Vacuum Presentation

Vacuum Soldering Systems

Since 2009

SMD Reflow-Soldering-Systems
Reflow-Soldering-Systems

Temperature Treatment
Curing Systems, Cooling Systems

Vacuum Soldering Systems
Vacuum Soldering Systems

Hot and Cold Function Tests
Inline Systems, Batch Systems, Lean concept...

Coating & Curing Systems
Coating/Curing, UV Systems, Molding lines

Customized Solutions
Conveyor Systems, Custom Designed Systems
First part:

SMT company
SMT in Wertheim

- Founded in 1987 by Hans-Günter Ulzhöfer
- “Made in Germany”
  6000 m² (64600 ft²)
- 160 employees
- Experts for thermal processes

Headquarter, Technology Center, Plant I and Plant IV

Plant II and Plant III
SMT Organisation

SMT worldwide

Registered SMT Sales + Service offices:

- Wertheim, Germany
- Richmond, Virginia, USA
- Singapore
- Suzhou China

Service availability 24/7

- With our local representative and
- With SMT offices
- Spare and Ware parts also included

Representatives located in

- Africa (Egypt, Marocco, South Africa, ...)
- Asia (China, India, Philippines, ...)
- Europe (Belgium, Italy, Spain, ...)
- North America (Canada, USA)
- South America (Brazil, Mexico, ...)
### Products

**SMD-Reflow Soldering**
- Lowest energy and media consumption
- Precise nitrogen control
- Low maintenance

**Vacuum Soldering**
- Voids reduced up to 99%
- One sealing surface

**Coating + Curing**
- High throughput
- Small footprint
- No maintenance

**Temperature Treatment**
- 1 to x-lane
- Heavy-duty transport
- Customized solutions

**Hot and Cold-Function Tests**
- High throughput
- Small footprint
- Lean systems

**Customized Solutions**
- Customized and solution-oriented

**Dispenser Coating UV Products Curing / Drying Ovens**
Customers worldwide

Industries served:

- Automotive
- Telecommunication
- Aerospace
- Medicine
- Defence

... and many more
Second part

Vacuum parameters
• Vacuum module between peak- and cooling zone
• Stainless steel vacuum chamber is externally heated
• Inline system
• Nitrogen capable
• Vacuum and non-vacuum process
• All process parameters are adjustable
• High installed base
**Principle vacuum reflow process**

<table>
<thead>
<tr>
<th>Conventional Reflow</th>
<th>Reflow-Process (liquid solder)</th>
<th>Vacuum-Process (liquid solder)</th>
<th>Cooling (solidified solder)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Printed solder paste</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Void</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Process steps:
  - heating  
  - vacuum 
  - cooling 

- Only one process step more compared to conventional reflow process

- Voids cause thermal resistance:
  - critical in terms of heat flow
  - lifetime reduction
Temperature profile

- Exemplary temperature profile of bare die on DBC
- Vacuum process is part of time above liquidus (TAL)
- Constant product temperature due to thermal balance between product and chamber

Vacuum Profile

- All vacuum parameter are adjustable
- Pressure range: 2 - 500 mbar
- Evacuating time: 5 - ... s
- Holding time: 0 - ... s
- Ventilation time: 5 - ... s
- Total vacuum cycle: 33 - ... s
### SMT Vacuum oven cycle time

<table>
<thead>
<tr>
<th>Transport speed</th>
<th>0.8m/min(13.3mm/s)</th>
<th>1.0m/min(16.7mm/s)</th>
<th>1.2m/min(20mm/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LP-length</strong></td>
<td>200mm</td>
<td>400mm</td>
<td>200mm</td>
</tr>
<tr>
<td><strong>Transfer into vacuum chamber</strong></td>
<td>15+2</td>
<td>30+2</td>
<td>12+2</td>
</tr>
<tr>
<td><strong>Close the chamber</strong></td>
<td>2.5s</td>
<td>2.5s</td>
<td>2.5s</td>
</tr>
<tr>
<td><strong>Vacuum 5mbar</strong></td>
<td>5s</td>
<td>5s</td>
<td>5s</td>
</tr>
<tr>
<td><strong>Hold time</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Ventilation</strong></td>
<td>5s</td>
<td>5s</td>
<td>5s</td>
</tr>
<tr>
<td><strong>Open the chamber</strong></td>
<td>2.5s</td>
<td>2.5s</td>
<td>2.5</td>
</tr>
<tr>
<td><strong>Transfer out of vacuum chamber</strong></td>
<td>15s</td>
<td>30s</td>
<td>12s</td>
</tr>
<tr>
<td><strong>Total cycle time</strong></td>
<td>47s</td>
<td>77s</td>
<td>41s</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Third part:

