Cleaning PCBs in Electronics

Understanding Today’s needs

By

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Reasons to deflux PCBAs

- Chemical compatibility with protection materials
  - Coatings & CC / Potting / Under fill
- Good adhesion with protection materials
- Optimal bonding of wire to substrate (wire bonding)
- Higher performance and reliability
  - HF microwave
  - High voltage
  - Safety, mission critical systems
- Requirements in aeronautics, defense & MIL, rail, automotive, medical, power electronics …
- Higher quality goals
Cleaners market situation

- CFCs ban 1987
- HCFCs ban 2004
- HCFC225 ban 2010
- nPB ban 2012

Hydrocarbons
- Petroleum distillates
- Brominated
- Detergents

No clean

Fluorinated HFEs, HFCs
- Glycols (modif. Alcohols)

Water
Miniaturization

High standoff
0.5 - 1.5 mm standoff
(20 - 60 in mils)

1.2 - 2.5 mm Pitch
(50 - 100 in mils)

0.05 - 0.5 mm standoff
(2 - 20 in mils)

1.2 - 0.5 mm Pitch
(50 - 20 in mils)

Very low standoff
0.02 - 0.5 mm standoff
(1 - 20 in mils)

0.5 - 0.3 mm Pitch
(20 - 12 in mils)

THT
THT + SMT (SMDs)
Pure SMT (SMDs)
Package Trend Chip Resistors. (Source: Rohm)
HI PCBA COMPLEXITY AND REDUCTION

From SURFACE to VOLUME

Surface (2D)  Volume (3D)
Reasons For New Alternative Cleaning Processes

- Different contaminants; Fluxes (lead-free, high temp alloys)
- Smaller Components
- Very low standoff and fine pitch in components
- Leadless components and BTCs
- Higher quality and reliability needs
- Medical quality standards
- Improve the cleaning performance
- Replace old equipment
- Environmental legislation issues
Typical contaminants
Typical contaminants

- Different contaminants; Fluxes (lead-free, high temp alloys)
- Natural and synthetic rosins
- Salts
- Solder balls
- Finger prints
- Particles of boards and others
- Ionic contamination
## Specifications set up

<table>
<thead>
<tr>
<th>Method of control</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optical IPC-A-610-D</td>
<td>Microscope 5-40 x</td>
</tr>
<tr>
<td>Contaminometer Mil-P-28809</td>
<td>≤ 1,56 µg Eq NaCl/cm²</td>
</tr>
<tr>
<td>Produce 600 PCBs for trials</td>
<td>Triple each results, strip comp.</td>
</tr>
</tbody>
</table>

**Type of fluxes for the trials:**

(IPC-TM-650)

- With lead, cleanable
- With lead, no clean
- Lead-free, cleanable
- Lead-free, no clean
- Taky Flux, no clean

Applied with stencil and dispensing
Specifications set up

PCBs for trials, rigid and flexible, components down to 1 mm
Cleaning products available

A. Detergents, salts, surfactants, wetting agents and water
B. Petroleum distillates, Alcohols, ketons, All class HC
C. Formulated Hydrocarbons, aliphatic, cyclo, iso-paraffins, C9-C11
   Terpens with additives, AIII Class blends
D. Bromated solvents, nPb blended with some alcohols
E. Glycols or modified alcohols, with additives and water
F. Fluorinated solvents, HFCs and HFEs, and azeotropes
Main Cleaning Processes

- Aqueous cleaning process: (Sprying) Dish washer type or sumps

![Diagram showing cleaning processes]
Main Cleaning Processes

- Aqueous cleaning process: (Sprying) Dish washer type or sumps
- Semi-aqueous process: Hydrocarbons rinsed with water
Main Cleaning Processes

- Aqueous cleaning process: (Sprying) Dish washer type or sumps
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- Vacuum cleaning process: Glycols or modified alcohols
Main Cleaning Processes

- Aqueous cleaning process: (Sprying) Dish washer type or sumps
- Semi-aqueous process: Hydrocarbons rinsed with water
- Vacuum cleaning process: Glycols or modified alcohols
- Vapour phase degreaser: HFEs, HFCs, nPb, azeotropes
Main Cleaning Processes

