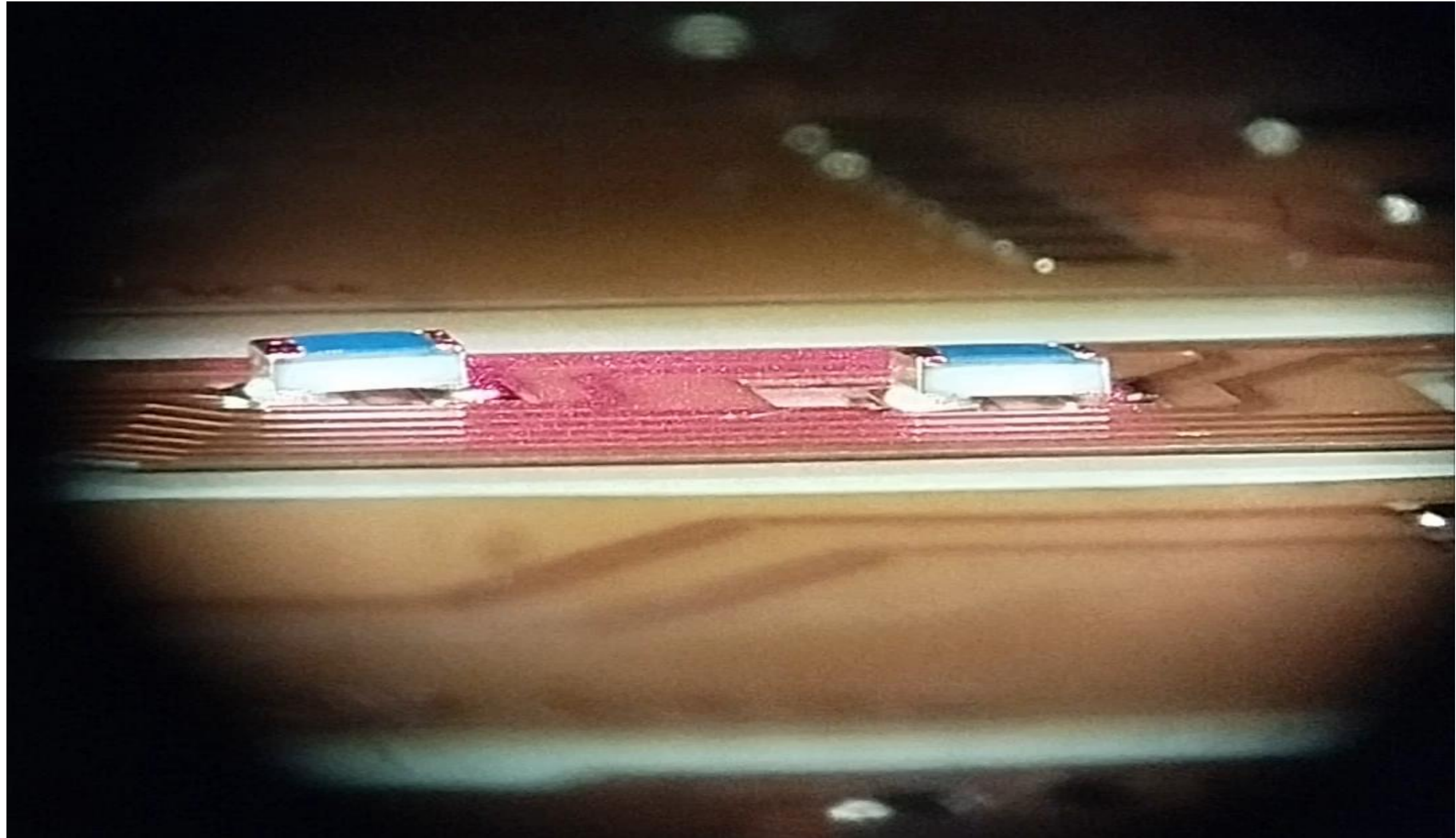
