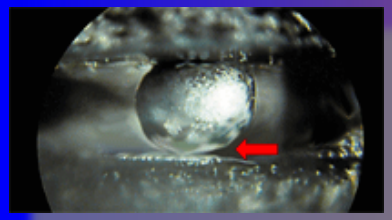
HIGH QUALITY VAPOR PHASE REFLOW SOLDERING

THE ADVANCED SOFT SOLDERING TECHNOLOGY

SMTA
Arizona-Sonora
December 4th 2012



Vapor Phase Reflow Soldering Process

Reflow soldering is a complex physical and chemical process.

The demand of lead free soldering is requiring higher soldering temperatures.
Components get smaller and more complex.
Boards can contain very different masses of components.
.....
Many companies are facing soldering problems.
(Especially with lead free soldering or lead free components)

Vapor Phase soldering is a solution.

The following presentation will show how modern Vapor Phase soldering is solving common soldering issues.

Vapor Phase Reflow Soldering Process

The Vapor Phase reflow soldering stands for:

- Lowest possible maximum temperatures
- No overheating of components
- Inert (oxygen free) atmosphere
- Best wetting of solder

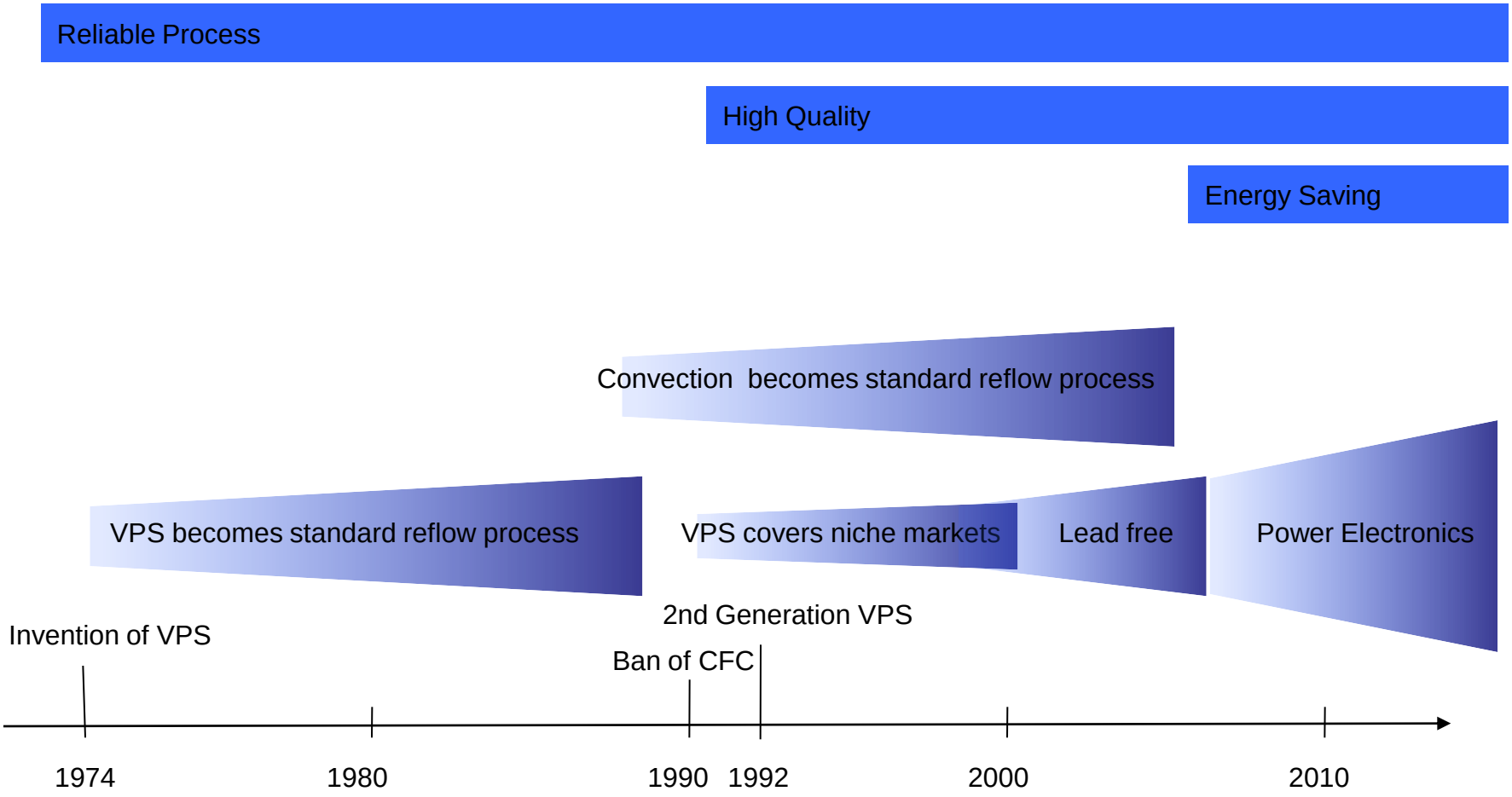
➔ Resulting in highest soldering quality

- Machines from laboratory to volume production
- Vacuum
- Environmental friendly
- Cost sensitive
- .....

History

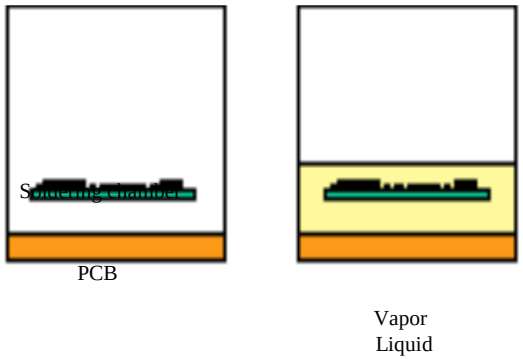
The development steps in vapour phase technology

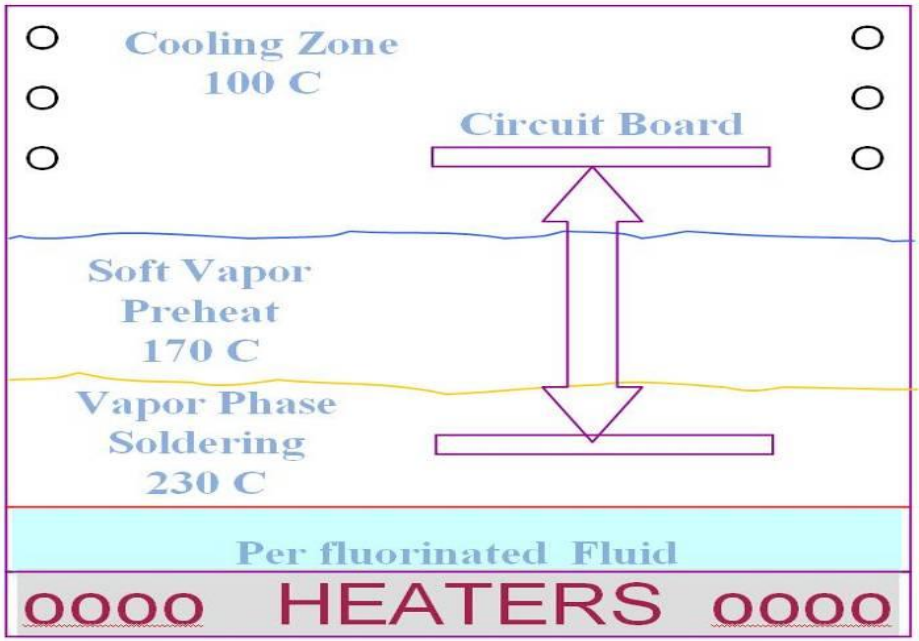
Key benefits



Vapor Phase Reflow Soldering Process

The Vapor phase process





Standard technology:

The heat transfer is controlled by the heating power of the heating elements and the time in the vapor

(Heat level mode)

Vapor Phase Reflow Soldering Process

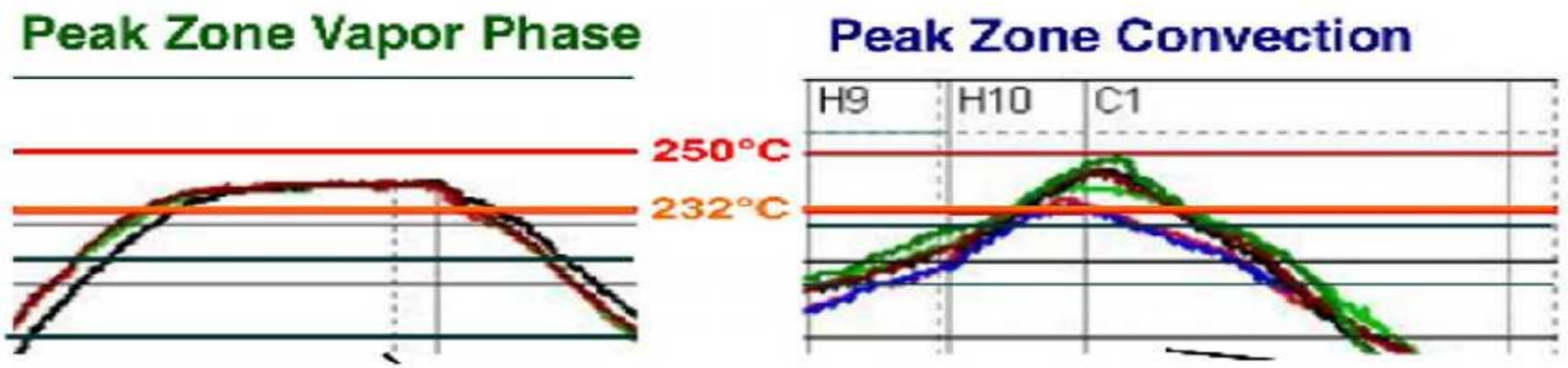
The heat transfer rates are much higher in condensation (Vapor Phase) than in convection.

Heat transfer coefficient: α [$Wm^{-2}K^{-1}$]		
radiation	20 - 30 60	preheating peak
convection	5 10 - 20 40 - 60	air in rest at 5 m/s at 5 - 20 m/s
condensation	100 - 400	
contact (liquid solder)	4000	

Heat transfer in reflow

As a result of a good heat transfer rate
there is no need for excessive heat in the process

The temperature of a typical lead free
Vapor phase reflow = 235° C



Vapor Phase Reflow Soldering Process

Lead-free Vapor Phase Soldering soldering as process of choice

Increased Quality

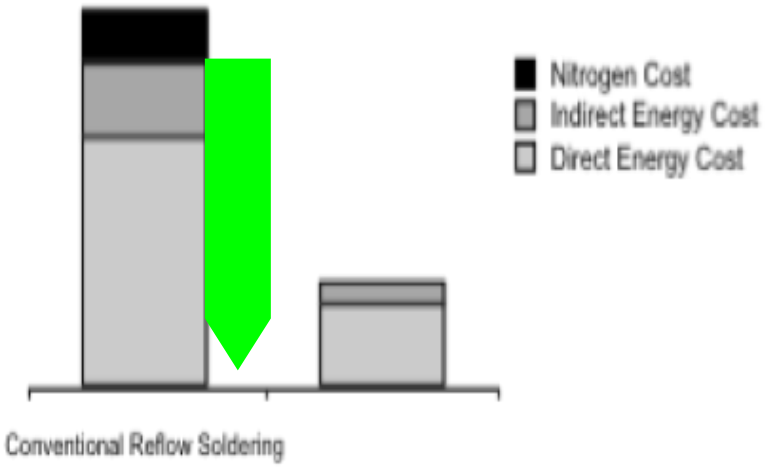
- Overheating is physically impossible
- No cold solders due to determined heat transfer and absence of shadowing

Reduced Cost

- 1/5 direct Energy consumption
- No Nitrogen due to inert vapor phase process
- Reduced heat up of factory saving in air conditioning cost
- No compressed air required
- Fast setup for new products
- Fast changeovers

Low/No emission

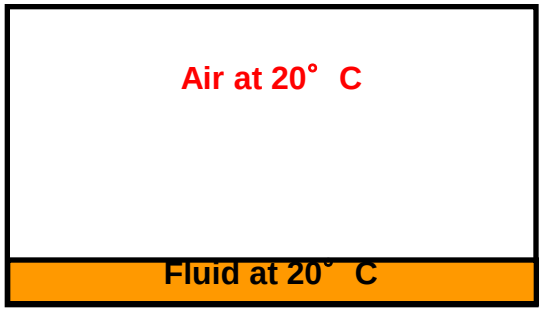
- Closed process
- inert area avoids creation of hazardous gases (burned flux)
- Neutral process fluid



Vapor Phase Reflow Soldering Process

Formation Of An Inert Gas Vapor Phase (1/4)

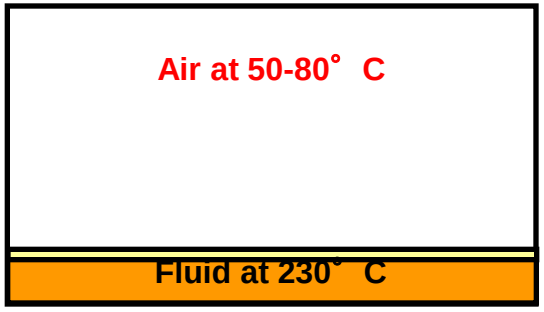
Start



The soldering chamber is filled with an inert liquid for the creation of the vapor.

The liquid (Galden) possesses a boiling point equal to the process temperature (e.g. 230° C for lead-free SnAg solders).

