Details are important

How can the designer help to make cleaning assemblies easy?

Vladimir Sitko
Founder, menthor of PBT Works s.r.o.

PBT Works s.r.o.

pbt Works 30 years | since 1992

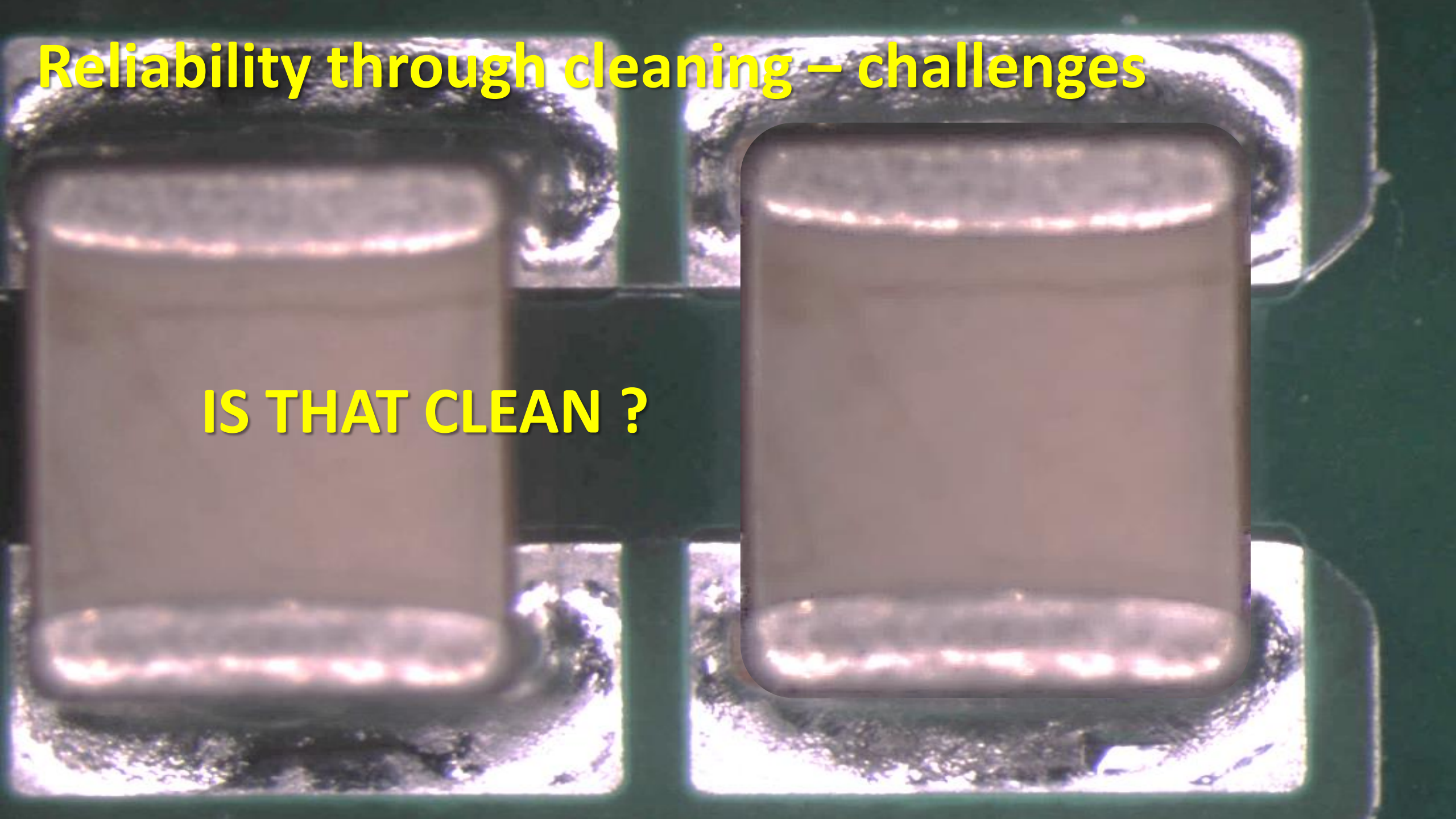
Cleaning machines for electronic assemblies