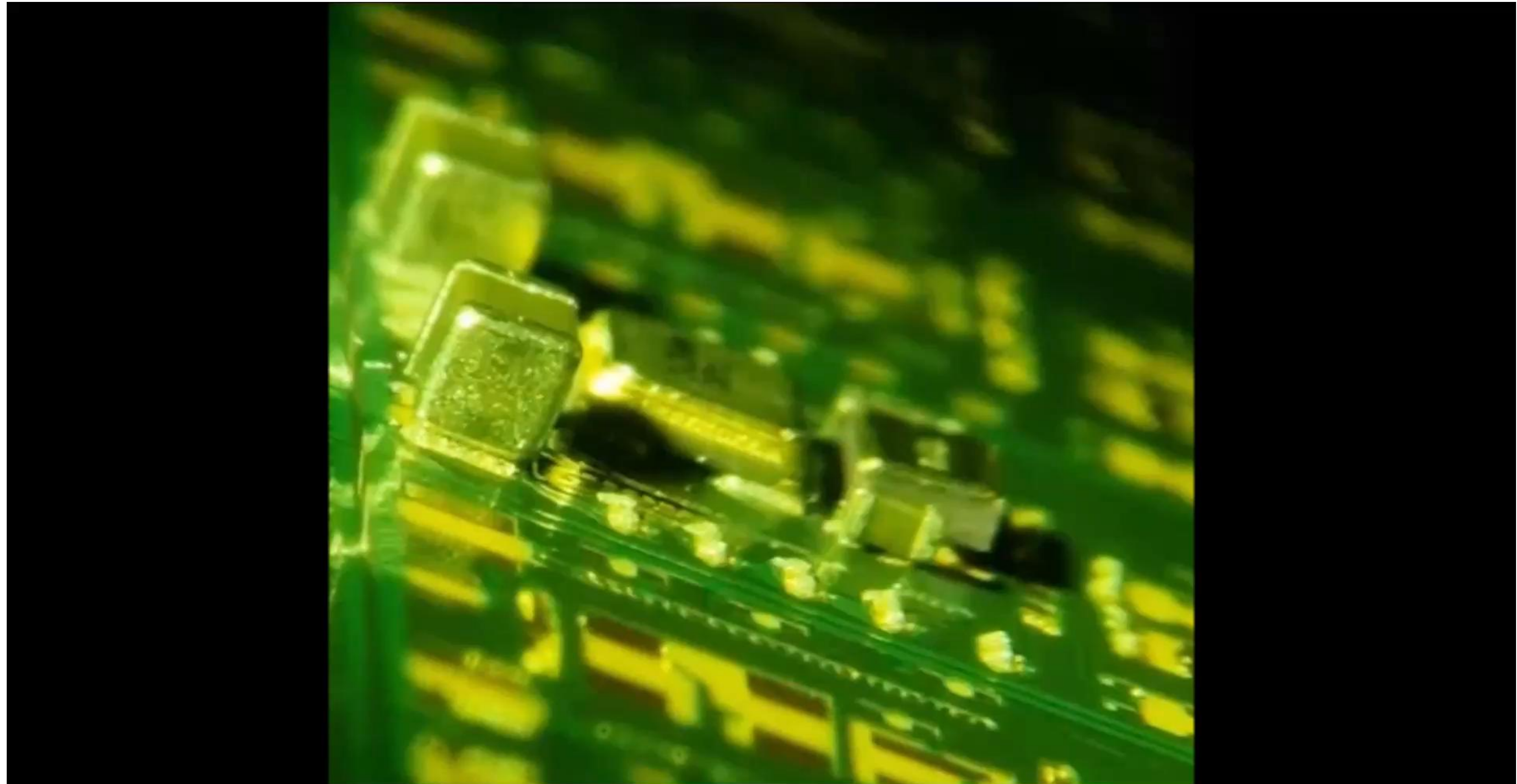
LAR → Process Video