Heating of the Liquid



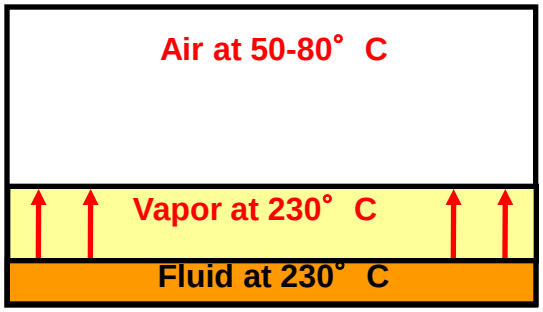
On start up the liquid is heated up to its boiling point.

Thus vapor raises above the liquid.

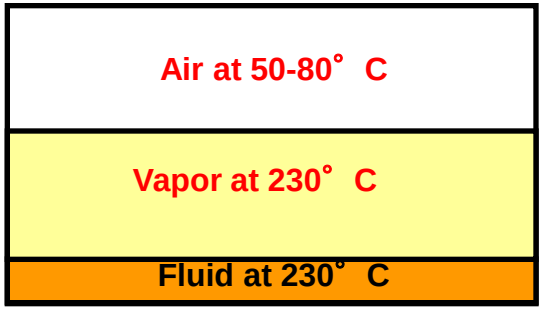
Vapor Phase Reflow Soldering Process

Formation Of An Inert Gas Vapor Phase (2/4)

Formation of a Vapor Phase



Vapor Phase



Due to its higher molecular weight the vapor displaces the ambient air upwards.

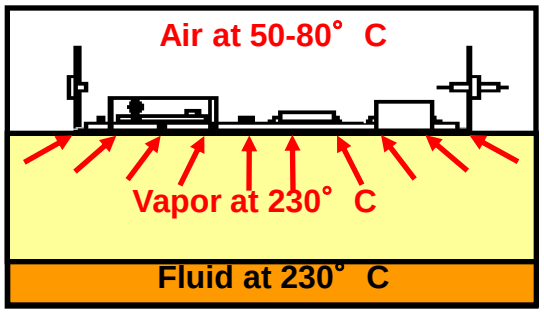
The properties of the heat transfer fluid ensure an inert (non-reactive) vapor phase.

The phase change from vapor to liquid sets free large amounts of thermal energy without any differences in temperature. Even high mass parts entered into the vapor phase are thoroughly heated up until the vapor temperature.

The process securely prevents any overheating.

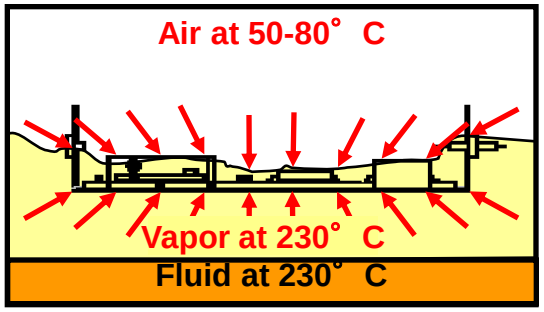
Vapor Phase Reflow Soldering Process

Heat Transfer Process within the Vapor Phase (3/4)



Upon contact with the vapor phase, the part is evenly heated up.

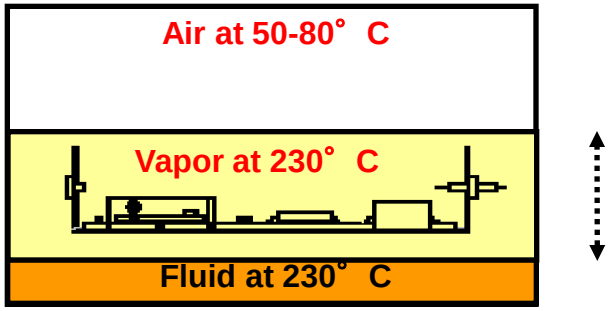
The patented Soft Vapor Phase procedure (SVP) provides maximum control of the heat up process ensuring an efficient and equally fast temperature increase.



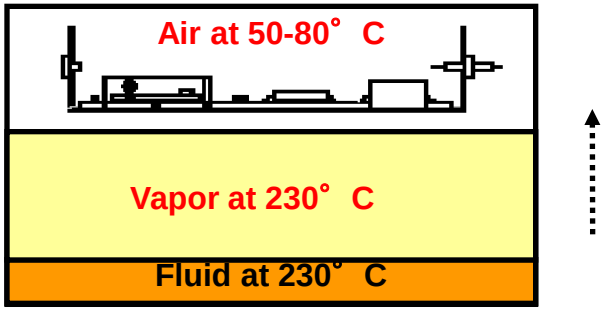
The vapor condenses while transferring its thermal energy of the phase transition into the part. During the soldering process, the vapor forms a protective, oxygen free (inert) gas atmosphere. Any use of protective gas becomes redundant.

Vapor Phase Reflow Soldering Process

Heat Transfer Process within the Vapor Phase (4/4)



Overheating is securely prevented, as the soldered parts cannot be heated up above the defined and constant vapor temperature.



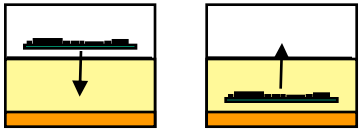
After leaving the vapor phase any remaining fluid evaporates and a dry and securely soldered PCB board leaves the soldering chamber.

Vapor Phase Reflow Soldering Process

History of Vapor Phase Development

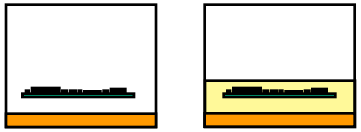
Increasing possibilities of influences of temperature profiles.

Standard-VP-mode



Changes of heat performance: N/A
Heat profile adjustment: N/A
IR Pre-Heating: N/A
Rapid Cooling System: N/A

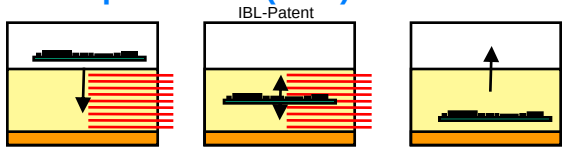
Heat Level mode (Economy line)



Changes of heat performance: Adjustable heating performance and heating time
Heat profile adjustment: N/A
IR Pre-Heating: N/A
Rapid Cooling System: N/A

Soft Vapor Phase (SVP) mode

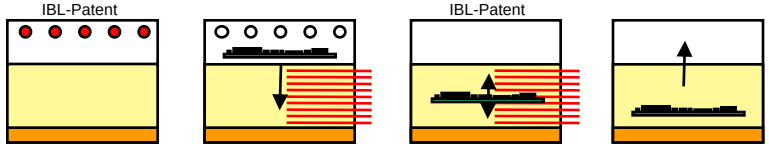
IBL-Patent



Changes of heat performance: Adjustable heating performance and heating time
Heat profile adjustment: Soft Vapor Phase (Patented)
IR Pre-Heating: N/A
Rapid Cooling System: N/A

IR & SVP-mode

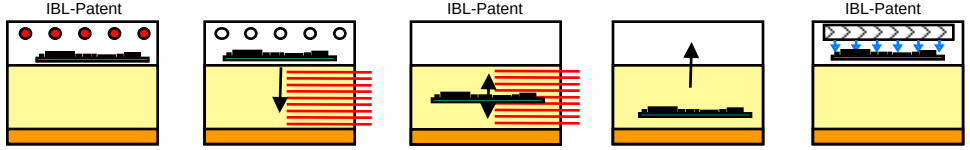
IBL-Patent



Changes of heat performance: Adjustable heating performance and heating time
Heat profile adjustment: Soft Vapor Phase (Patented)
IR Pre-Heating: Infrared Preheating (Patented)
Rapid Cooling System: N/A

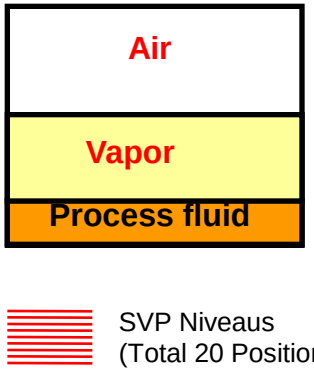
IR & SVP & RCS-mode

IBL-Patent



Changes of heat performance: Adjustable heating performance and heating time
Heat profile adjustment: Soft Vapor Phase (Patented)
IR Pre-Heating: Infrared Preheating (Patented)
Rapid Cooling System: Fast Cooling system (Patented)

Legend

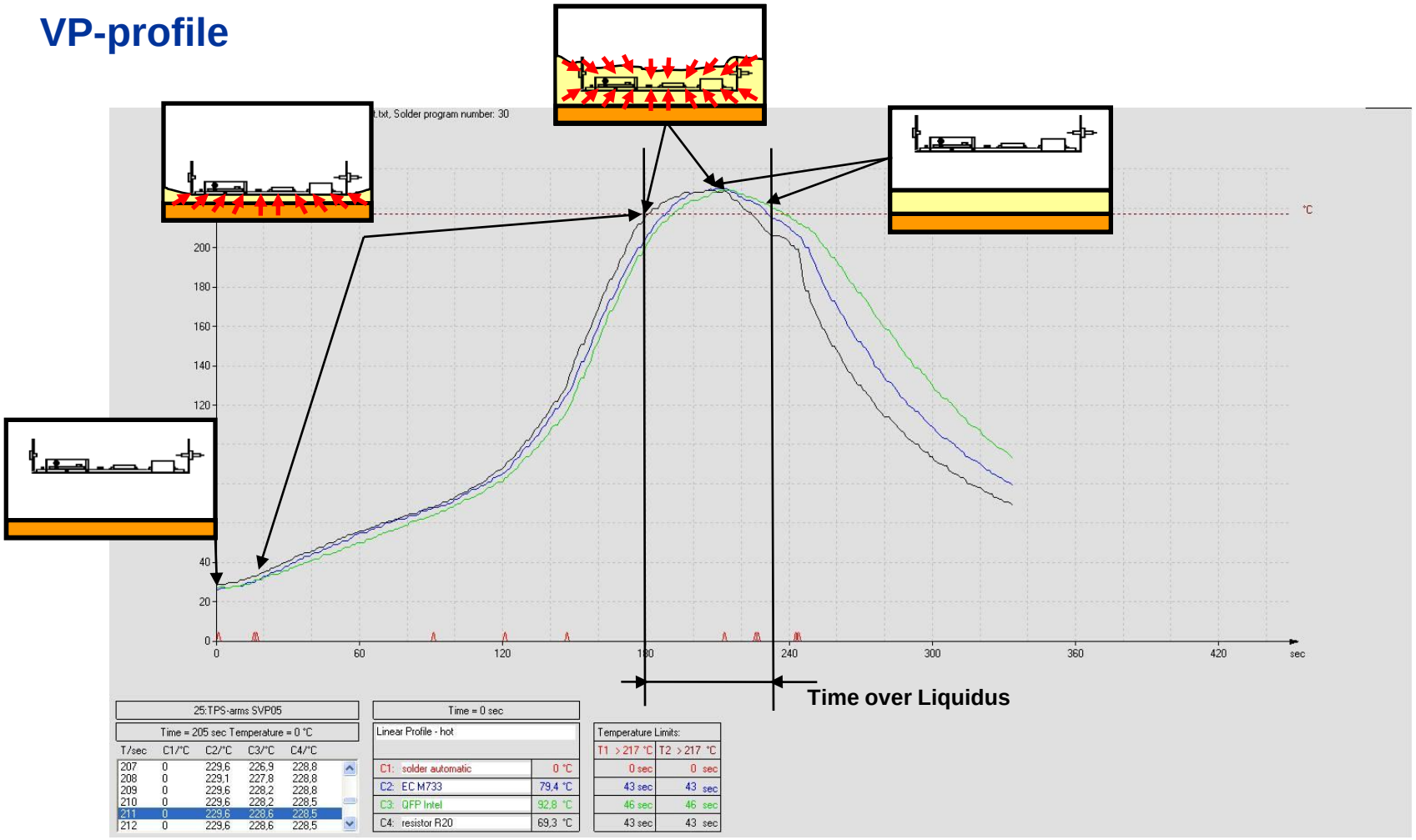


SVP Niveaus
(Total 20 Positions)

