BTC and SMT Rework Challenges

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Abstract

Rising customer demands in the field of PCB repair are a daily occurrence as the rapid electronic industry follows new trends in a blink of an eye. New strategies and technologies are required to fulfill those demands. Out of the long list of today's customer demands for efficient BTC and SMT PCB repair some subjects show up on a daily basis and are agreed to be relevant for the coming years:

- BTC types with new effects -> voidless treatment
- Smaller components -> miniaturization (01005 capability)
- Large board handling -> dynamic preheating for large board repair
- Repeatable processes -> flux and paste application (Dip and Print), residual solder removal (scavenging), dispensing, multiple component handling, and traceability
- Operator support -> higher automation, software guidance (Human Computer Interface) • Cost effectiveness -> Rework Systems for different budgets and ROI situations

Introduction

Some of the listed topics have not shown their practical relevance yet. There have been a number of discussions about 01005 rework capabilities, but up to now there is no proven evidence that those technologies that claim to be capable, can truly run successful rework processes on this tiny component in a daily real world rework situation. Many parameters need to be observed and controlled in precision line-production like:

desoldering and lifting of component without affecting very close neighbouring components
- new selective solder paste supply for the small joints
- picking, adjustment and placement of the component
- PCB coating
- PCB cleaning and others

Nevertheless, as the 01005 components exist, the challenge is set. While the component size is shrinking and integration as well as the packing density are rising, on the other hand the PCB size is growing. Mainly driven by telecommunication and internet data transmission (cloud computing, IOT) the processing power of today's computer centers is increasing rapidly. And in the same way parallel processing computer boards are growing in size! One challenging question is: How to homogeneously preheat a fully populated 24" x 48" multilayer PCB during rework?

Other topics like tracing and documenting the individual board treatment in the rework area seem to become a must in times of soaring electronic production and as repair processes have become an acknowledged part of electronic assembly. Out of the above mentioned topics, which basically describe a roadmap for rework capabilities until 2021, three subjects will be introduced subsequently. Other than issues that will be important for future repair and rework feasibility they have already reached practical necessity since a while ago and thus need to be fully implemented or improved in today's rework systems.

Voidless treatment during a rework process

In the assembly of bottom terminated components (BTC) the formation of voids has become a serious problem in many applications.

A definition for a void is given in the context of soldering defects as:

[…] then solder will quickly fill the opening of the fitting, trapping some flux inside the joint. This bubble of trapped flux is the void; […] the joint, preventing solder from occupying that space. An area inside a soldered joint where solder is unable to completely fill the fittings' cup, because flux has become sealed inside [1]

And in SMT only one of the possible effects is explained as:

[…] The reliability of solder joints becomes more of a concern, as less and less solder is allowed for each joint. Voiding is a fault commonly associated with solder joints, especially when reflowing a solder paste in the SMT application. The presence of voids can deteriorate the joint strength and eventually lead to joint failure. [2]

The following impacts of void formation inside a solder joint have been reported:

- reduced **thermal transfer** from component to the PCB with risk of overheating the component
- reduced **mechanical strength** of a solder joint
- possibility of spontaneous **out gassing** – creation of solder splashes
- impact to the **ampacity** of a solder joint – connection may overheat because of higher electrical resistance
- impact on the **signal transmission –** in high frequency applications voids may dampen the signals

Especially in power electronics the formation of voids in the thermal pad of e.g. QFN packages is currently an increasing problem. The necessary transfer of energy from the component into the PCB for cooling purposes might be disabled. The components lifetime will be drastically reduced.

Besides other methods like using "low voiding" solder pastes, optimizing the reflow profile and applying the correct amount of solder paste with optimized stencils, a void reduction treatment of the entire assembly while the solder is in its liquid phase is an option to choose.

So the question is, how is it possible to implement a void treatment technology into an open environment of a rework machine? The vacuum technology known from Reflow ovens is not an option. The technique used is based on a sinusoidal actuation of the PCB substrate (Figure 1). Primarily the PCB is stimulated by a longitudinal wave with an amplitude of less than 10 µm on the PCB level. During this sinusoidal actuation of the PCB in a defined frequency range, the self-resonances of this area are stimulated regardless of the PCB layout and population. When the PCB is in sweep motion, the component remains in its location and the voids, trapped in the boundary layer, the liquid solder, have the ability to escape.