Solder joint results

Conventional process

Vacuum process
Vacuum results: bare die on DCB

- Vacuum reflow is designed for:
  - PCB
  - DBC
  - Lead frame
  - anything!
- Power electronics:
  - voiding < 5%
- Automotive:
  - voiding < 10%

![Comparison of conventional reflow (b) and vacuum reflow (c)](image)
Total voiding, bare die on DBC

- 1,000 analyzed solder joints
- 7 bare dies on 1 DBC
- Voiding requirement: < 5%
- Conventional reflow: 99% waste
- Vacuum reflow: 0% waste
Largest void, bare die on DBC

- Single void requirement 1%
- Conventional reflow:
  - solitary large single voids
  - single voids with more than "1%"
- Vacuum reflow:
  - reduction of single void area
  - hotspots are eliminated
  - high quality gain
Influencing factors on void reduction

**Cause**

- Vacuum pressure
- Temperature profile
- Nitrogen

**Effect**

- Void reduction
- Wettability
Effect of nitrogen (on MOS-FET)

- X-ray pictures
- Nitrogen 🅋 marginal improvement
- Our experience:
  If solder paste wetting is not improved by nitrogen, aire or nitrogen atmosphere can be applied for vacuum process to eliminate voids.
- Nitrogen in vacuum process used to avoid oxidated (bonding) surfaces.
- Nitrogen in high power electronics improves quality of following process steps, e.g. wahing, bonding.
Effect of pressure

- Investigation: bare die on DCB
- Each value is calculated by means of 44 analyzed solder joints
- Vacuum pressure has low impact on void reduction quality
- Pressures $<50$ mbar → good result
Effect of bad temperature profile

- Temperature profile is too short
  - Wettability is poor underneath
- Voiding ist poorly reduced despite vacuum!
- X-ray inspection of components:
  - Voiding > 5%
- Improved temperature profile, same vacuum parameters:
  - Voiding < 1%
Detailed vacuum reflow process

• Void extraction is done by:
  1. Void inflating,
  2. Void gets in touch with solder joint surface,
  3. Void is extracted by means of surface tension,

• Critical process step:
  - Displaced liquid solder must reflow above surface.

• Good wettability surfaces are fully wetted with solder
• Bad wettability surfaces are partly wetted with solder remaining voids
Conclusion

• SMT vacuum reflow is mighty technology for:
  - nitrogen, air, vacuum and non-vacuum processes
  - solder joint quality improvement

• Great advantage compare to other vacuum soldering technologies:
  - homogeneous heat transer
  - simple profiling
  - fully inline capable
  - suitable for any reflow product (DCB, PCB, lead frame, ... any!)

• Combination of profiling, solder paste wettability and vacuum must be considered.
Fourth part:

Lead free vacuum reflow processes:
Effect on mass and capacity of electrolyte capacitors
Goal of investigations

- Does the reflow process effect the capacity or the weight of electrolyte capacitors?
- Does the electrolytes solution boil?
Capacitor specifications

Data sheet:

- Copied specification of Nippon Chemi-Con
- Voltage $V_{dc} = 35$ V
- Capacity $F = 470\mu$F