Vapor Phase Reflow Soldering Process

Linear Profile with Vapor Phase

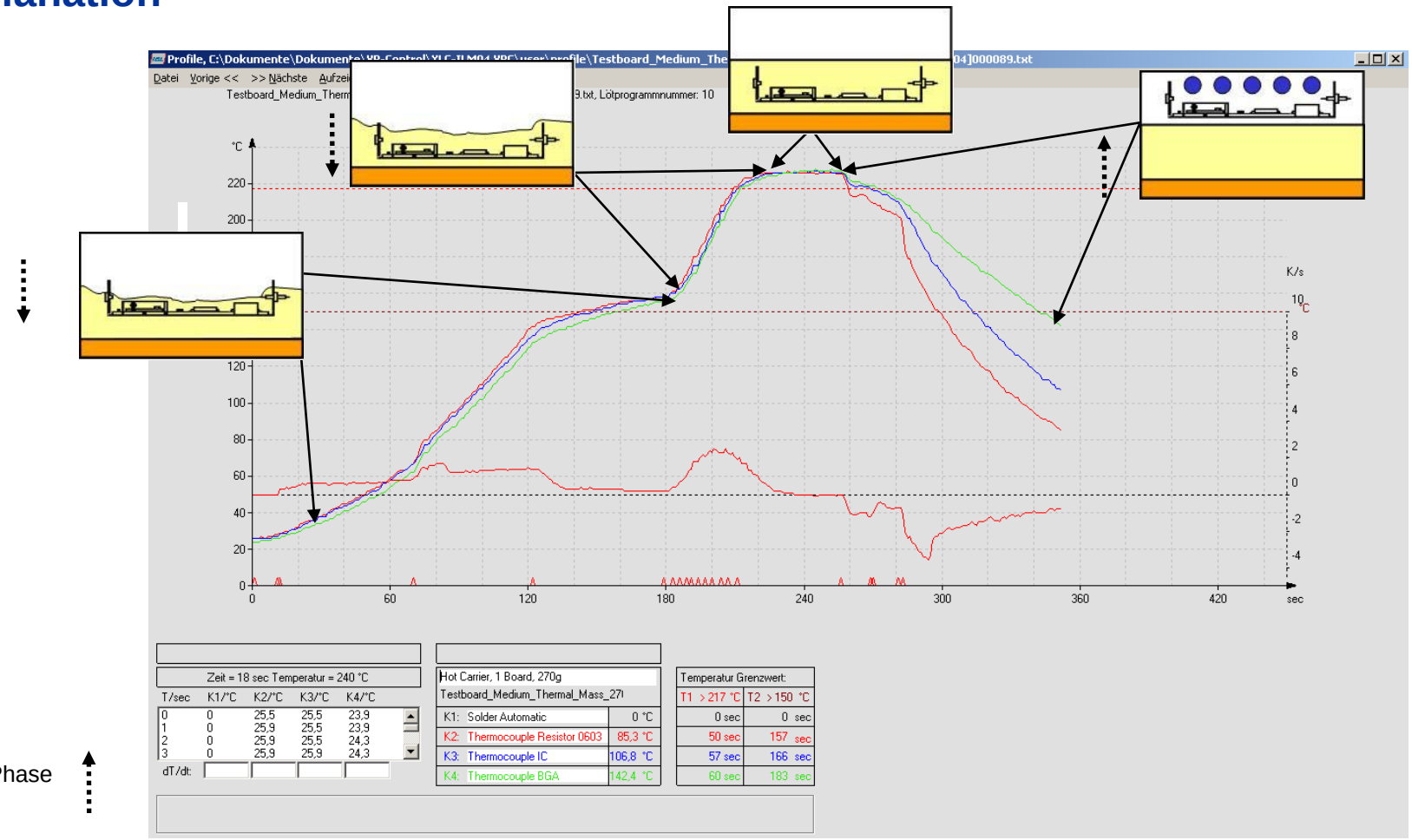
VP-profile



Vapor Phase Reflow Soldering Process

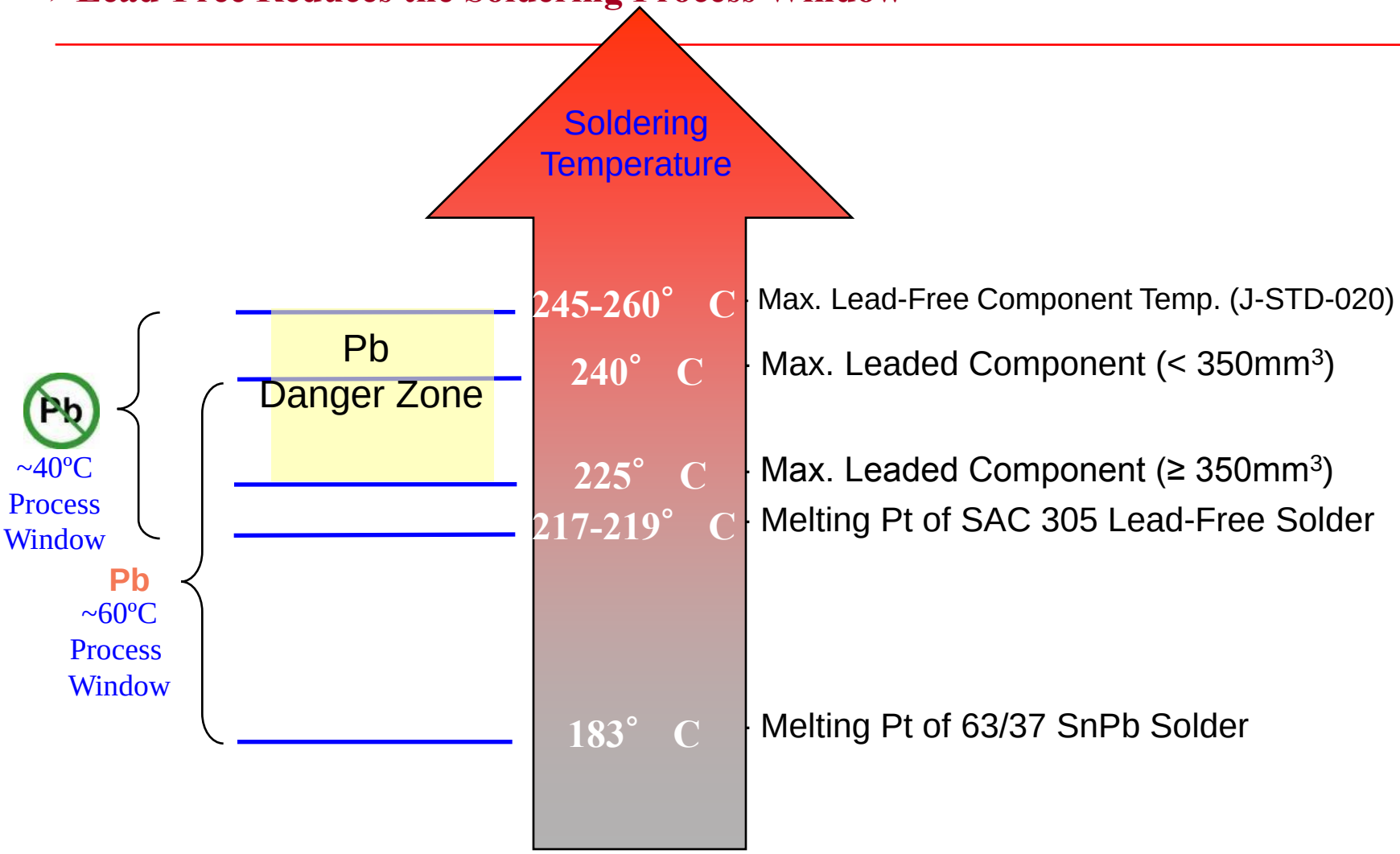
Easy Profiling with IBL Smooth Vapor adjustment, soldering automatic and RCS

Explanation



Soft Vapor Phase movement

➢ Lead-Free Reduces the Soldering Process Window



Vapor Phase Reflow Soldering Process

Heat transfer Fluid used in **IBL** vapor phase reflow soldering machine (1/2)

1. Adjust maximum vapor temperature

→ **select suiting vapor fluid**

Leaded

- LS 200
- LS 215

Lead-free

- LS 230
- HS 235
- HS 240

Higher temp

- HT 260

Perfluorpolyether

$$CF_3\text{-}[(O\text{-}CF\text{-}CF_2)_n\text{-}(O\text{-}CF_2)_m]O\text{-}CF_3$$
$$|$$
$$CF_3 \qquad n/m = 40$$

Vapor Phase Soldering Process

Heat Transfer Fluid 2/2)

The fluids used in Vapor Phase soldering have a range of supporting characteristics.

The physical and chemical properties provide excellent conditions for reliable heat transfer to materials of all types and shape.

Main characteristics are:

- High stability (chemically inert)
- Environmentally-friendly
- No CFC
- Non-toxic
- Non-degrading
- Non-flammable
- Non-aggressive
- Electrically non conductive
- Definite boiling points
- High molecular weight
- Inert gas atmosphere (Oxygen-Free)

Vapor Phase Reflow Soldering Process

Vapor Phase Reflow Soldering - Challenges

The soldering results in a Vapor Phase are excellent – even with simple, linear profiles - due to the better heat transfer, lower ΔT and the oxygen free atmosphere.

But common solder issues require flexibility !

For example:
- Tombstoning
- Voiding
- Delamination, popcorning
- Extreme masses of soldering units
- Complex boards, BGA, stacked packages, GCB, Ceramic, ..
- Mix of leaded and unleaded production

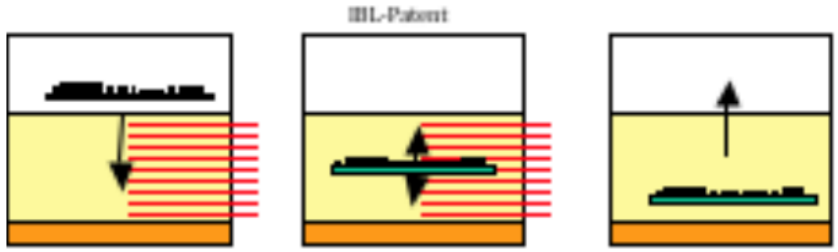
Vapor Phase Reflow Soldering Process

Soft vapor Phase mode

The Vapor phase process and control : SVP is flexibility !

Standard technology:

The heat transfer is controlled by the heating power of the heating elements and the time in the vapor (Heat level mode)



Modern technology:

The heat transfer is controlled by the height level in the vapor

(Soft Vapor Phase (SVP) mode)

Vapor Phase Reflow Soldering Process

Tombstoning - challenges

Tombstoning can be avoided by reducing the gradient before liquidus

A sample from real life:

Situation: The customer had severe problems with tombstoning (20 to 60 capacitors and resistors 0603) on one assembly.
The pads on the PCB were oversized, but as an EMS supplier he had no influence on the board design.

Solution: With the anti-tombstoning profile the problem was reduced to zero.

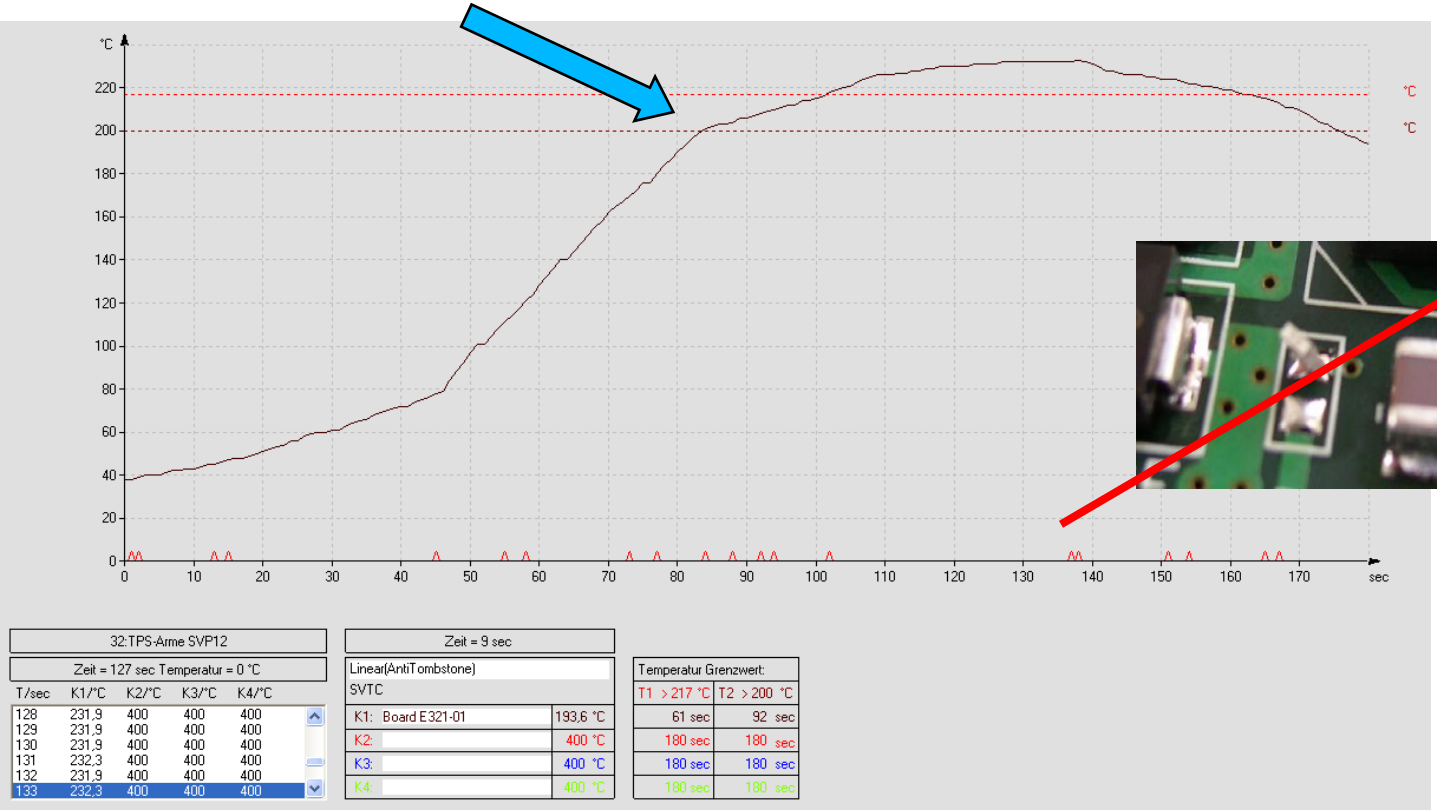
Note: Tombstoning has various reasons and not all of them can be eliminated with a solder profile only. The solder paste, the paste handling, the printing and placement process are important factors too.