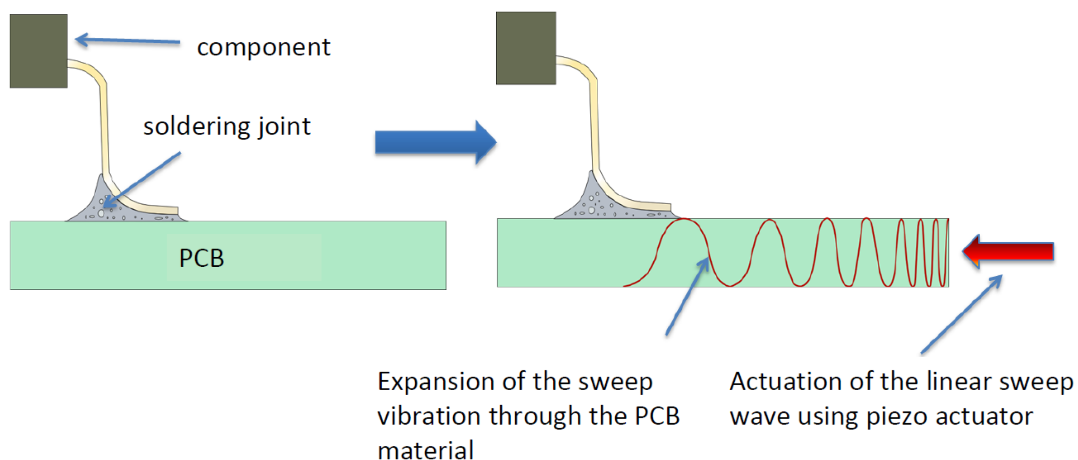

Figure 1 Voidless treatment of a PCB with piezo actuator

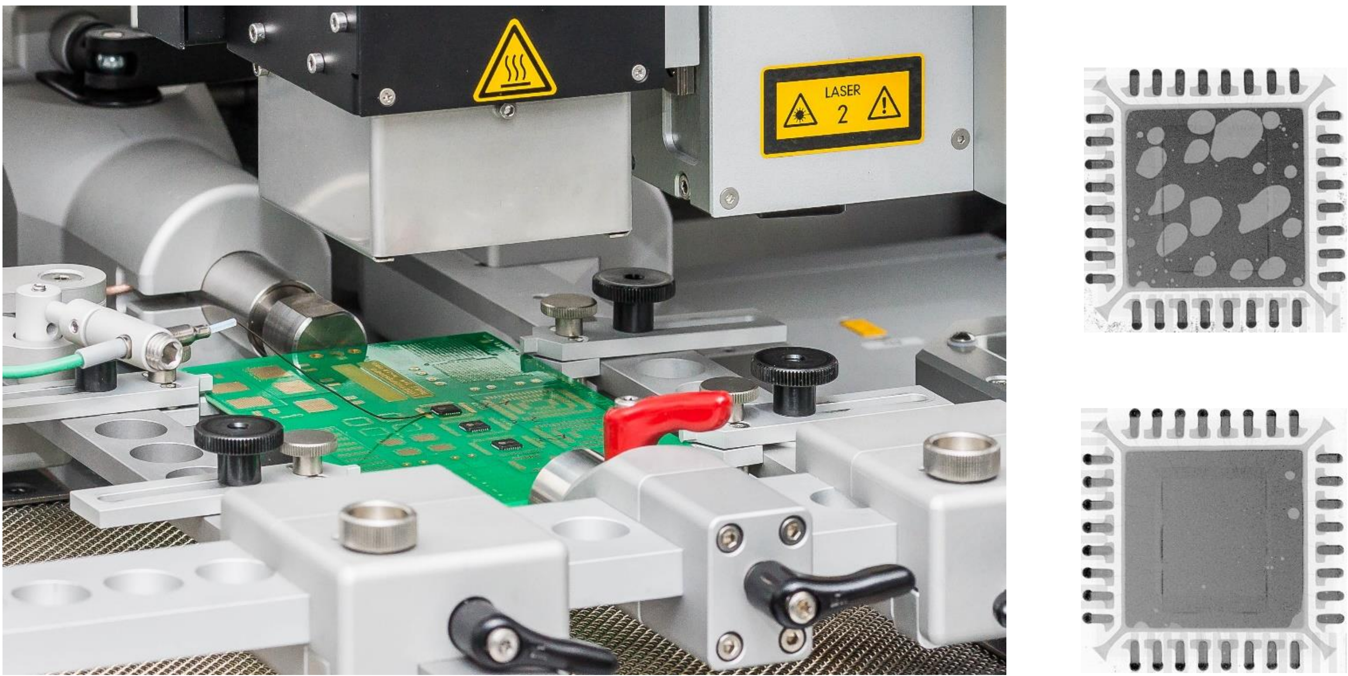

Figure 2 Actuation of a PCB during reflow, to reduce the void rate in an MLF (results before and after treatment)

By this method void reduction during new component installation down to void rates of 2% is possible (Figure 2). Even a significant void reduction can be achieved during a second reflow on an existing assembly. As in the case of a voidless rework treatment, only a selected area of the PCB is heated up to reflow and only this section is treated with the actuation, with no negative side effects to the assembly can be expected.

Residual solder removal - scavenging

Other than in production, one important step during the repair of a printed circuit board is the removal of residual solder on top of the components board land pads. It is necessary to properly reinstall a new component onto a defined surface and achieve repeatable and reliable soldering results. Today's hand operated methods are related to the operator's skills and thus are a hidden risk.

A manually operated but non-contact residual solder removal module has many benefits:

- repeatable process and non-contacting suction of the solder
- no risk of pad damage or rip off
- no solder mask damage
- no contamination of the PCB with flux or solder residues

The method is to use a gentle air flow along with the PCB bottom side preheating to melt the remaining solder on the PCB and suck off the liquid solder with a vacuum nozzle shortly above the PCB surface (Figure 3).

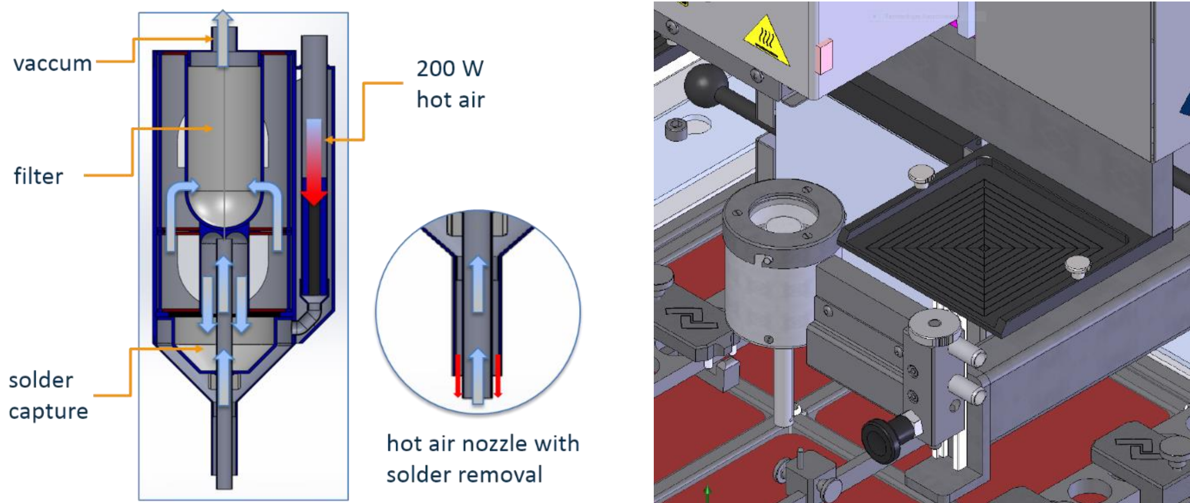

Figure 3 Scavenging system for residual solder removal during SMT rework and mounting

Besides the known technology of melting the solder with a gentle air flow and cleaning off the solder from the PCB with vacuum, it is necessary to control the height above the PCB in order to keep the boards undamaged. In first applications the height adjustment will be manual, in advanced systems there will be an automatic height adjustment based on pressure control or with a laser triangulation sensor.
Solder separation and flux filtration as well as an acceptable maintenance of the unit are crucial features for successful daily operation.
This module cannot be seen as completely independent from a rework machine, but an integrated part. The board temperature should be known and the PCB bottom side preheating must be active and controlled during the process.

Operator guidance - software assisted operation

The market clearly asks for flexible and easy to operate rework systems and at the same time for high automated, user independent equipment. For all of them a clearly structured interaction with the operator or the system administrator is essential.

One clear customer expectation towards rework processes is to achieve user independent high quality results. This is why more automated process steps are implemented into rework units and improvements on the HCI (human computer interface) are requested. It is obvious that operator guidance and assistance is decreasing operator failures during the rework procedure. Clearly structured software surfaces provides all necessary information along the single operations from profile selection, component removal until the final installation with flux or solder paste (Figure 4).

Figure 4 Clearly structured profile selection for a rework process

All process steps are assisted, the operator is guided through the process and instructed about the next working step. Pictograms show the next manual procedure if the system is not automatically executing the operation (Figure 5).

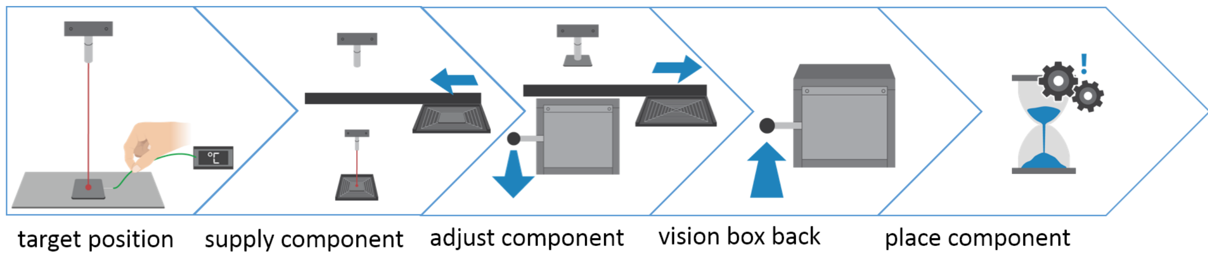

Figure 5 Placement process with pictograms guiding the operator step by step

Computer aided placement (CAP) is another tool, supporting the operator by means of image processing to achieve the best results. In the example the so called "comparator mode" shows coloured images of pads and pins and the best overlay in false colours (Figure 6). Component pins are shown in red, pads on the PCB are shown in green. Once the pins overlap to the pads the colour changes to blue and indicates to the operator when the best placement condition is reached.