- Aqueous cleaning process: (Spraying) Dish washer type or sumps
- Semi-aqueous process: Hydrocarbons rinsed with water
- Vacuum cleaning process: Glycols or modified alcohols, HC
- Vapour phase degreaser: HFEs, HFCs, nPb, azeotropes
- **Mixed co-solvent process:** HC mixed with HFEs or others

Hydrocarbon mixed with HFE for Cleaning step
Main Cleaning Processes

- **Aqueous cleaning process:** (Sprying) Dish washer type or sumps
- **Semi-aqueous process:** Hydrocarbons rinsed with water
- **Vacuum cleaning process:** Glycols or modified alcohols, HC
- **Vapour phase degreaser:** HFEs, HFCs, nPb, azeotropes
- **Mised co-solvent process:** HC mised with HFEs or others
- **Separated co-solvent process:** Formulated Hydrocarbons +HFEs

Separated co-solvent

Segregated Bi co-solvent rinsed with chlorine free HFEs
The Kauri-butanol value ("Kb value") is an international, standardized measure of solvent power for a hydrocarbon solvent, and is governed by an ASTM standardized test. The result of this test is a scaleless index, usually referred to as the "Kb value". A higher Kb value means the solvent is more aggressive or active in the ability to dissolve certain materials. Mild solvents have low scores in the tens and twenties; while in the other side powerful solvents like chlorinated solvent TCE and nPBs have ratings that are within 130 - 150.
The surface tension factor

Low surface tension / high wetting power allow for deep cleaning in micro areas

DI Water | Tap Water | Detergents + Water | Cosolvent Topklean | Novec™ Promosolv™ Range

Best cleaning with lowest Surface Tension
Wetting contact angle

- $> 90^\circ$ Bad wetting $\Rightarrow$ poor penetration
- Between $45^\circ$ and $90^\circ$ Good to enough wetting $\Rightarrow$ good to enough penetration
- $< 45^\circ$ very good wetting $\Rightarrow$ good penetration
All type of technics can be very efficient when used with the right product under the good conditions
### Effects of Ultrasonics on Quartz

<table>
<thead>
<tr>
<th>Code article</th>
<th>Désignation</th>
<th>Housing</th>
</tr>
</thead>
<tbody>
<tr>
<td>129393</td>
<td>Crystal 26 MHz</td>
<td>SMD</td>
</tr>
<tr>
<td>129404</td>
<td>Crystal 3.68 MHz</td>
<td>SMD</td>
</tr>
<tr>
<td>147583</td>
<td>Crystal 3.68 MHz</td>
<td>SMD</td>
</tr>
<tr>
<td>147584</td>
<td>Crystal 32 kHz</td>
<td>SMD</td>
</tr>
<tr>
<td>127455</td>
<td>Crystal 32 KHz</td>
<td>SMD</td>
</tr>
<tr>
<td>121431</td>
<td>Crystal 32 kHz</td>
<td>Leaded comp.</td>
</tr>
<tr>
<td>126973</td>
<td>Crystal 4 MHz</td>
<td>SMD</td>
</tr>
<tr>
<td>148121</td>
<td>Crystal 7.33 MHz</td>
<td>SMD</td>
</tr>
<tr>
<td>126817</td>
<td>SELF 220UH 0.25A</td>
<td>TH Comp.</td>
</tr>
<tr>
<td>128320</td>
<td>Toroidal Step-up Transformer</td>
<td>Leaded comp.</td>
</tr>
</tbody>
</table>
Effects of ultrasonics
Effects of ultrasonics