Vapor Phase Reflow Soldering Process

Profile to avoid Tombstoning

Anti-Tombstone soldering profile in a IBL SLC 509:

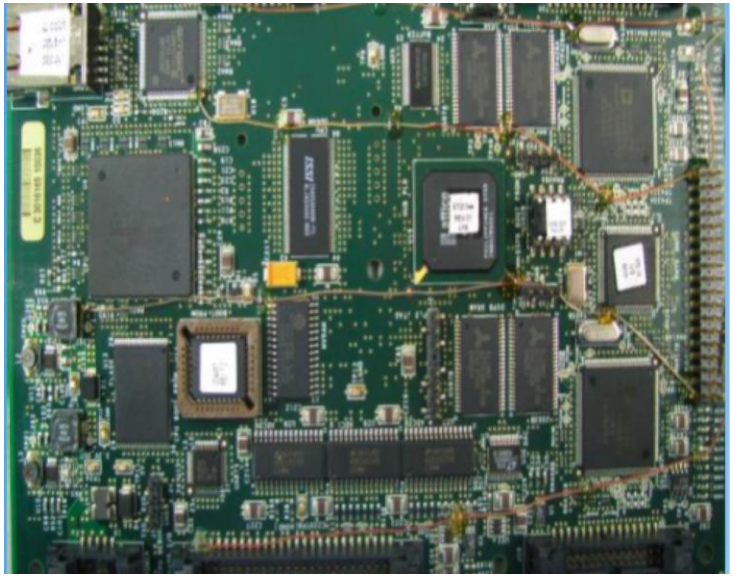
Reducing the gradient before liquidus is avoiding tombstoning in VP



Vapor Phase Reflow Soldering Process

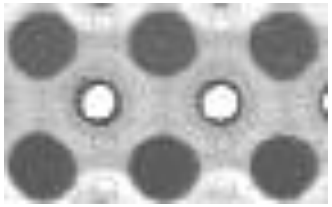
Voiding

Reduction of voiding: Profiles with a thermal soaking zone



Situation:
Voiding too high

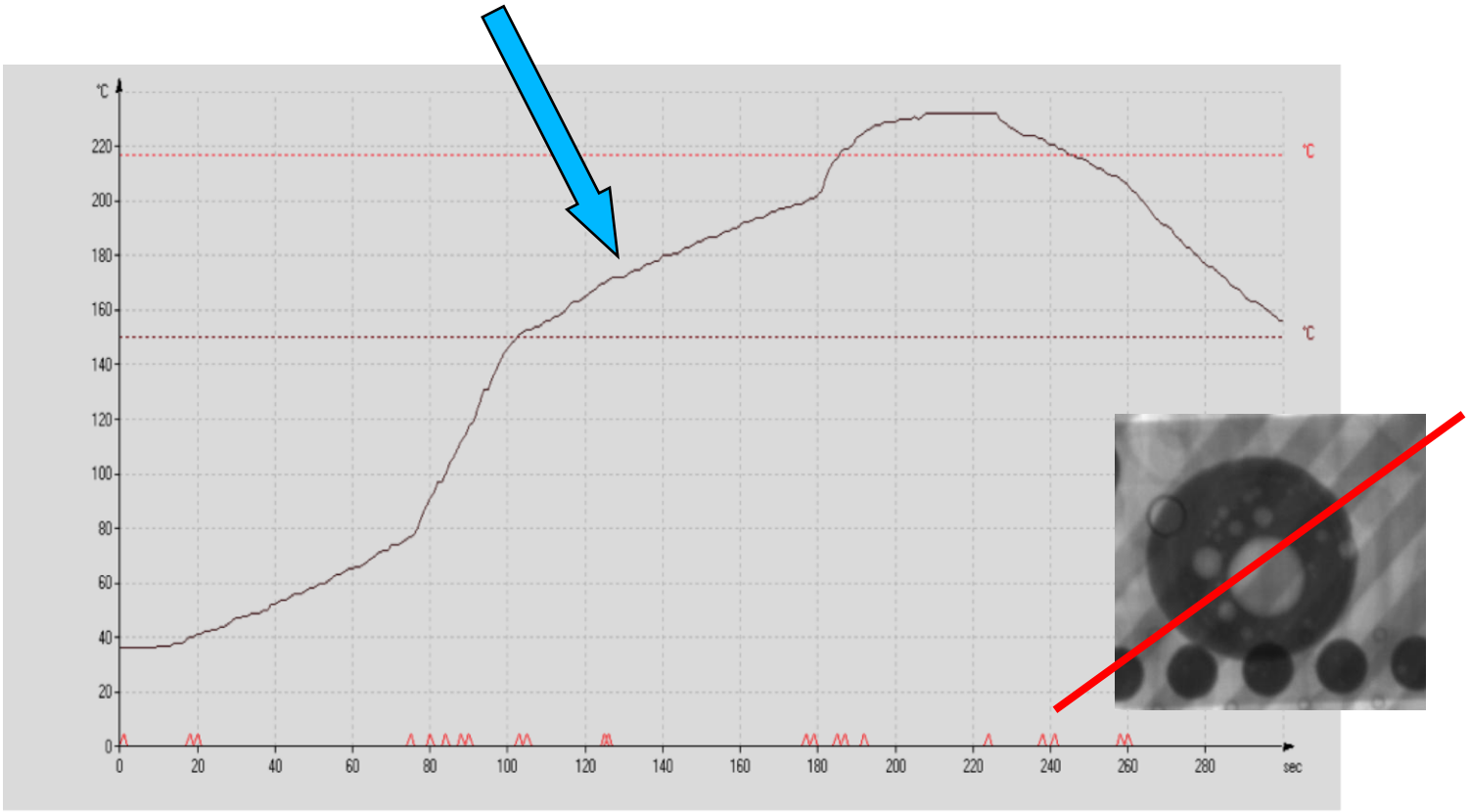
Solution:
Custom profile



Vapor Phase Reflow Soldering Process

Profile to reduce Voiding

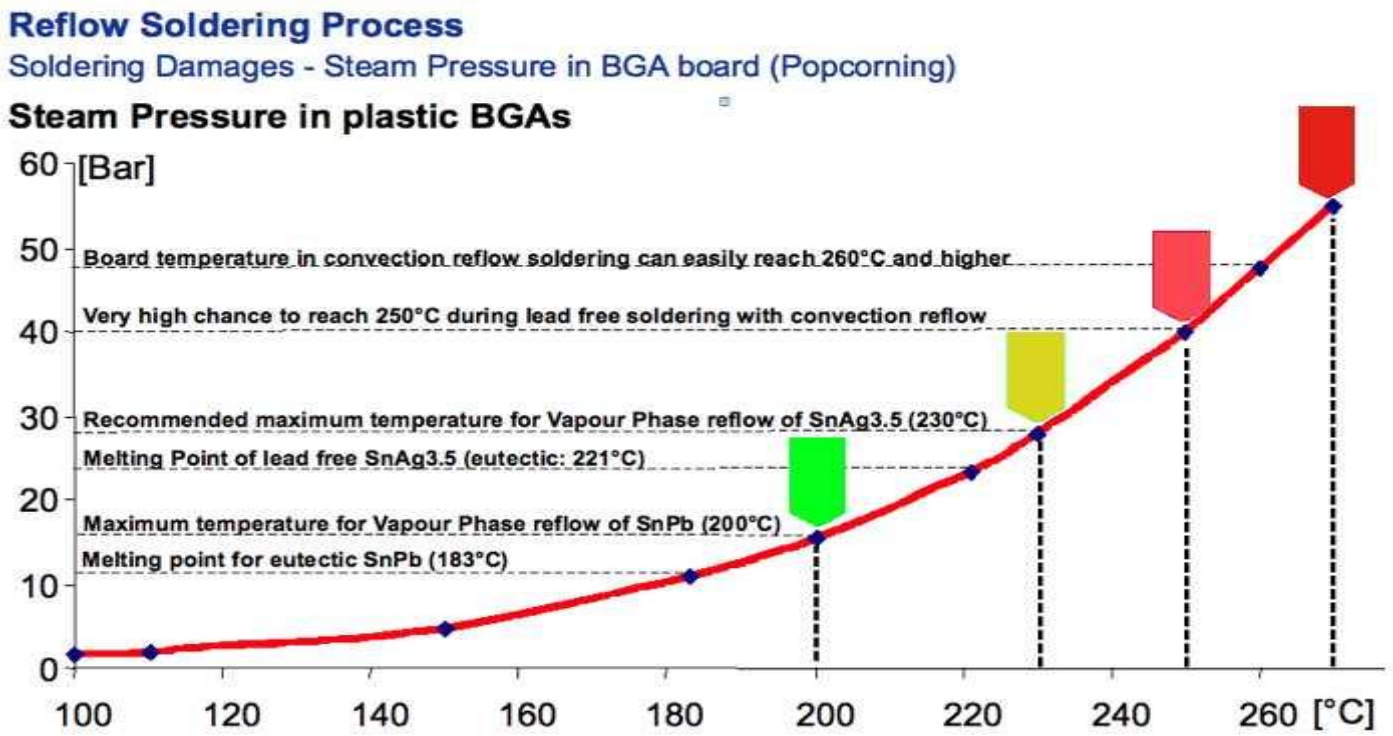
Profiles with a thermal soaking zone to **reduce voiding**



Vapor Phase Reflow Soldering

VP soldering significantly reduces the risk of popcorning or damaging components due to lower max temperatures

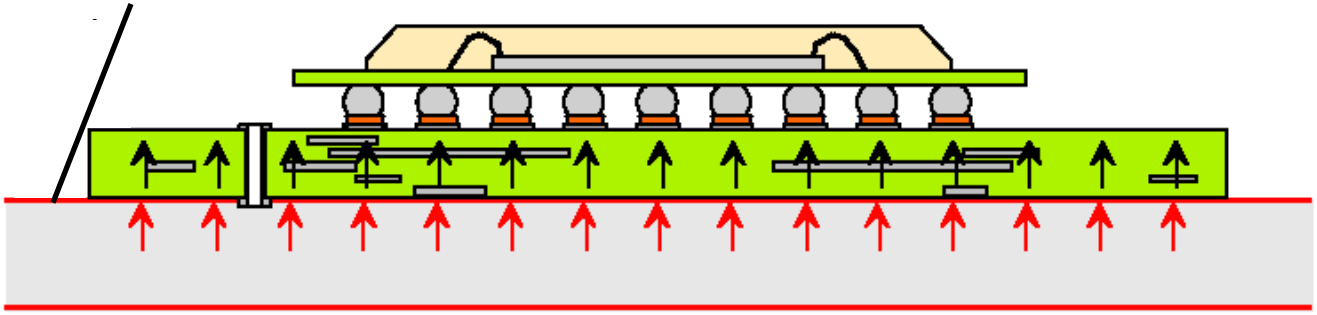
Steam pressure in plastics and laminates



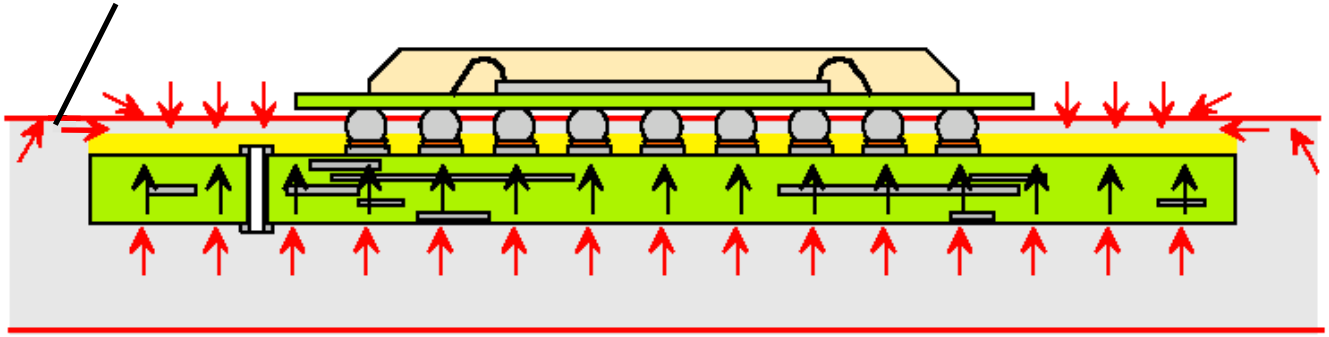
Vapor Phase Reflow Soldering Process

Soldering process of BGA (1/3)

1. The vapor being heavier than the surrounding air reaches the PCB from below



2. The vapor rises above the PCB and transfers heat also from above.



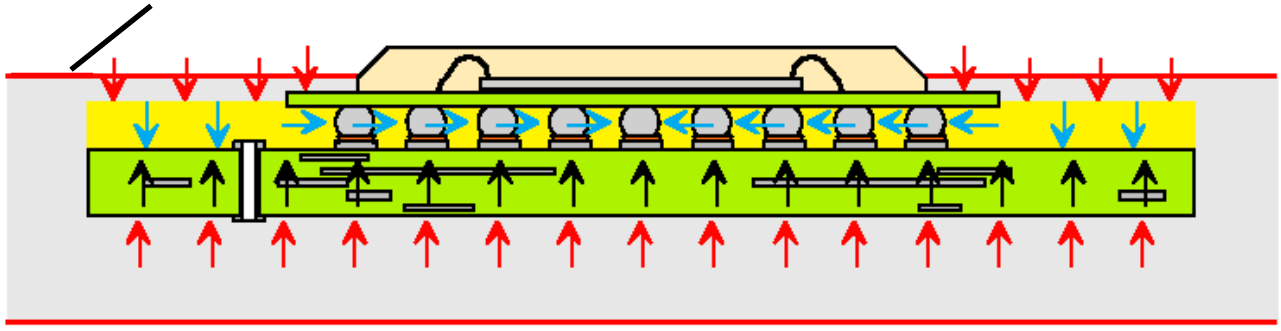
Note

- Maximum vapor temperature = defined boiling point of heat transfer fluid
- Vapor completely displaces all ambient air ensuring a protective area (oxygen free)