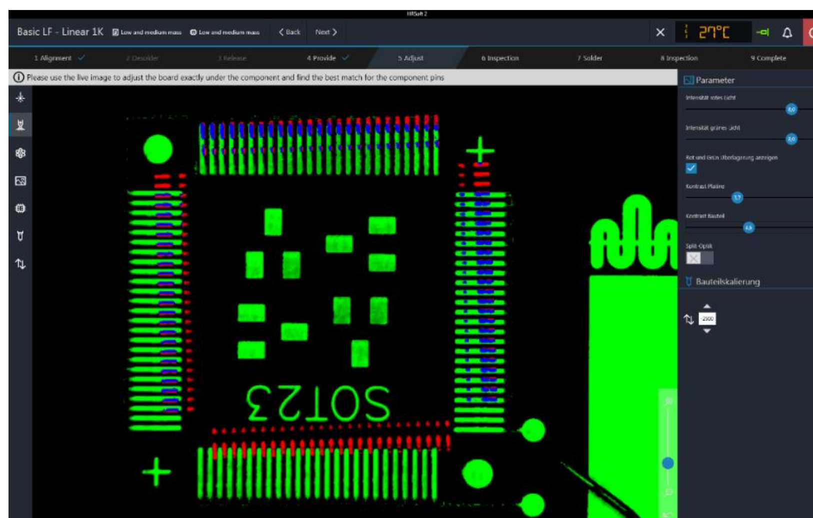

Figure 6 Computer aided placement with overlay of pins and pads in false colour depiction

Other than in a live camera image, the computer aided placement uses means of image processing to provide best contrast pictures. Like for an air traffic controller (Figure 7), the system clearly visualizes the relevant data for the operator. Hereby the concentration of the operator is focused on the alignment task and exhausting working conditions are minimized.

Figure 7 Flight radar image shows only relevant information in high contrast [as a reference]

Another element of computer aided placement is the implementation of a digital split optic. It supplies images of i.e. large (QFP) components in high magnification for most accurate alignment (Figure 8).

Instead of optical magnification with additional lenses, the high resolution camera image is split into four segments. Each segment displays one component corner. Alignment is supported in large magnification. Matching of pins and pads becomes much easier for the operator's eyes.

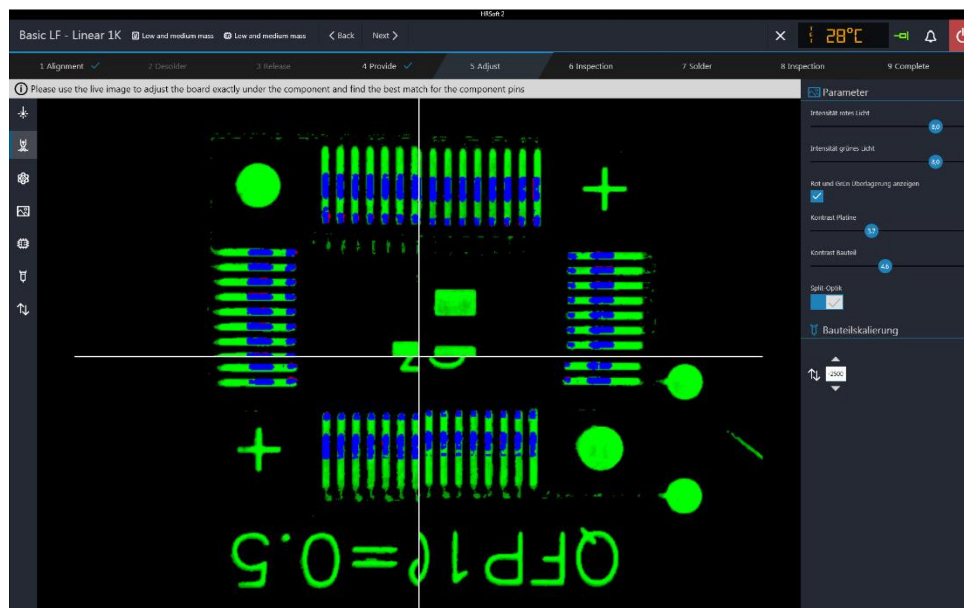

Figure 8 Digital split optic shows for corners of a component – here with ideal pin to pad matching

Summary and Future Outlook:

Even if production quality throughout the electronic industry is constantly rising, rework will remain a challenging topic for the next decades. Electronic assemblies are reaching higher integration and a generally increasing complexity. The rework system supplier's task will be to follow these market movements and offer solutions that provide the ability to rework boards successfully. At the same time the degree of automation will rise in the segment of rework equipment, and operator assistance will become more important. Besides technological challenges as many features as possible of the high end rework systems need to find their way down to the entry level rework units as a spin off.

Commercial and environmental benefits due to less scrap and electronic waste will thus be achieved.

References

[1], [2] Wikipedia: "Void" in (soldering defect) and (surface mount technology)

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Strategies And Technologies for Future Rework Demands

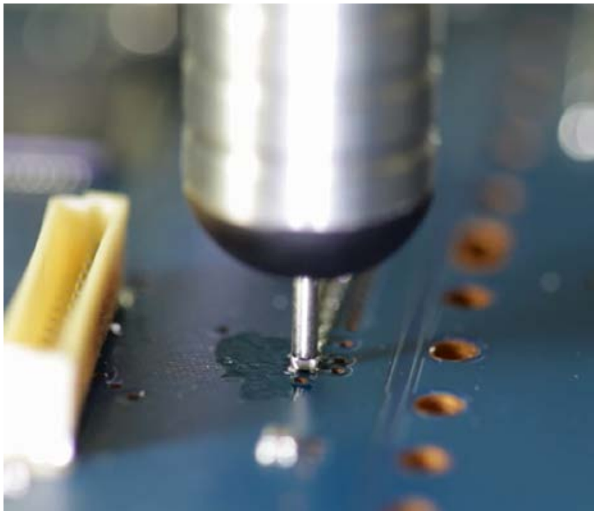
Joerg Nolte, Ersa GmbH

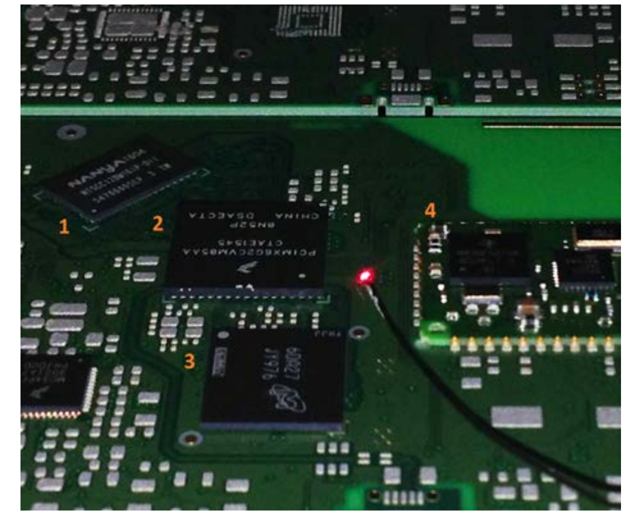
Overview – Rework Challenges

- BTC types with new effects -> **voidless treatment**
- Smaller components -> miniaturization (01005 capability)
- Large board handling -> dynamic preheating for large board repair
- Repeatable processes -> flux and paste application (Dip and Print), residual solder removal (**scavenging**), dispensing, multiple component handling, and traceability
- Operator support -> higher automation, **software guidance** (Human Computer Interface)

Overview – Rework Challenges

- smaller components -> miniaturization (01005 capability)
- large board handling, with multiple zone heating
- multiple component handling