- Example video NTCs on flex (2s)



- Example video multi component reflow (3s)



LAR → Application Examples

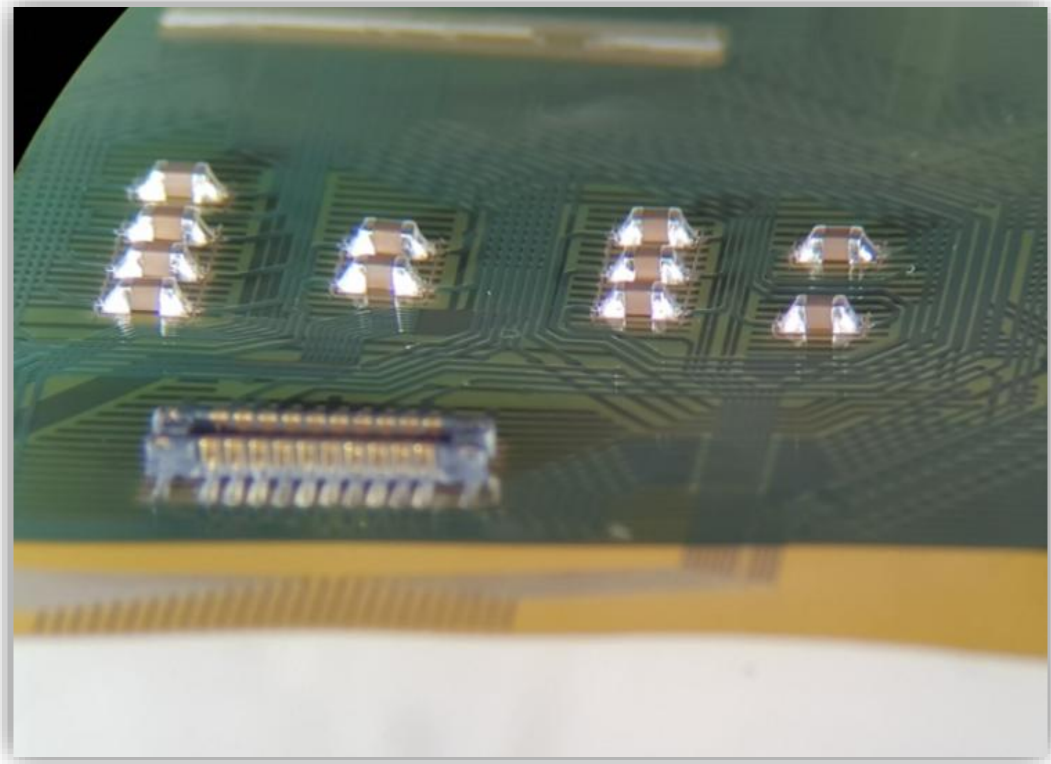


fig. 1: SMD on flex