Without ultrasonics

With ultrasonics
Picture Comparative Results

Typical Aqueous Cleaning Residues
Picture Comparative Results

Typical Semi-Aqueous Cleaning Residues
Picture Comparative Results

Typical Vacuum Cleaning Resisues
Comparative Results

Typical Solvent Vapour Degreaser Cleaning Resisues
Comparative Results

Typical
Mixed
Co-solvent
Vapour
Phase
Cleaning
Residues
Comparative Results

Typical
Separated
Co-solvent
Vapour
Phase
Cleaning
Residues
Ionic Contamination

For 23 PCBs

Immersion US 38 kHz, co-solvent sep
### Table of Results

<table>
<thead>
<tr>
<th>Cleaning process</th>
<th>Product Family</th>
<th>Equipment type</th>
<th>Comparative Scale 1:10 best</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspersion, aqueous</td>
<td>Detergent 1</td>
<td>Dish washer type</td>
<td>4</td>
</tr>
<tr>
<td>Immersion US 40 kHz, aqueous</td>
<td>Detergent 2</td>
<td>Sumps in line</td>
<td>1</td>
</tr>
<tr>
<td>Immersion jets, semi-aqueous</td>
<td>Glycol formulation 3</td>
<td>Sumps in line</td>
<td>3</td>
</tr>
<tr>
<td>Immersion US 40 kHz, semi-aqueous</td>
<td>Glycol formulation 3</td>
<td>Sumps in line</td>
<td>7</td>
</tr>
<tr>
<td>Immersion US 30 kHz, mono-product</td>
<td>Glycol formulation 4</td>
<td>Vacuum machine</td>
<td>7</td>
</tr>
<tr>
<td>Immersion US 40 kHz, semi-aqueous</td>
<td>Glycol formulation 5</td>
<td>Sumps in line</td>
<td>1</td>
</tr>
<tr>
<td>Immersion, co-solvent mixed</td>
<td>Form hydrocar/HFE</td>
<td>Vapor degreaser</td>
<td>4</td>
</tr>
<tr>
<td>Immersion, co-solvent mixed</td>
<td>Form hydrocar70/HFE</td>
<td>Vapor degreaser</td>
<td>2</td>
</tr>
<tr>
<td>Immersion US 25 kHz, co-solvent sep</td>
<td>Form hydrocar/HFE</td>
<td>Co-solvent/vapour degreaser</td>
<td>9</td>
</tr>
<tr>
<td>Immersion US 38 kHz, co-solvent sep</td>
<td>Form hydrocar/HFE</td>
<td>Co-solvent/ vapour degreaser</td>
<td>9</td>
</tr>
<tr>
<td>Immersion Jets, co-solvent separated</td>
<td>Form hydrocar/HFE</td>
<td>Co-solvent/vapour degreaser</td>
<td>8</td>
</tr>
<tr>
<td>Immersion US 40 kHz, vapour phase</td>
<td>Brominated solvent</td>
<td>Vapour phase</td>
<td>4</td>
</tr>
</tbody>
</table>

Above 8, the results are outstanding and fulfilling Medical customers’ requirements
### IPC, PCBs cleaning Costs

<table>
<thead>
<tr>
<th>Process</th>
<th>Throughput Parts/h</th>
<th>Equipment Euro k€</th>
<th>Capital Costs k€ Acc/Space/Fill</th>
<th>Annual Costs K€ / Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aqueous</td>
<td>~ 100</td>
<td>150</td>
<td>35</td>
<td>150</td>
</tr>
<tr>
<td>Aqueous Spray-in-air</td>
<td>~ 50</td>
<td>30</td>
<td>17</td>
<td>21</td>
</tr>
<tr>
<td>Semi-aqueous</td>
<td>~ 100</td>
<td>170</td>
<td>40</td>
<td>130</td>
</tr>
<tr>
<td>Hybrid</td>
<td>~ 100</td>
<td>170</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td>Vacuum</td>
<td>~ 30</td>
<td>140</td>
<td>25</td>
<td>80</td>
</tr>
<tr>
<td>Co-solvent</td>
<td>~ 100</td>
<td>60</td>
<td>25</td>
<td>23</td>
</tr>
<tr>
<td>Solvent</td>
<td>~ 100</td>
<td>50</td>
<td>20</td>
<td>16</td>
</tr>
</tbody>
</table>

These results are averages of at least 5 years of experience
Boards are of 100 x 150mm
Conclusions

- Miniaturization has a direct impact on cleanability
- No clean fluxes and Lead-free soldering impact cleanliness
- The Surface tension parameter should be understood and considered prior to implementation of the cleaning process
- Any cleaning process must have a mechanical agitation
- The ultrasonics effects on Quartz (Crystal oscillators) were evaluated, and no damage has been observed so far.
- The separated Co-solvent used with HFE azeotrope showed the best cleaning result vs the others.
- Jets under immersion with Co-solvent/HFEs provide excellent results but ultrasonics with Co-solvent provide outstanding results.
- High optical quality and very low ionic contamination were achieved with Co-solvent cleaning.
Thanks!