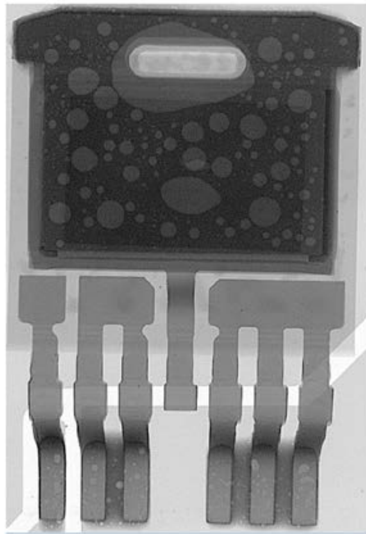
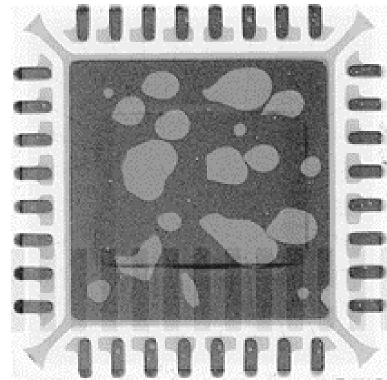
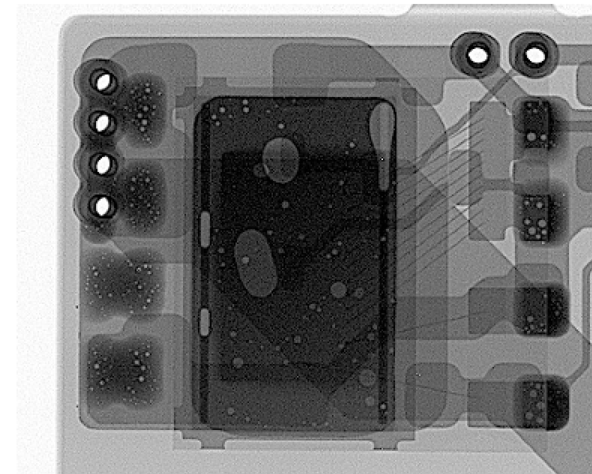
Rework topics with immediate practical necessity

- Voidless treatment during a rework process
- Residual solder removal - scavenging
- Operator guidance – software assisted operation

All the other topics need also to be part of the rework manufacturers roadmap!