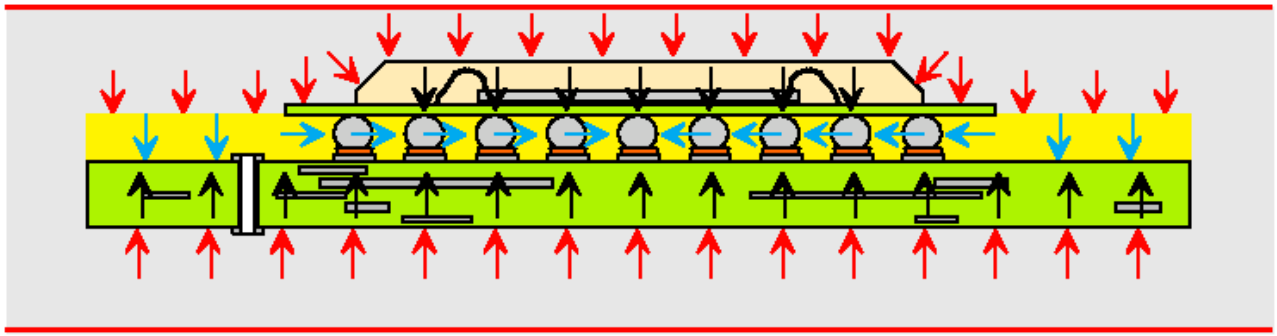
Vapor Phase Reflow Soldering Process

Soldering process of BGA (2/3)

3. The vapor raises to BGA level and transfers heat directly to the BGA.



4. The vapor raises over the BGA. Heat transfer is done on the whole assembly.



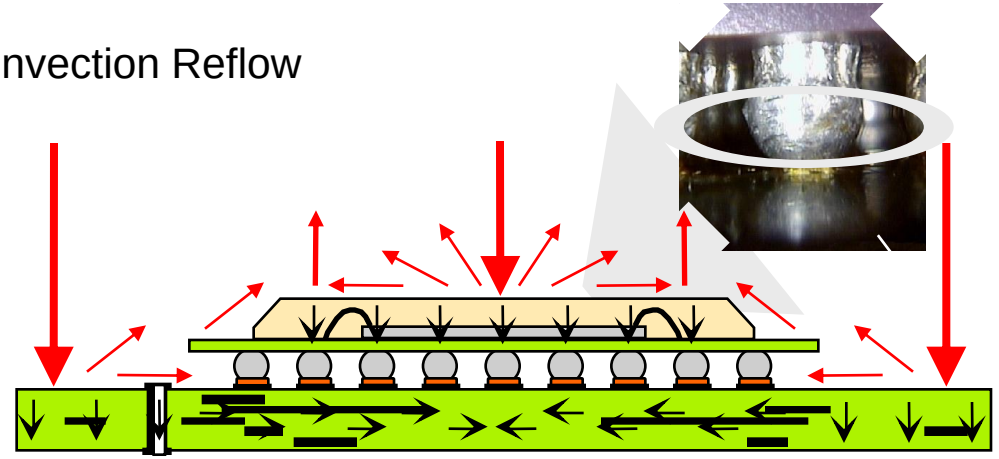
Summary

- Excellent heat transfer throughout the whole board
- No overheating due to defined maximum temperature within the vapor phase

Vapor Phase Reflow Soldering Process

Soldering process of BGA (3/3) - Comparison Vapor Phase and Convection Reflow

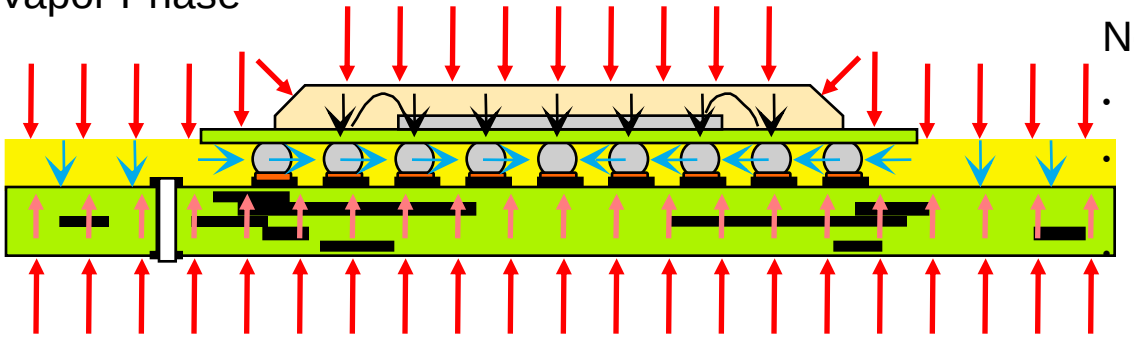
Convection Reflow



Note

- Shadowing of lower side of BGA requires exces temperature on top of BGA
- Unsoldered balls result from shadowing effects

Vapor Phase



Note

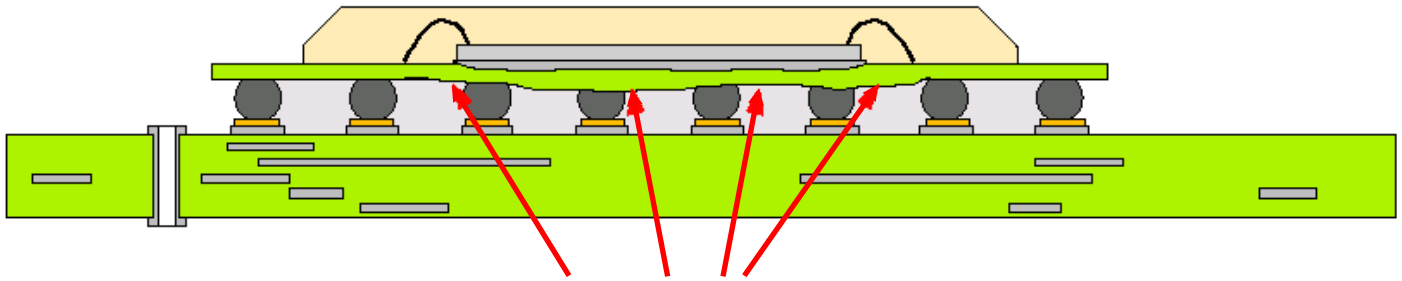
- Vapor rises above and below the BGA.
- Heat transfer is done to the whole assembly
- No Shadowing

Vapor Phase Reflow Soldering Process

Lead Free Soldering Damages - Pop corning

Characteristics

- Plastics are hygroscopic allowing water to diffuse into the mold mass of the BGA
- During convection soldering the steam pressure of the water drastically increases
- High pressure in the mold mass causes delamination of the substrate (Pop corning)



- Pop corning is being observed in conventional soldering from process temperature above 210° C and becoming increasingly critical on lead-free process parameter
- The appearance of pop corning is hard to detect as it happens below the BGA preventing it to be visually observed
- Due to limited thermal stress on the BGA, Vapor Phase soldering minimizes the risk of pop corning

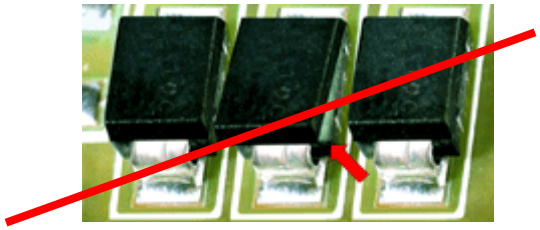
Vapor Phase Reflow Soldering Process

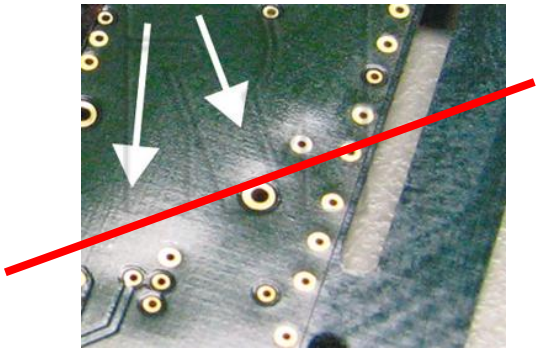
Popcorning and Delamination

Popcorning is hard to detect, typically at IC- or functional test only.

Rework is expensive and some times not accepted at all.

Vapor Phase soldering is reducing the potential risk dramatically



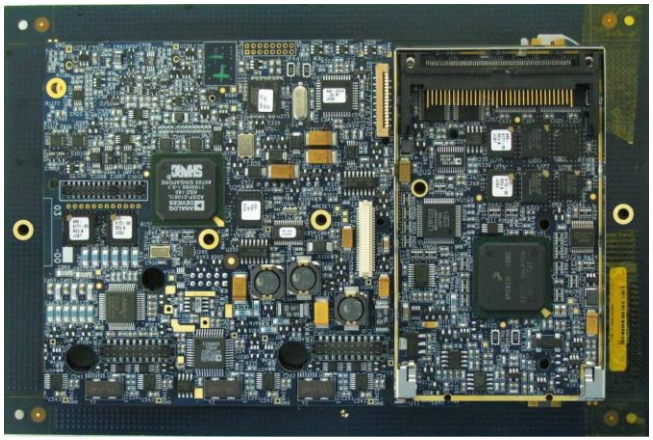


Vapor Phase Reflow Soldering Process

Complex PCBs

Complex boards:

A sample from a customer:



Double sided PCB with BGAs
Solder: SnAg3,5

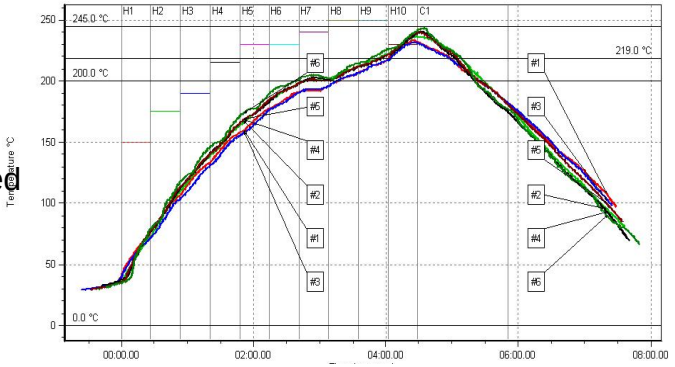
Convection:

ΔT = 12° C

Max. temp. 250° C

Problem: Unsoldered BGA balls.

Expensive rework

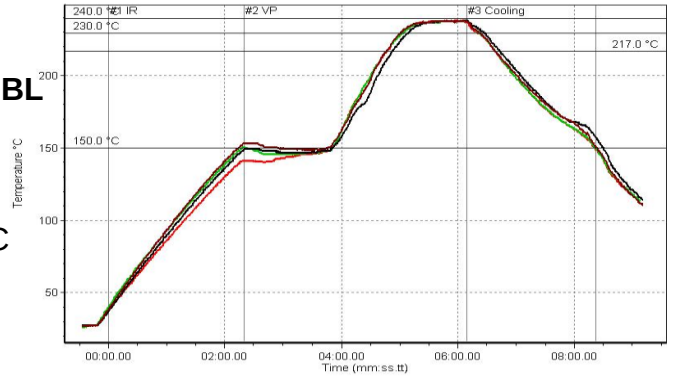


Vapor Phase (IBL CM800):

ΔT = 0° C

Max. Temp. 230° C

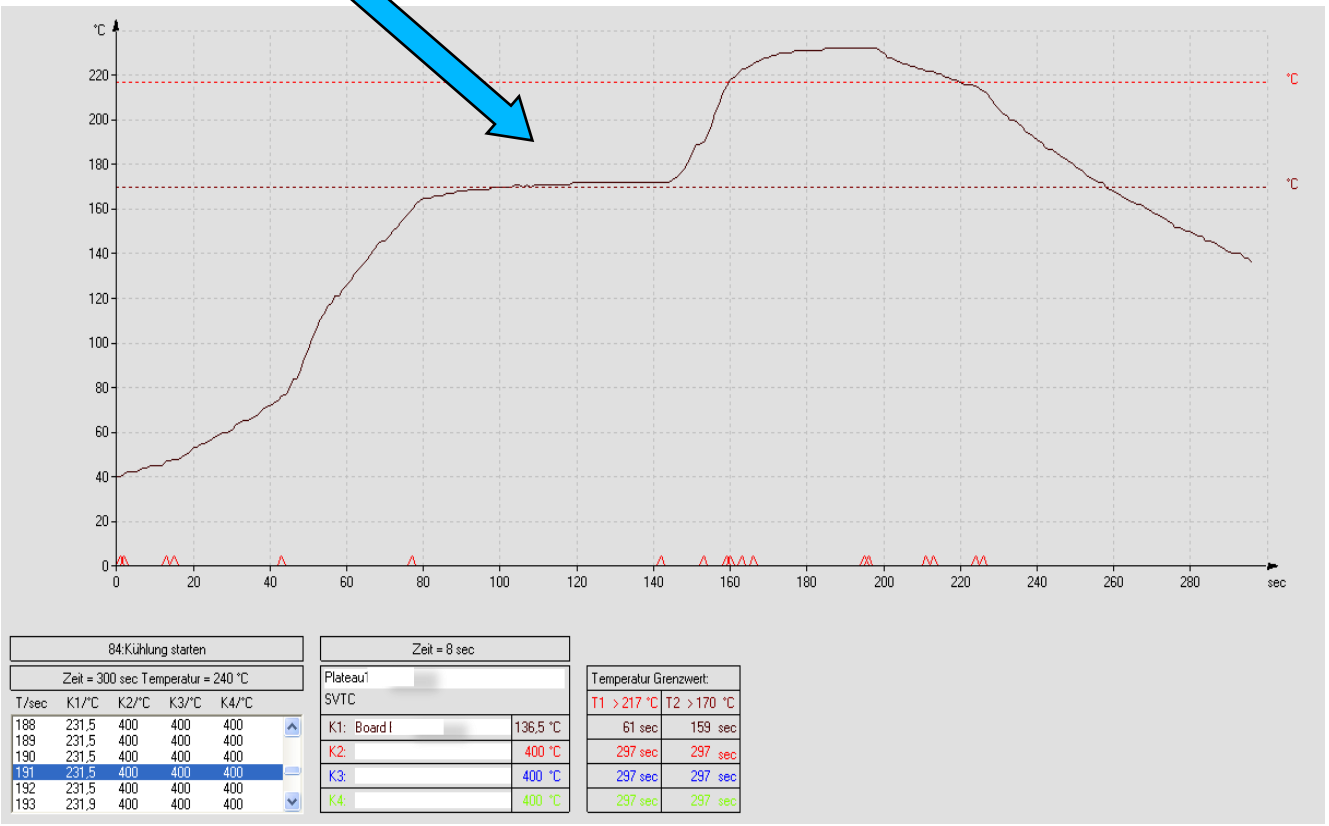
Good results



Vapor Phase Reflow Soldering Process

Profile for Complex PCBs

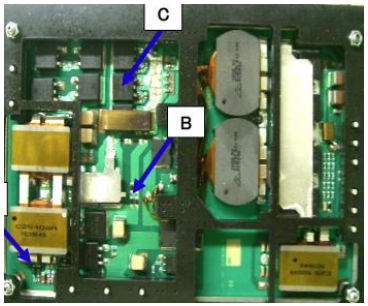
Complex electronics: Profiles with a thermal soaking zone to improve difficult solder jobs