<table>
<thead>
<tr>
<th>WV (Vdc)</th>
<th>Cap (µF)</th>
<th>Size code</th>
<th>ESR (Ω max/100kHz)</th>
<th>Rated ripple current (mArms/125°C)</th>
<th>Part No.</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>20°C</td>
<td>-40°C</td>
<td>100kHz</td>
</tr>
<tr>
<td>35</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>F60</td>
<td></td>
<td>1.6</td>
<td>24.0</td>
<td>69</td>
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<tr>
<td>22</td>
<td>F60</td>
<td></td>
<td>1.6</td>
<td>24.0</td>
<td>69</td>
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<td>0.90</td>
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<td>14.0</td>
<td>110</td>
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<tr>
<td>47</td>
<td>HA0</td>
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<td>0.40</td>
<td>6.0</td>
<td>220</td>
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<tr>
<td>100</td>
<td>HA0</td>
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<td>0.40</td>
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<td>330</td>
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<td>0.14</td>
<td>2.1</td>
<td>750</td>
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<tr>
<td>330</td>
<td>LH0</td>
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<td>0.10</td>
<td>1.5</td>
<td>1,000</td>
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<tr>
<td>470</td>
<td>KG5</td>
<td></td>
<td>0.11</td>
<td>1.5</td>
<td>900</td>
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<tr>
<td>470</td>
<td>LH0</td>
<td></td>
<td>0.10</td>
<td>1.5</td>
<td>1,000</td>
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<tr>
<td>680</td>
<td>MH0</td>
<td></td>
<td>0.10</td>
<td>1.5</td>
<td>1,200</td>
</tr>
</tbody>
</table>
Investigation

Activities:
- Arranging 4 groups each with 25 capacitors
- Measuring weight and capacity of each capacitor
- Applying 4 different reflow profiles: 1 profile for each group
- Measuring weight and capacity of each capacitor
- Comparing the results before and after thermal treatment
SMT vacuum reflow system

- Reflow set up (top and bottom):
  Zone 1: 150°C
  Zone 2: 160°C
  Zone 3: 170°C
  Zone 4: 190°C
  Zone 5: 235°C
  Zone 6: 275°C
  Zone 7: 260°C
  Zone 8: 260°C (vacuum chamber)
  Zone 9: 80°C
  Zone 10: 40°C
  Zone 11: 40°C

- Conveyor speed: 0.8 m/min
- Fan frequency: 50 Hz
Temperature, vacuum profiles

• **Process variations:**
  1. **No vacuum**
     - Stopping $6 \text{s} + 8 \text{s} = 14 \text{s}$ in vacuum chamber
  2. **Vacuum:**
     - $6 \text{s}$ evacuating, **0 s holding,**
     - $8 \text{s}$ soaking
  3. **Vacuum:**
     - $6 \text{s}$ evacuating, **30 s holding,**
     - $8 \text{s}$ soaking
  4. **Vacuum:**
     - $6 \text{s}$ evacuating, **60 s holding,**
     - $8 \text{s}$ soaking

• **Remark:**
  Vacuum holding times are typically shorter than 10 s.
Average weights before and after thermal treatment

- Measurement error:
  $\Delta m \approx +/- 0.001 \text{ g}$

- Absolute loss of weight after thermal treatment: $0.002 \text{ g} < \Delta m < 0.004 \text{ g}$

- Relative loss of weight after thermal treatment: $0.03 \% < \Delta m/m < 0.08 \%$

- Loss of weight is always smaller 0.004 g, independent from reflow or vacuum process.

- Conclusion:
  - Vacuum and non-vacuum treatments slightly reduce the weight of capacitors
  - No negative effect of vacuum.
• Measurement error:
  \( \Delta C \approx 1 \ \mu F \)

• Absolute capacity loss of after thermal treatment: 
  \(-1.24 \ \mu F < \Delta F < 0.016 \ \mu F\)

• Relative Capacity after thermal treatment: 
  \(0.25\% < \Delta F/F < 0.03\%\)

• Maximum capacity loss is 1.24 \(\mu F\) for non-relevant capacity loss is 1.24 \(\mu F\) for non-relevant vacuum process with 60 s holding time.

• **Conclusion:**
  - No significant impact on capacity.
Conclusion

- All thermal treatments (vacuum and conventional processes) slightly reduce the weights of the capacitors.

- However, these losses are very small: <0.1% relative loss.

- The same conclusion holds for the capacities:
  - Capacity losses are very small: <0.25%
  - Capacity losses appear for conventional and vacuum reflow processes