Voidless treatment during a rework process

- Voids in solder joints are a widespread risk for certain BTCs

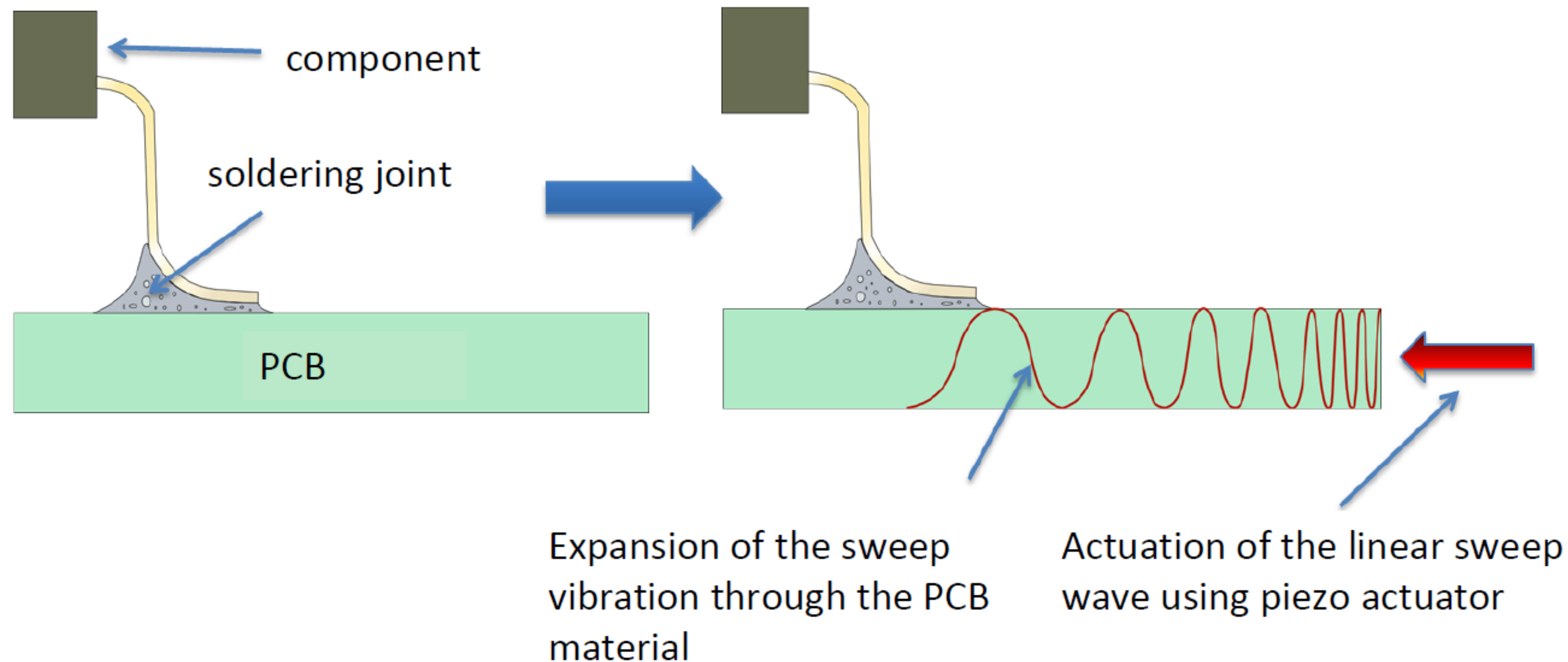




Risks caused by voids in solder joints

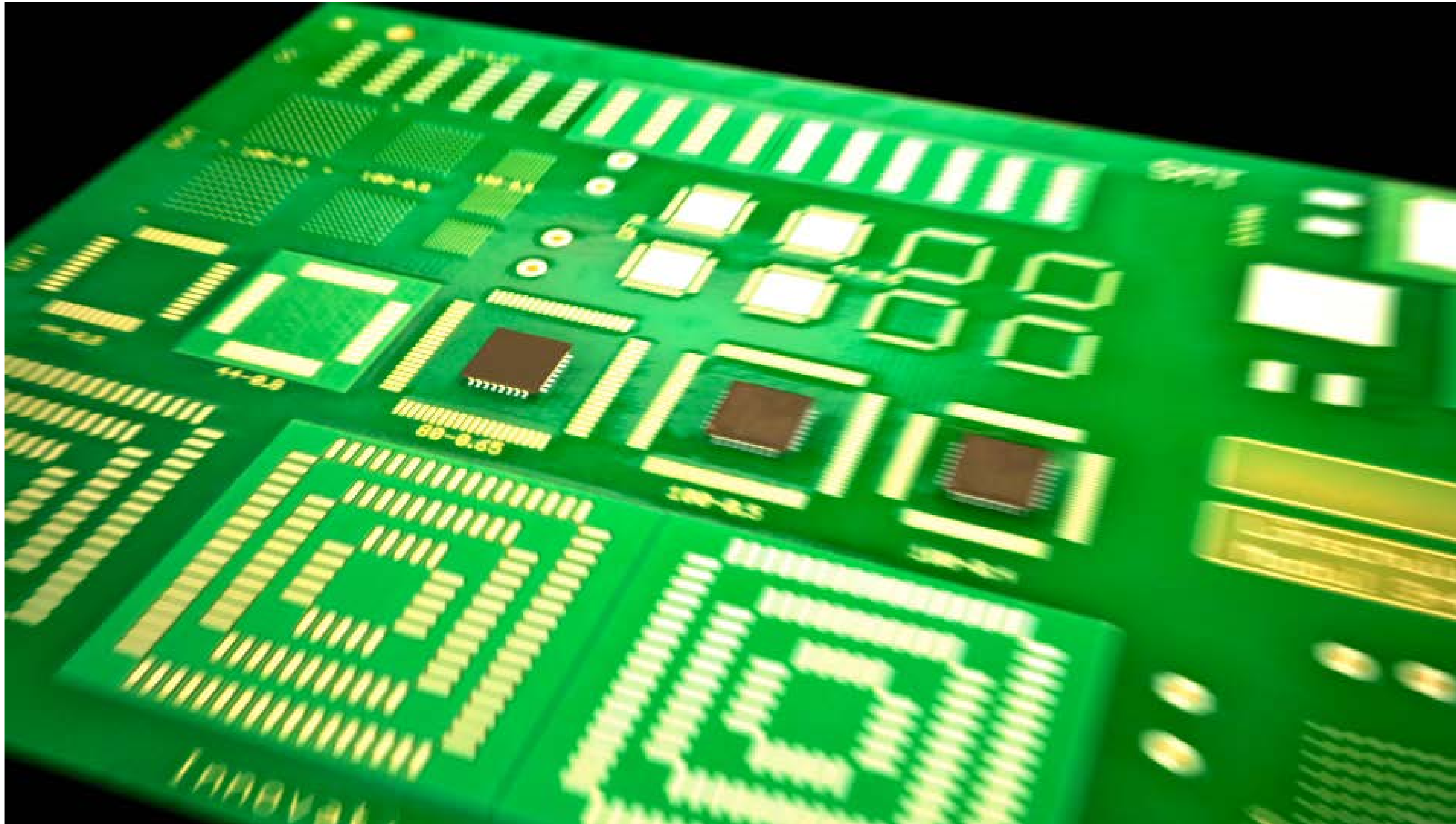
- reduced **thermal transfer** from component to the PCB risk of overheating the component
- reduced **mechanical strength** of a solder joint
- possibility of spontaneous **outgassing** – creation of solder splashes
- impact to the **ampacity** of a solder joint – connection may overheat because of higher electrical resistance
- impact on the **signal transmission –** in high frequency applications voids may dampen the signals

Voidless treatment

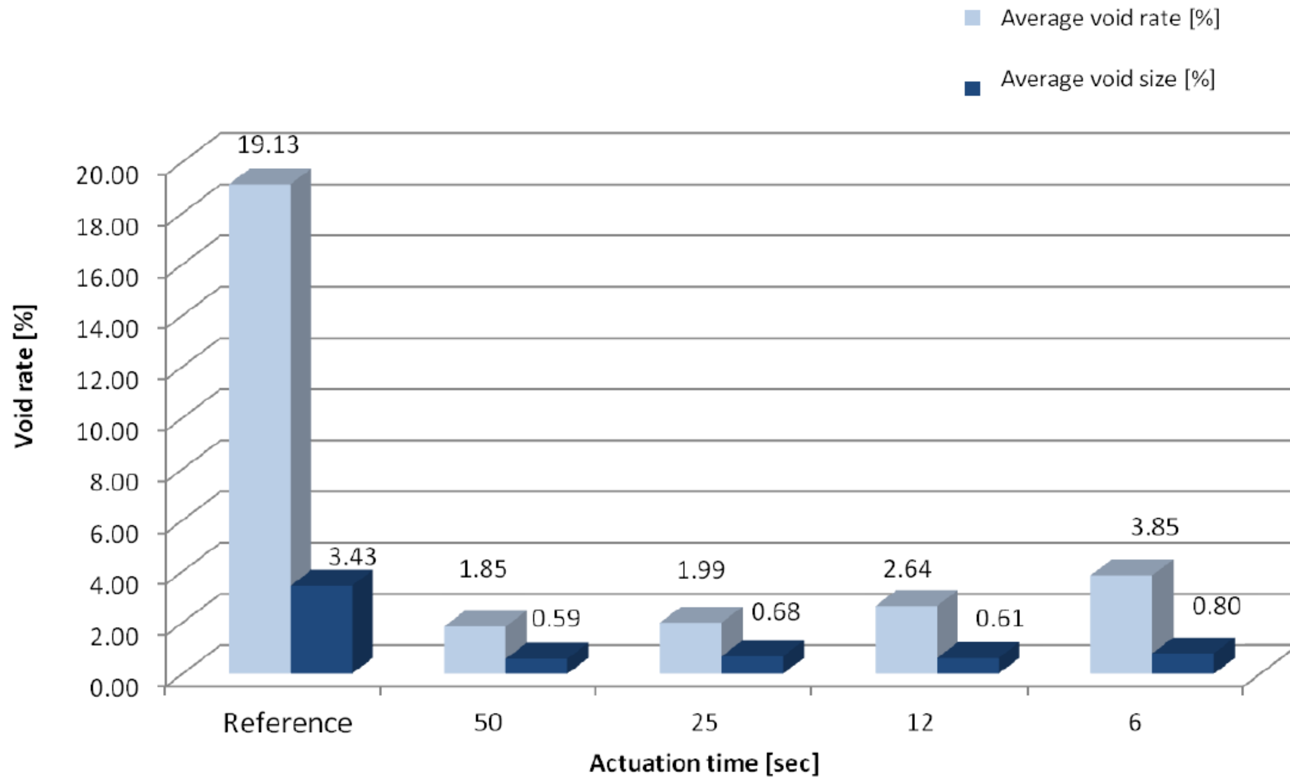
- sinusodial stimulation of the PCB with typically approx. 10 µm travel
- Voids escape from the liquid solder between the static component and the stimulated PCB substrate.

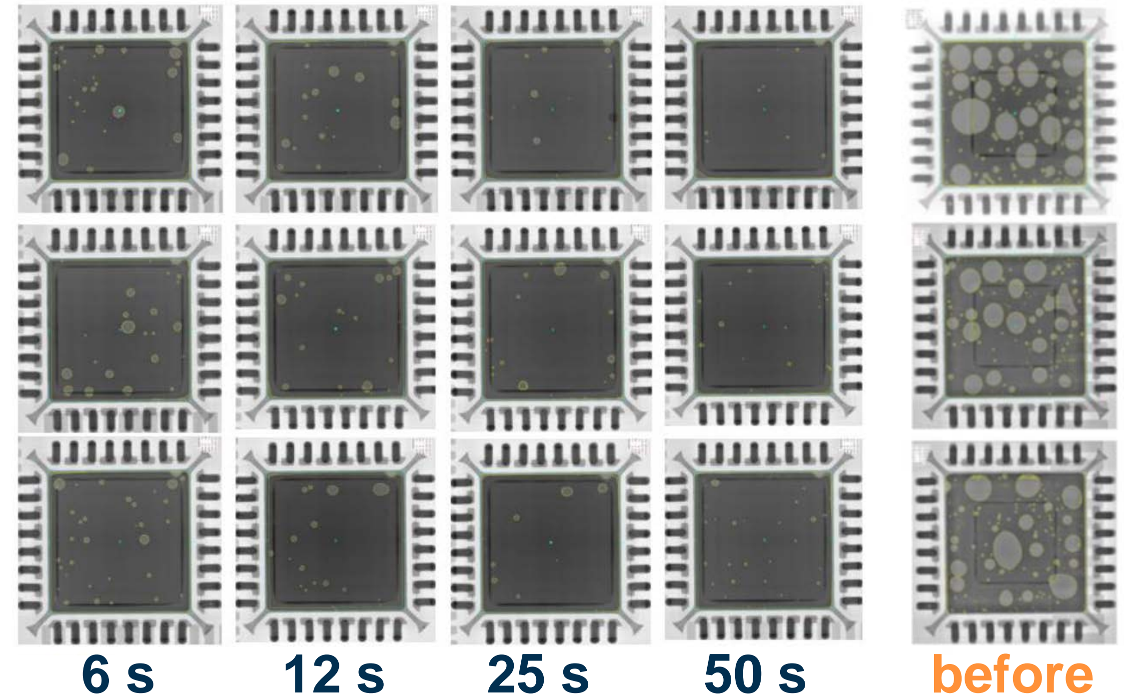


Voidless treatment (video)