Vapor Phase Reflow Soldering Process

Linear Profiles

Linear profiles
Convection vs. Vapor Phase
An example:



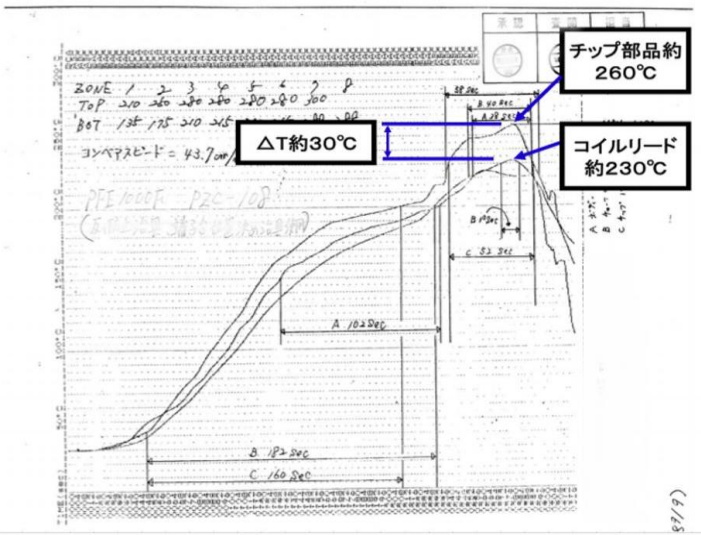
Unit with 3 thermocouples for profile recording, A, B, C.
Solder: SnAg3,5

Convection (9 Zones):

ΔT = 30˚ C

Max. temp. 260˚ C

High temperature differences of components caused high rework and cold solder joints

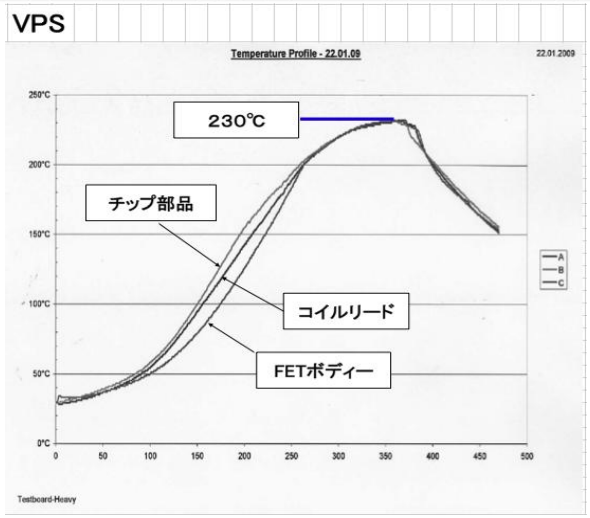


Vapor Phase (IBL SV260):

ΔT = 0˚ C

Max. temp. 230˚ C

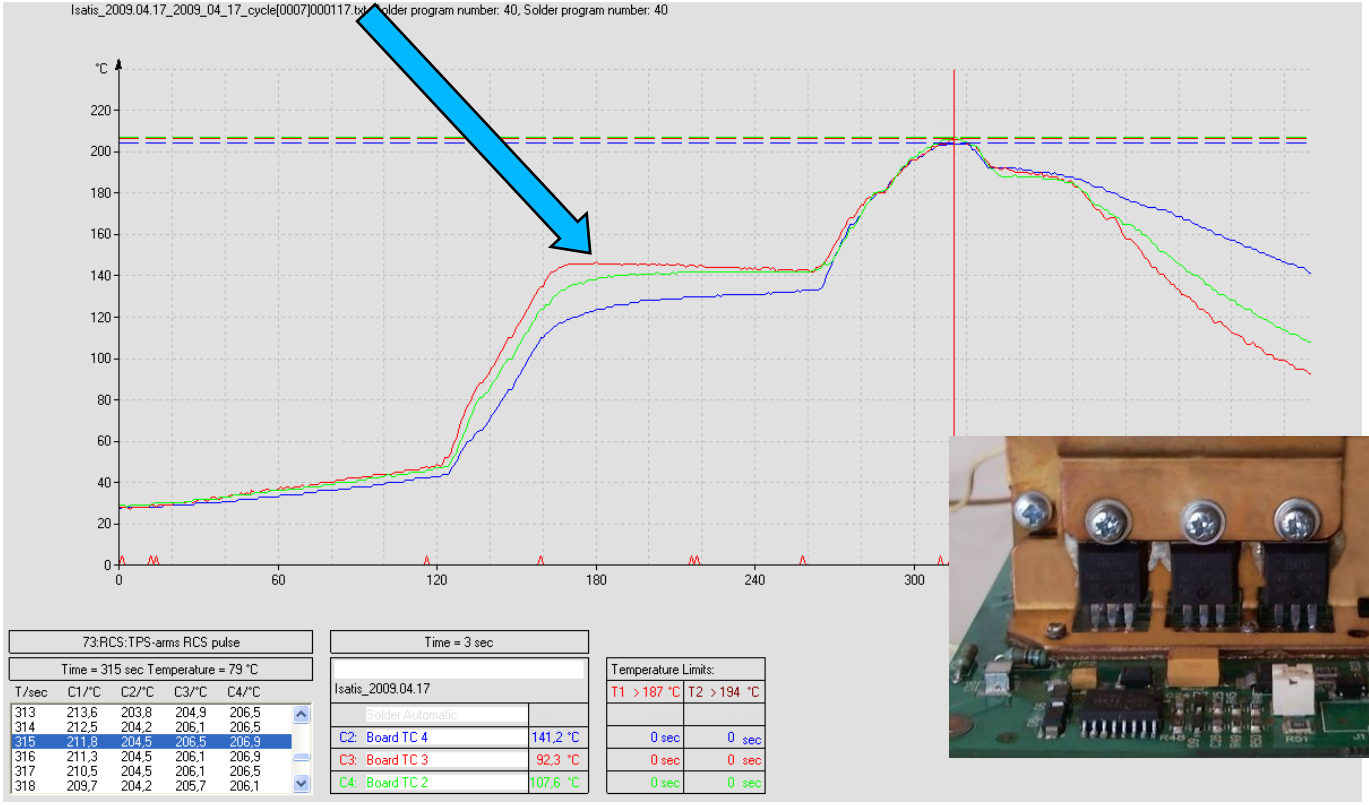
Perfect results



Vapor Phase Reflow Soldering Process

Extreme Masses of PCB and components

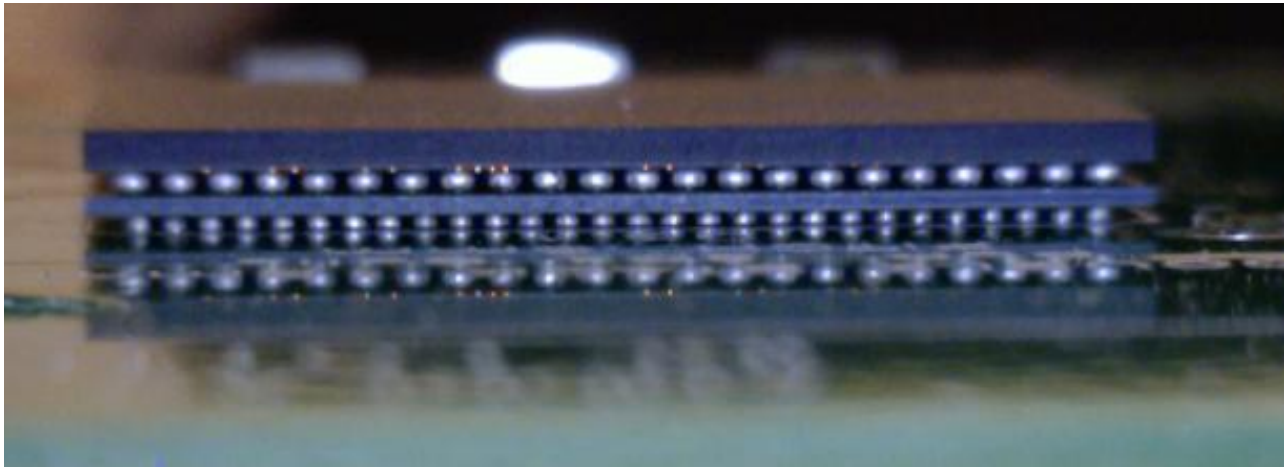
High mass electronics: Profiles to reduce ΔT to „0“ - For less stress of components at the lowest possible temperatures

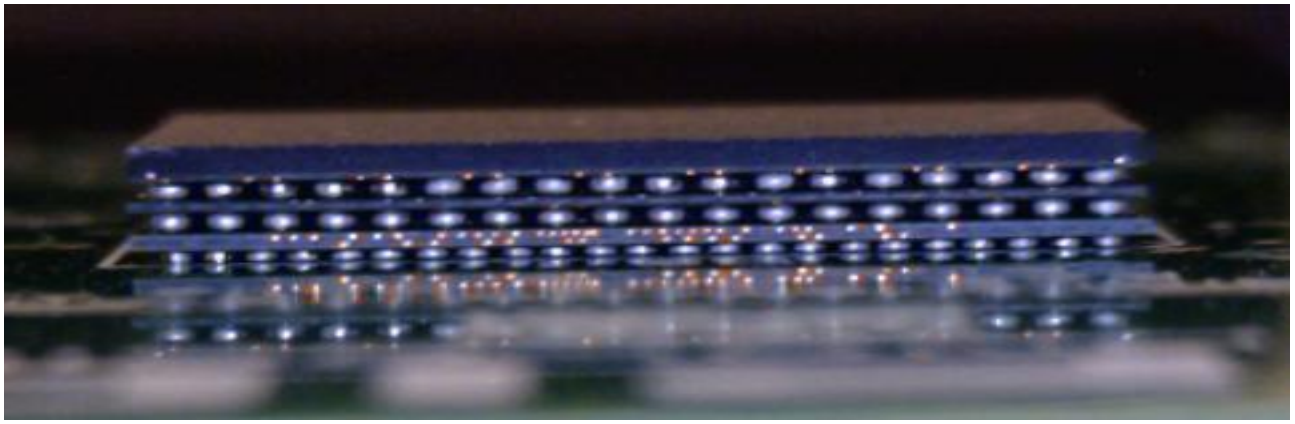


Vapor Phase Reflow Soldering Process

Complex assemblies – PoP double and triple stack

PoP double and triple stack: Reduce ΔT to close of „0“ - No overheating of components at the lowest possible temperatures