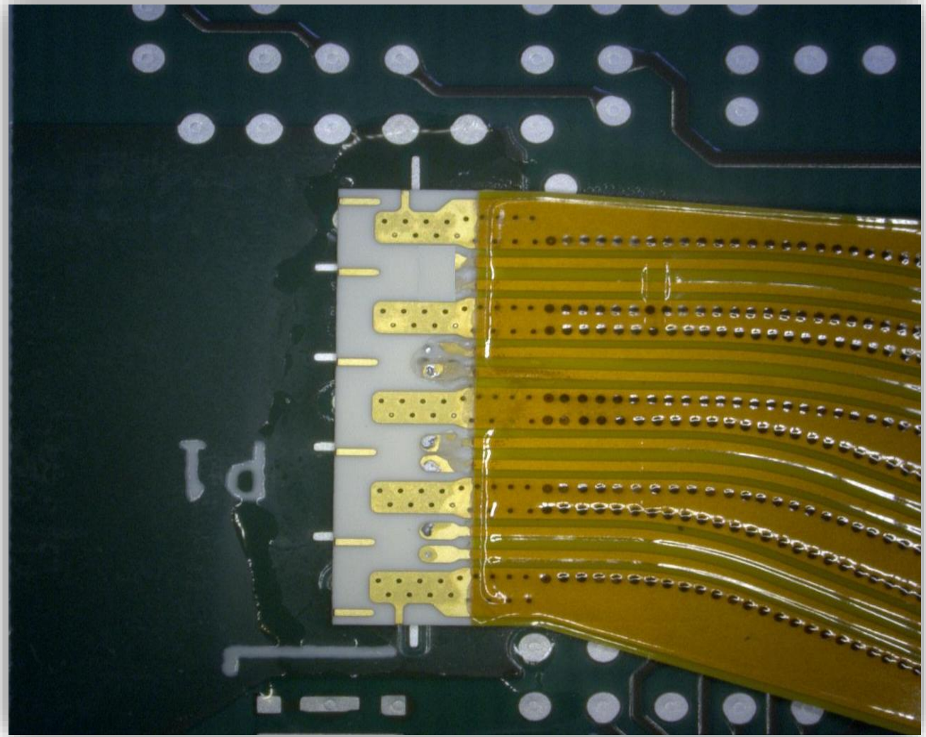


fig. 2: Flex on Board

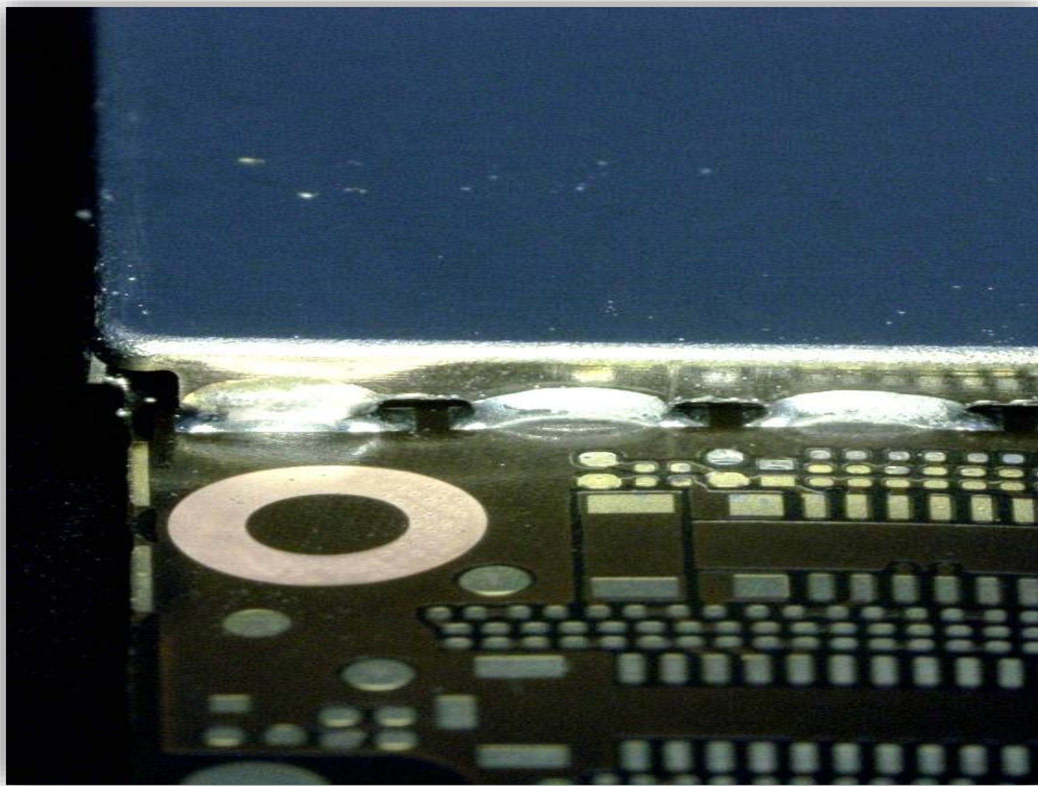


fig 3:HF-shield on board

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