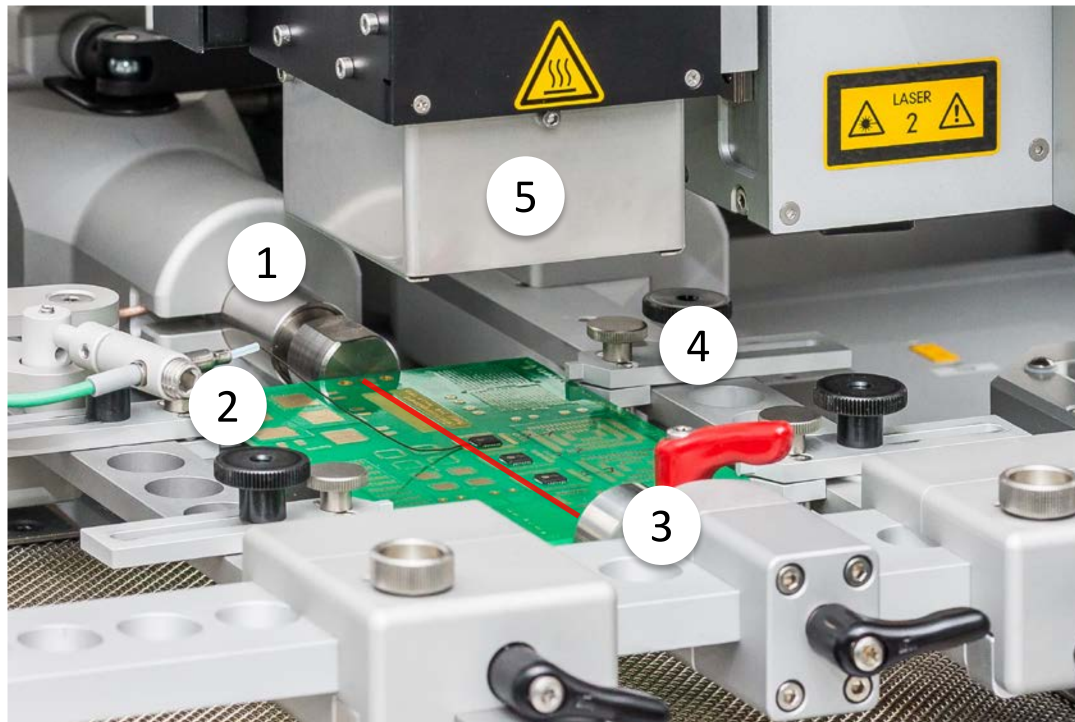


Voidless treatment test results





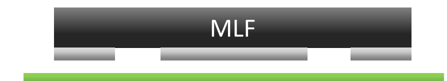
Voidless module on a rework system



1. piezo-stack actor
   typically 10 µm travel
2. thermocouple
3. end support
4. PCB fixture
5. hybrid heater

Fields of application for VOIDLESS rework

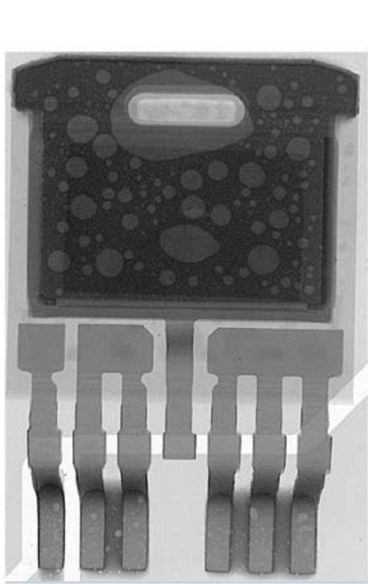
1. void reduction during installation of a **new component**
   - while using solder paste (component printed or dipped in)
   - while using flux (dipped in)

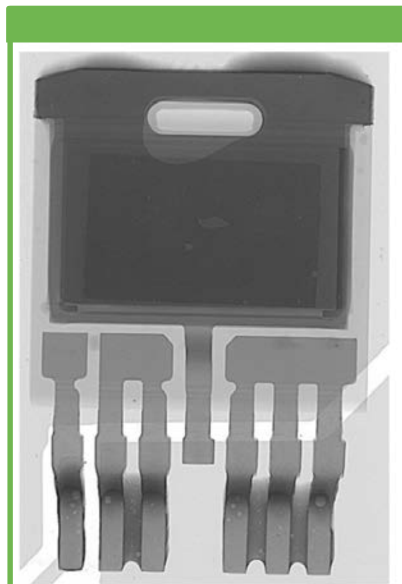


2. rework with **second reflow** (adding of flux is recommended)
   the component is reflowed again, VOIDLESS stimulation during liquid solder phase

Voidless rework results on customer applications

- multiple fields of applications (**MLF, TQFP, DPak, BGA, LGA, LED** …)





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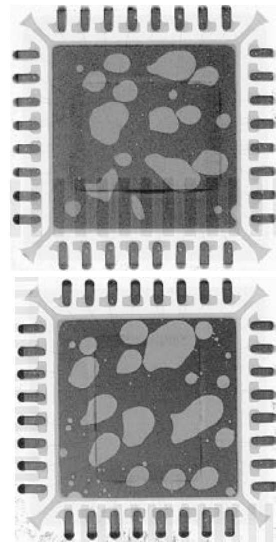