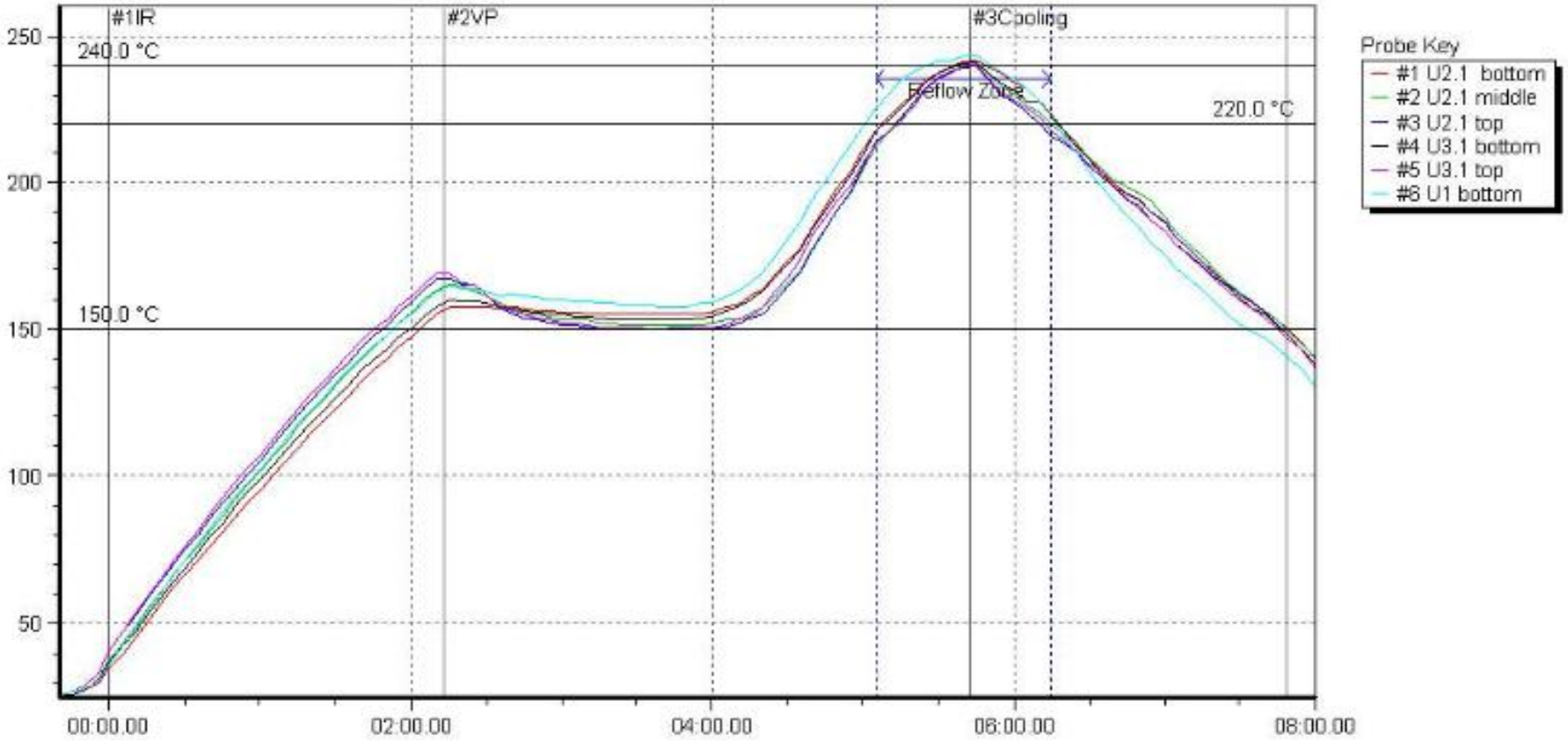




Vapor Phase Reflow Soldering Process

Profile PoP double and triple stack

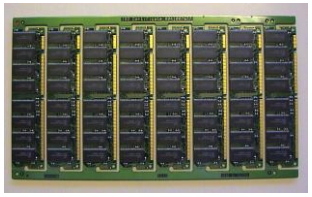
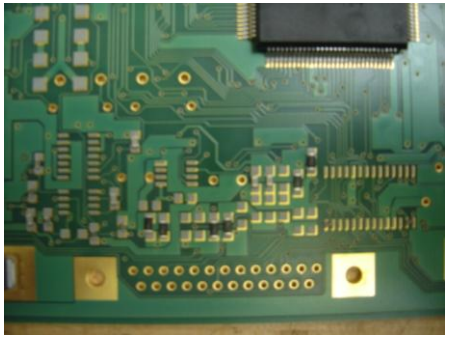
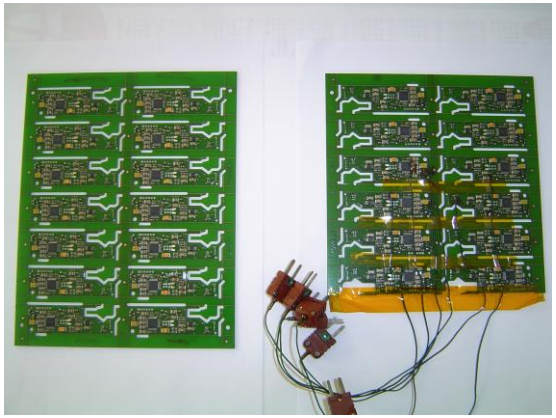
Profiles to reduce ΔT to „0“ - Plateau Profile with long soaking time



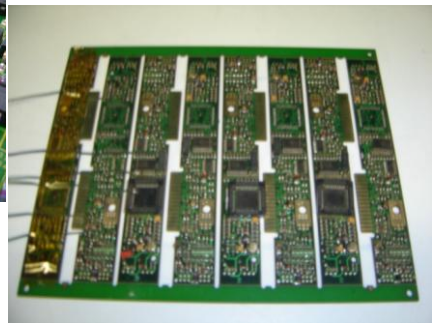
Vapor Phase Reflow Soldering Process

Mix of leaded and unleaded production

Mixed Production: Soldering **leaded** PCBs with liquid typically used for **unleaded** solder.
No change over time for change of fluids plus saving cost for different liquids



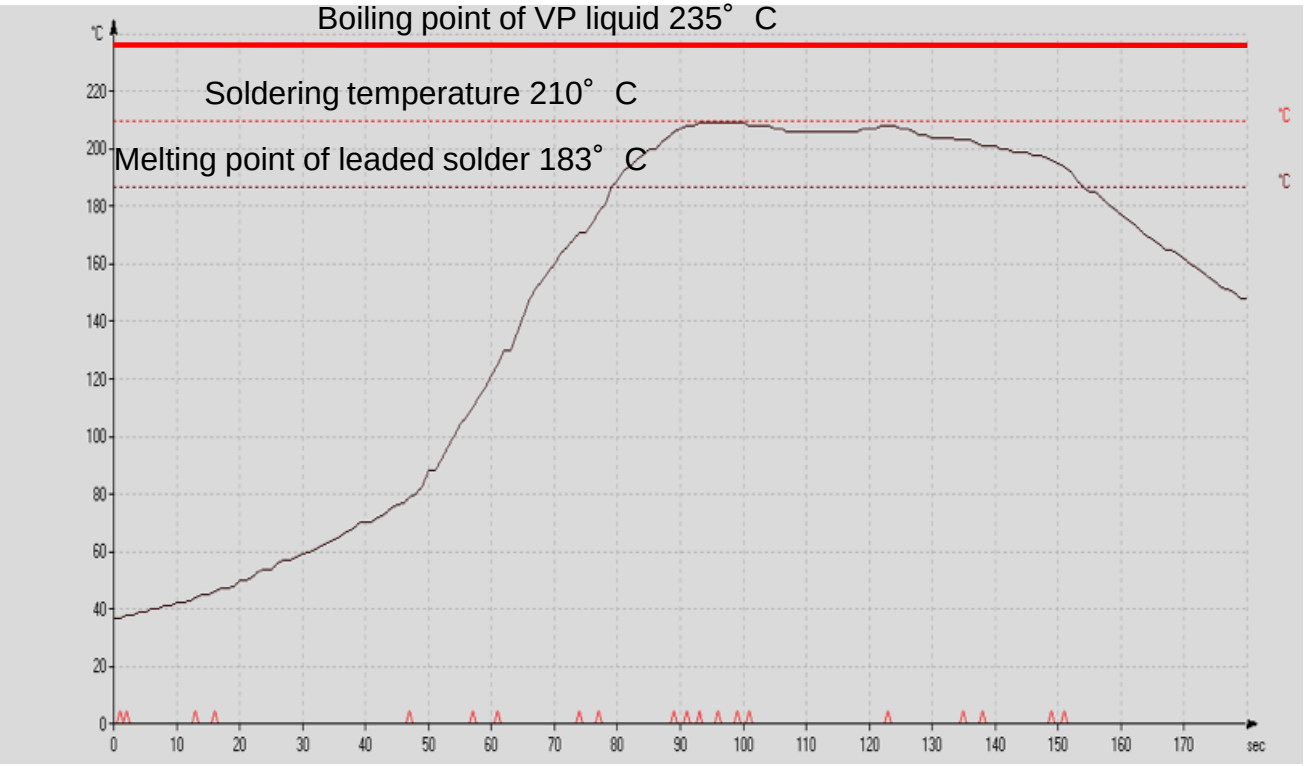


Vapor Phase Reflow Soldering Process

Profile for leaded product with higher fluid boiling point in mixed production

Mixed Production: ***Soldering leaded AND unleaded PCBs with the same fluids.***

No change over time for change of fluids plus saving cost for different liquids



Vapor Phase Reflow Soldering Process

Conclusion

Modern Vapor Phase reflow soldering can combine the advantages of VP with the ability of profiling

Vapor Phase soldering has general advantages over other soldering processes
Lower process temperatures, better wetting, less ΔT, small footprint of the machines, less power consumption, life Profile monitoring ...

In most cases a linear profile in Vapor Phase is sufficient.
Great quality, easy process, less change over time, fast process time.

For difficult solder jobs, customized profiles are the solution
Tombstoning, voiding, very high masses such as GCB, high mass differences, ...

The vacuum Vapor phase reflow soldering process

Reflow solder joints and soldered areas contain voids due to the air and flux in the solder paste.

When low void or void free soldering is needed, it can be achieved with vacuum solder processes.

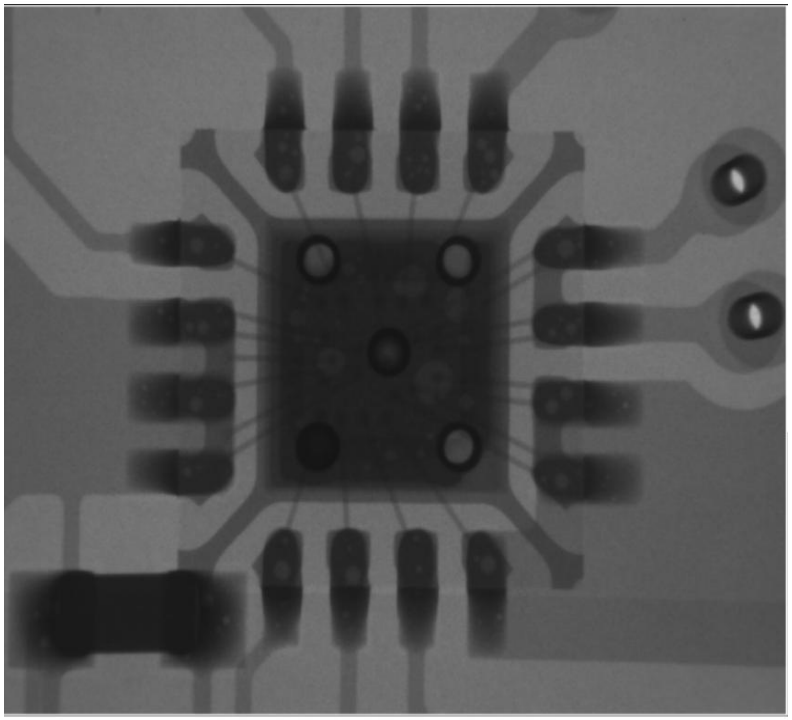
Never leaves inert area and no additional heating required during vacuum

Vapor Phase Reflow Soldering Process

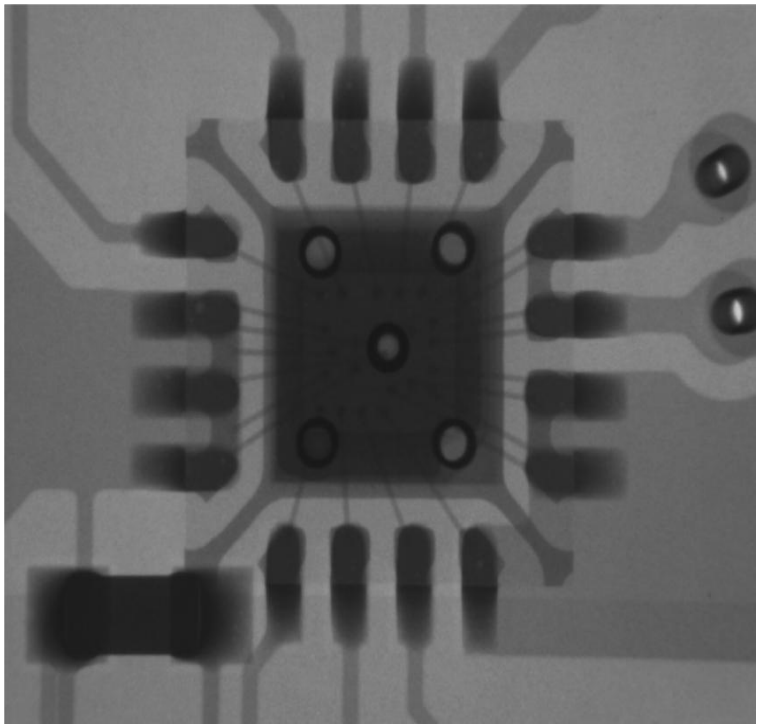
Vacuum Soldering Production Board

Reduce Voiding with Vacuum vapor phase

Convection Oven



Vacuum vapor phase

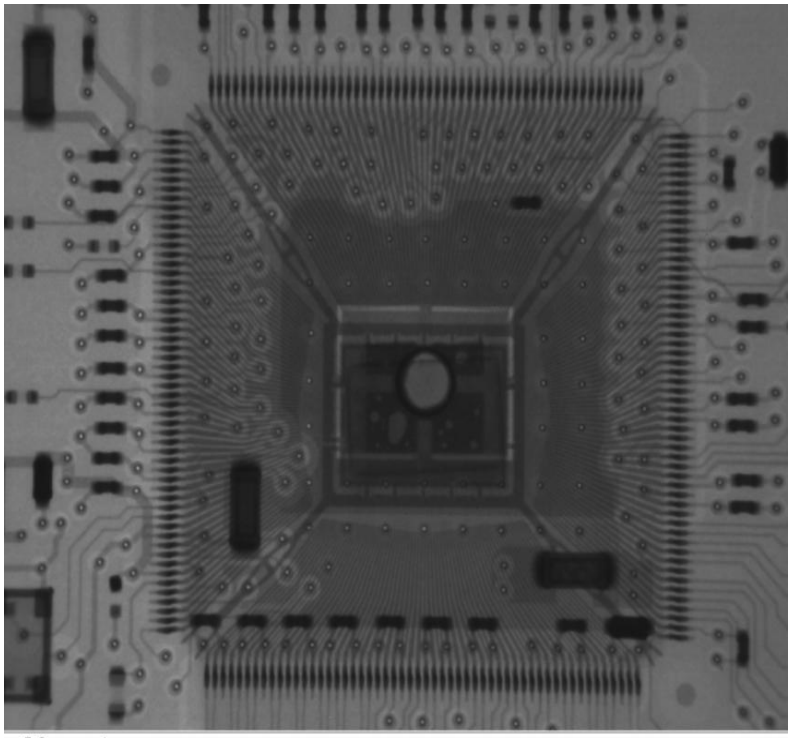


Vapor Phase Reflow Soldering Process

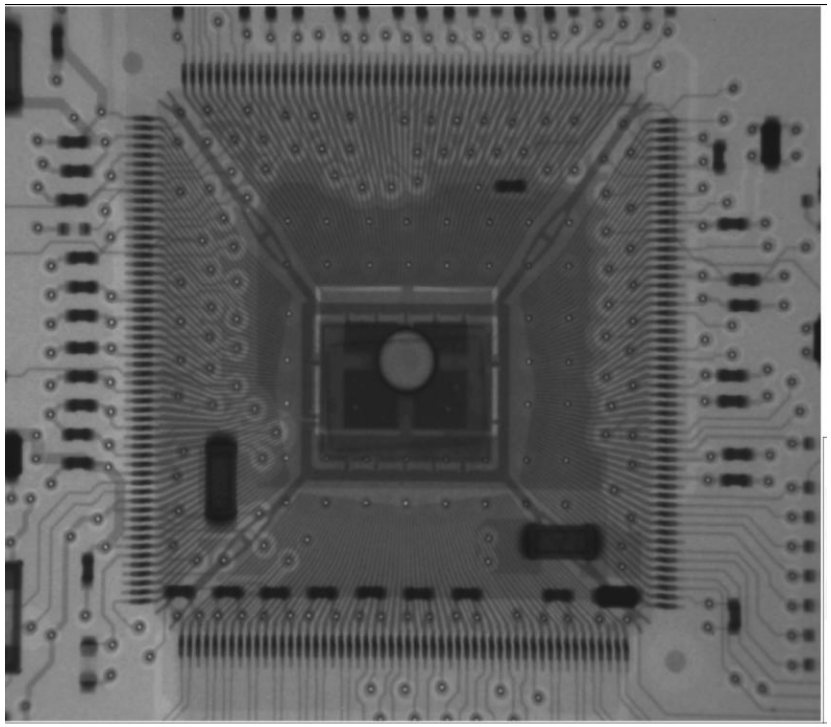
Vacuum Soldering Production Board

Reduce Voiding with Vacuum vapor phase

Convection Oven



Vacuum vapor phase

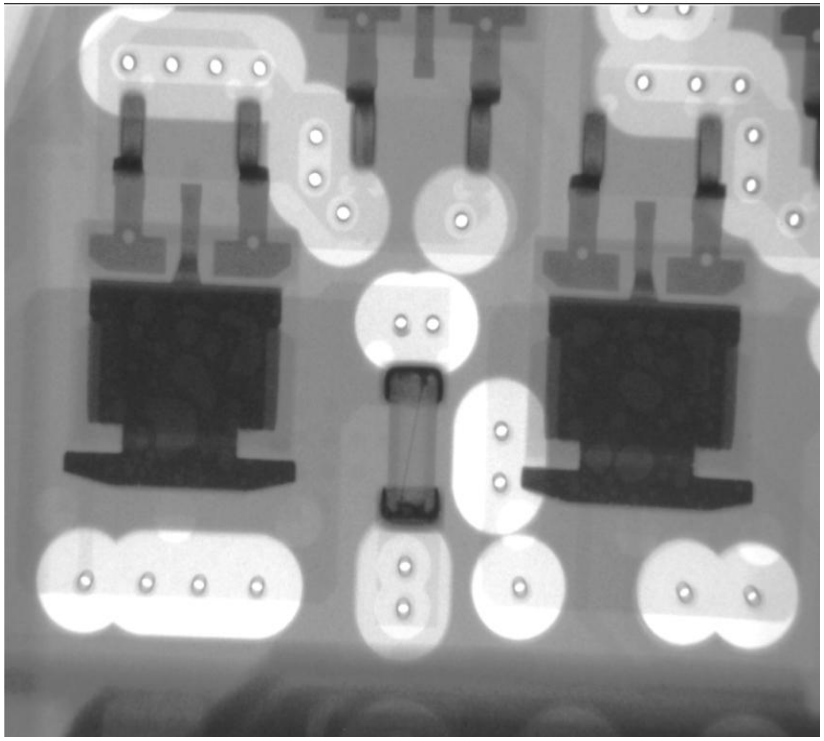


Vapor Phase Reflow Soldering Process

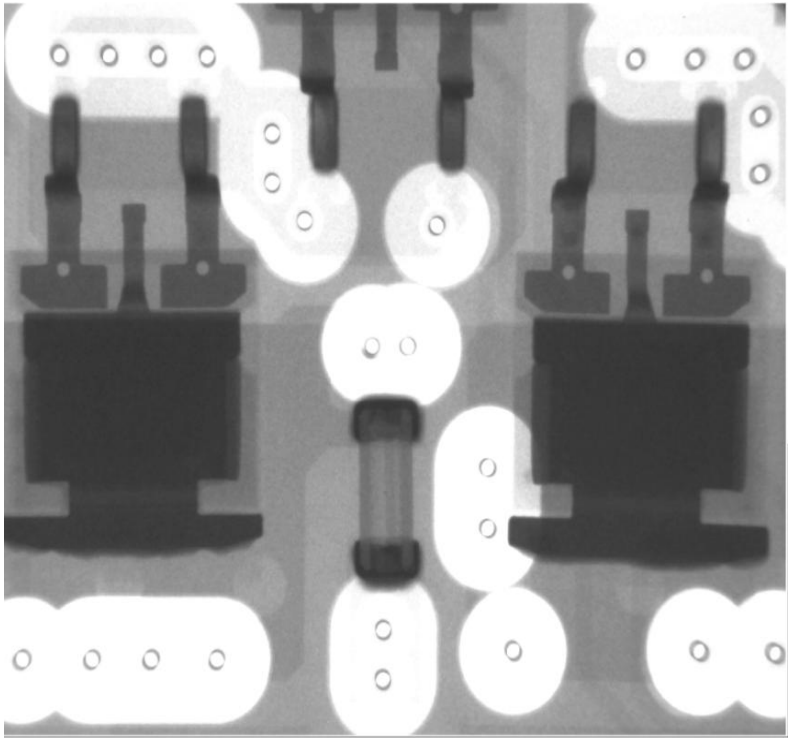
Vacuum Soldering Production Board

Reduce Voiding with Vacuum vapor phase

Convection Oven



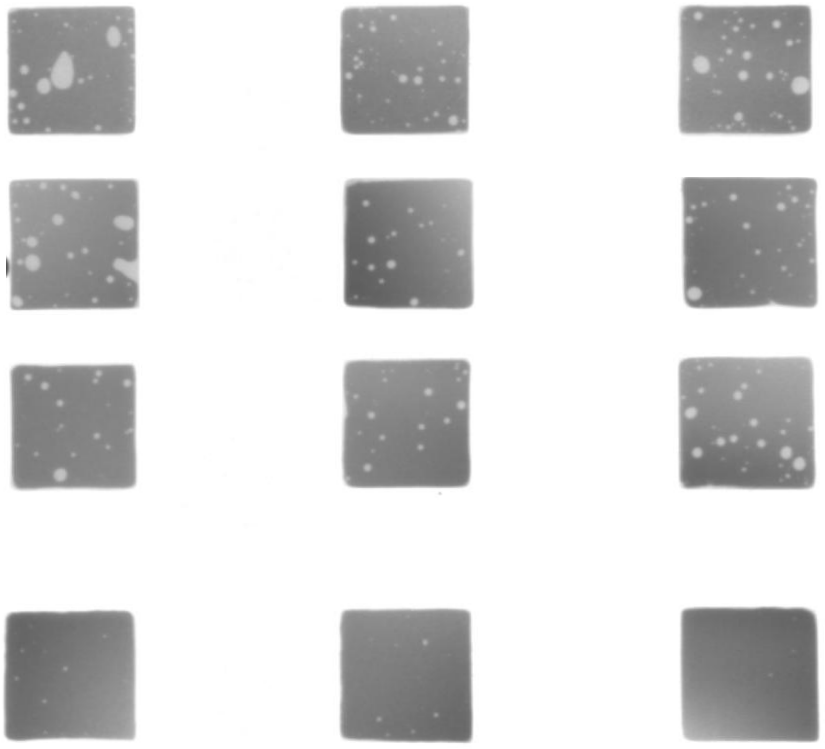
Vacuum vapor phase



Vapor Phase Reflow Soldering Process

Vacuum Soldering Test Board

Test pad 10 x 10 mm²



Soldered with a linear profile

Soldered with a plateau profile

Soldered with a optimized plateau profile

Vacuum solder process at 50 mbar

The IBL VAC system can go down to 5 mbar

Vapor Phase Reflow Soldering Process

Premium Batch & Inline Series VAC 645/665 (Vacuum machine for highest quality)

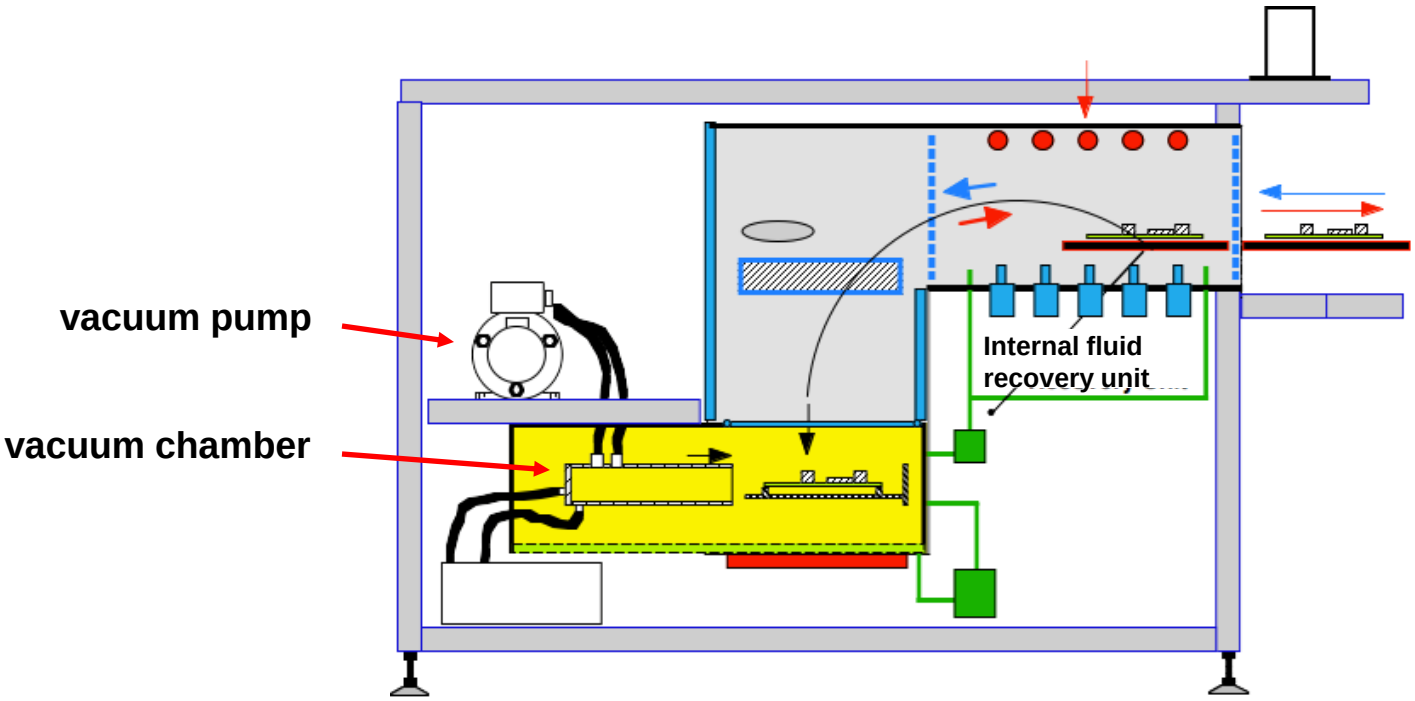
Vacuum Vapor Phase soldering machines

- Invapor Technology for lower temperatures
- Reduction of voids, even for large soldering areas
- Evacuation of the modules during the entire vapor reflow soldering process
- Inline or Batch machines
- max Board Size [mm]: 630 x 640 x 70

Vapor Phase Reflow Soldering Process

The **IBL** Principle of Vacuum Vapor Phase Soldering (Type VAC 645/665)

Vacuum System Vac665 side view



Vapor Phase Reflow Soldering Process

Repair and rework

Repair and rework with a vapor phase soldering system using IBL Rework system (ReSy)

BGA repair/rework with a ReSy

Vapor Phase Reflow Soldering Process

Overview **IBL** Vapor Phase Reflow Soldering Machines

- **MiniLab**

- **SV 260**

- **SV 360**

- **CM 800**

- **SLC/BLC**

- **SLC/BLC inline**

- **VAC 645/665**

Thank you
If you have any questions please feel free to contact us

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915 929 0033