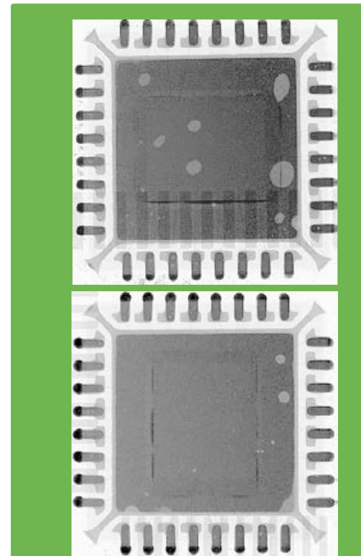

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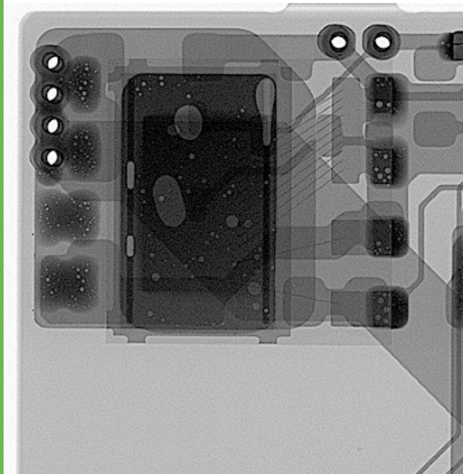
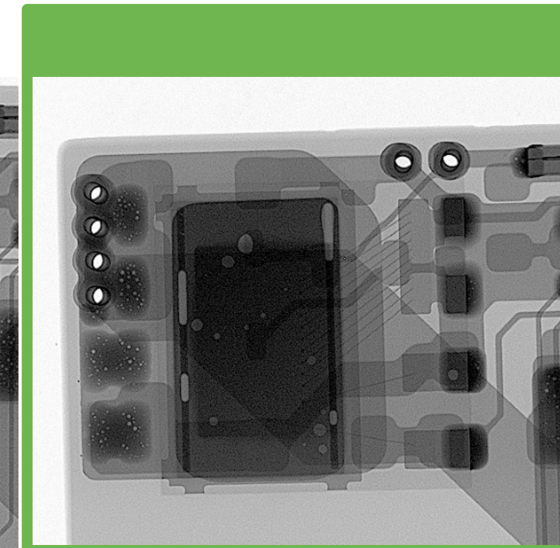
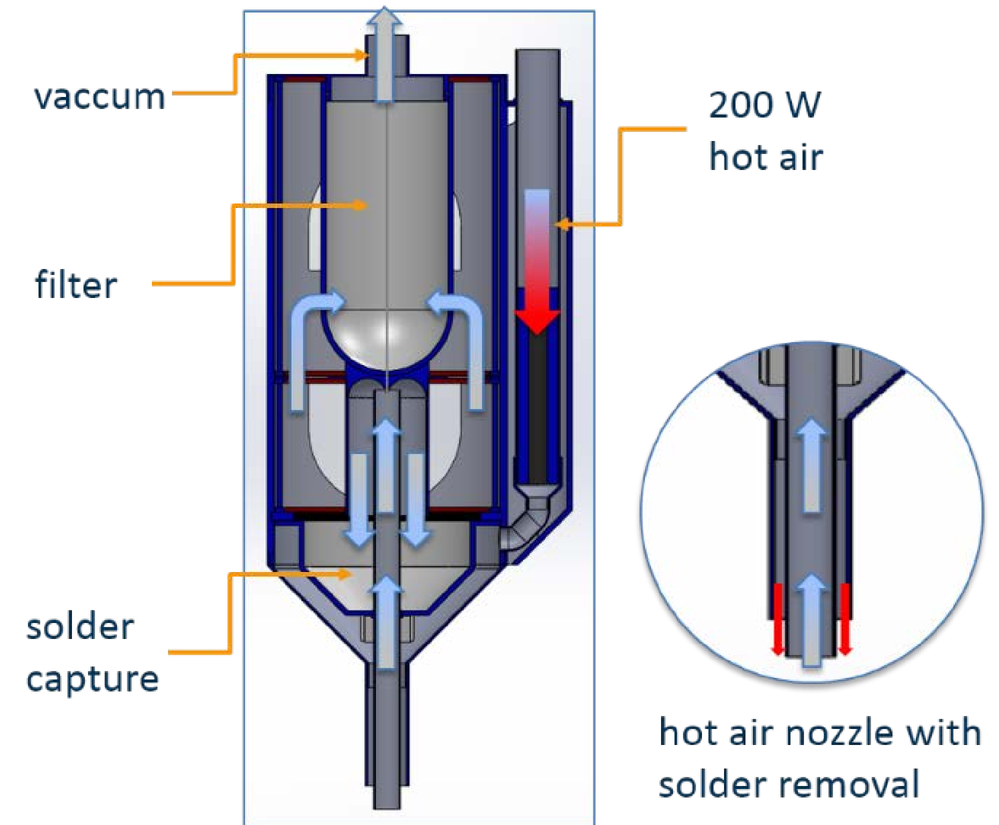




passed

Residual solder removal - scavenging

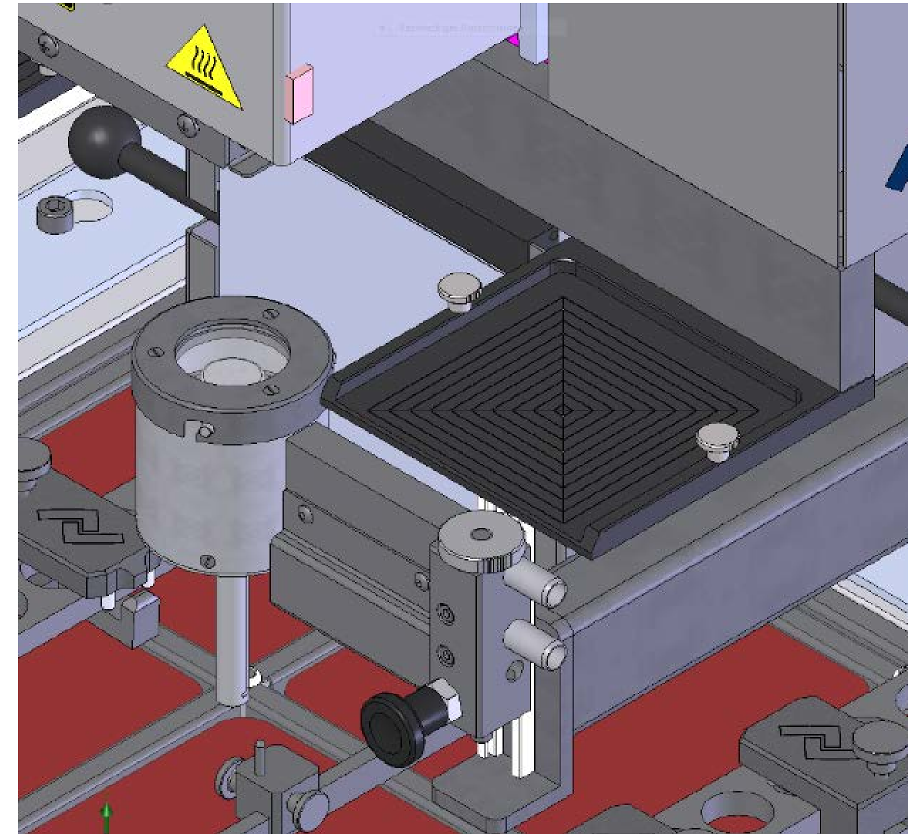
- Non contacting solder removal
- Not pad damage or rip off
- No solder mask damage
- No contamination with flux or solder residues



schematic of scavenging unit

Residual solder removal - scavenging

- manual or automated movement (X,Y)
- manual, pressure- or laser controlled height (Z)
- used in combination with IR-bottom heater
- solder separation, flux filtration
- easy maintenance



scavenging unit adapted to a rework machine

Operator guidance – software assisted operation

- Clearly structured HCI (Human Computer Interface)
- Operator assistance by pictograms
- Computer Aided Placement (CAP)
- Digital Split Optic

„It is important to guide the operator thru the process or let the machine do it.“

(customer demand for rework system)

Clearly structured HCI (Human Computer Interface)

1. select profile

2. set process

3. start process

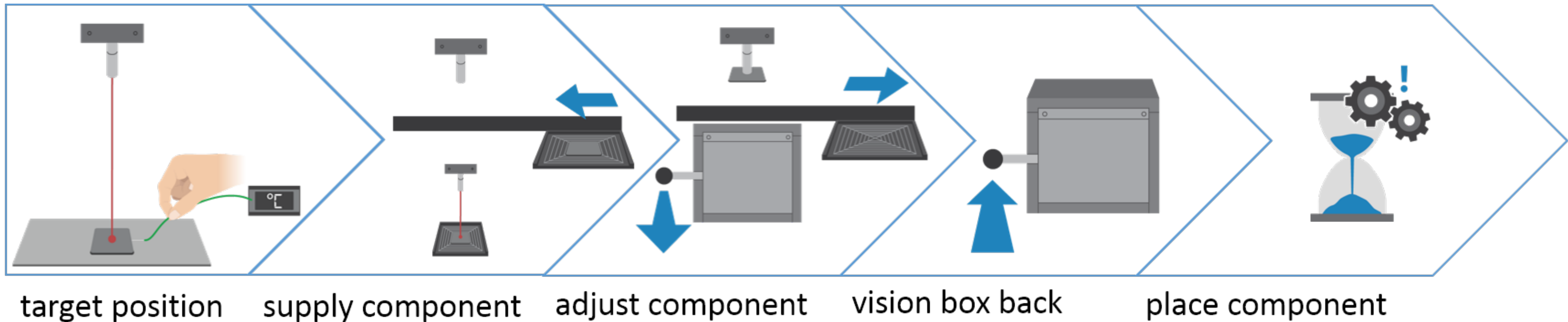
Process automation

Desolder | Placement | Inspection | Solder | Inspection

START

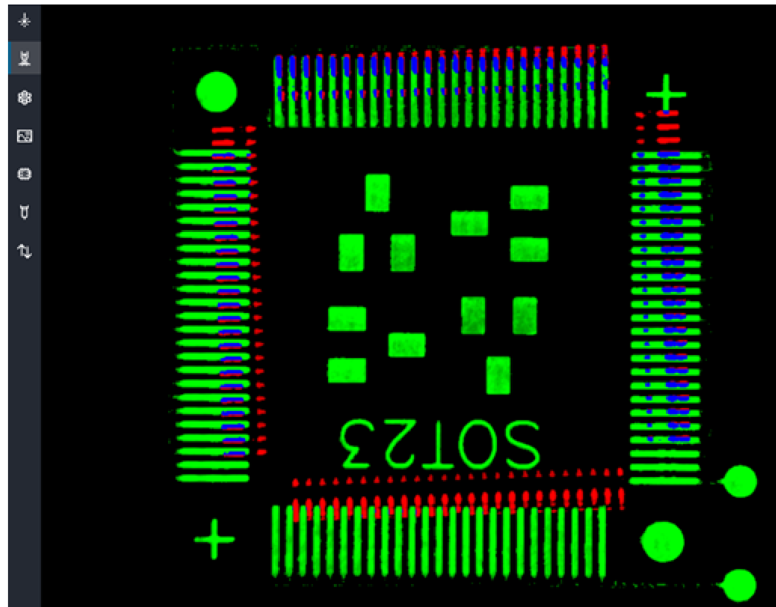
Operator assistance by pictograms

- Show the NEXT working step to the operator
- Use mainly images – multilingual users
- Let the operator confirm his action NEXT step



Computer Aided Placement (CAP)

- False color images with high contrast provide **relevant information**

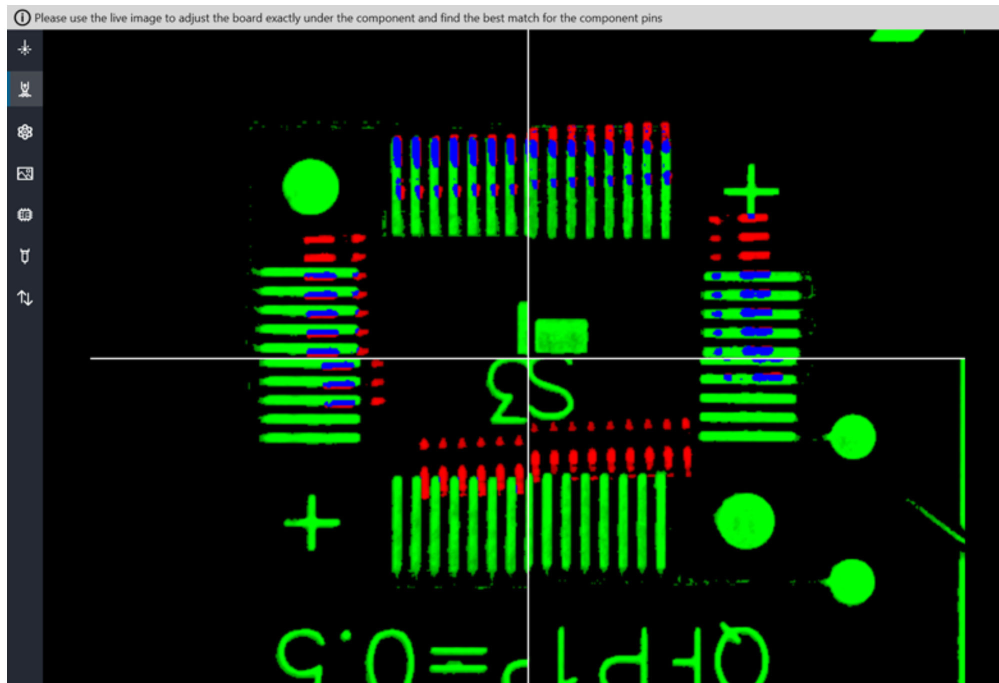


overlay pins and pads in comparator image

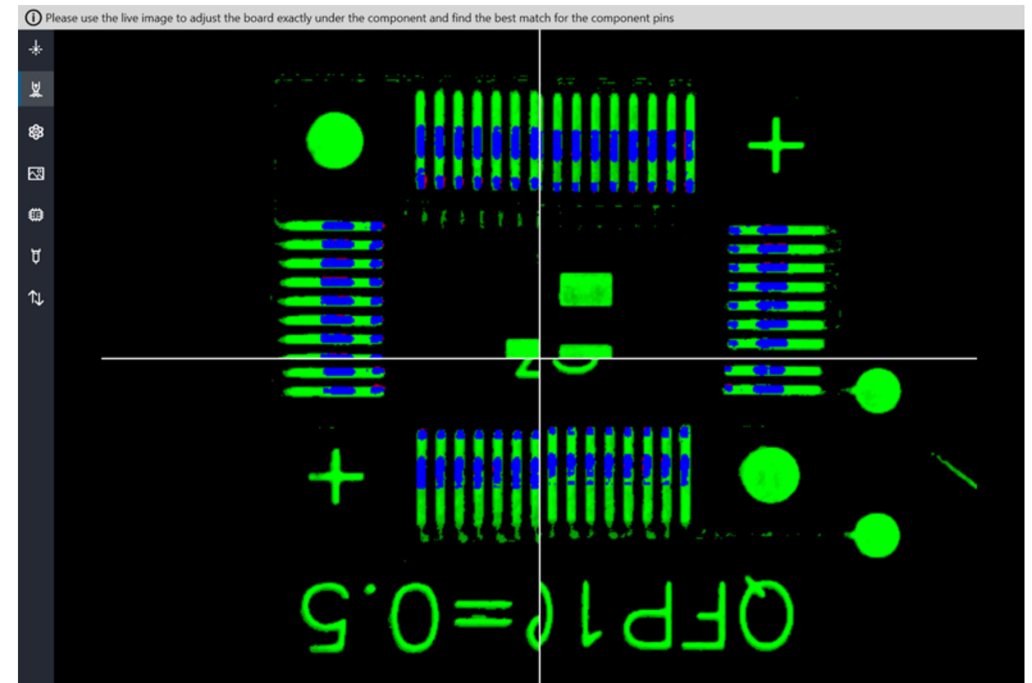
reference: flight radar image

Digital Split Optic

- **four segments** of large component provide high magnification images



component before alignment



component after alignment

Thanks for your attention!

I have questions – do you?