+

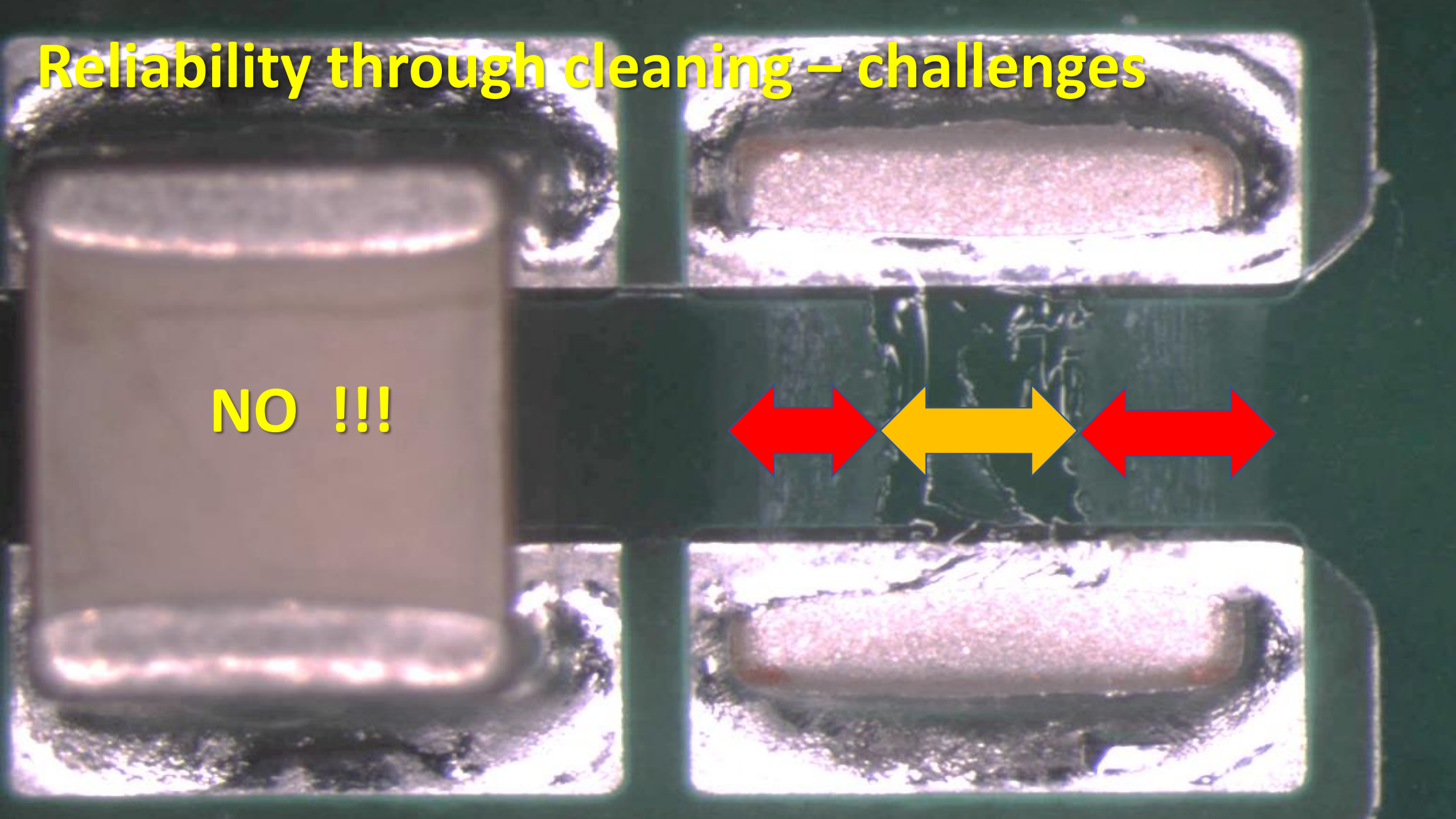
30 years experience in cleaning for reliability


TESLA
Town of Rožnov - Czechia
Electronics production since 1948
Tesla Rožnov had 8500 employees until 1990

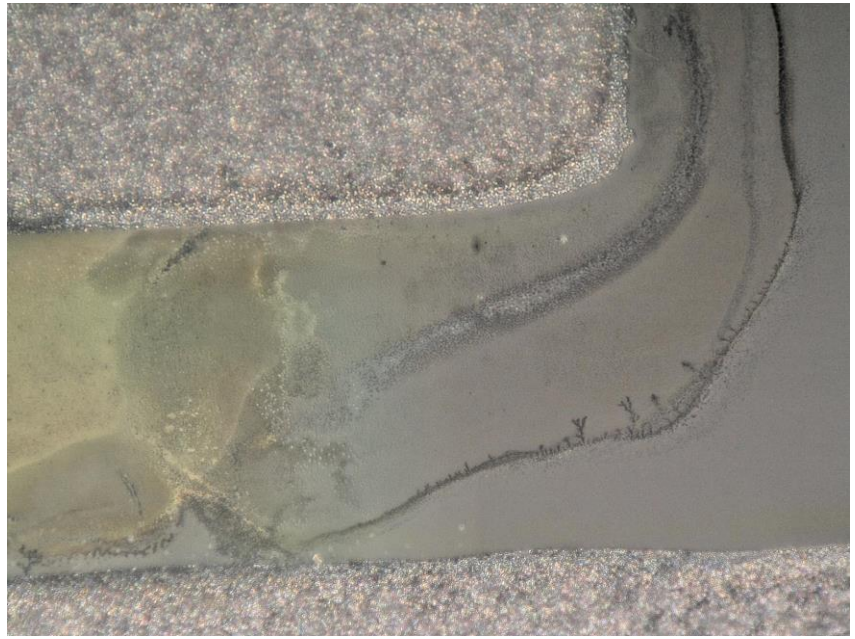
Reliability through cleaning – challenges



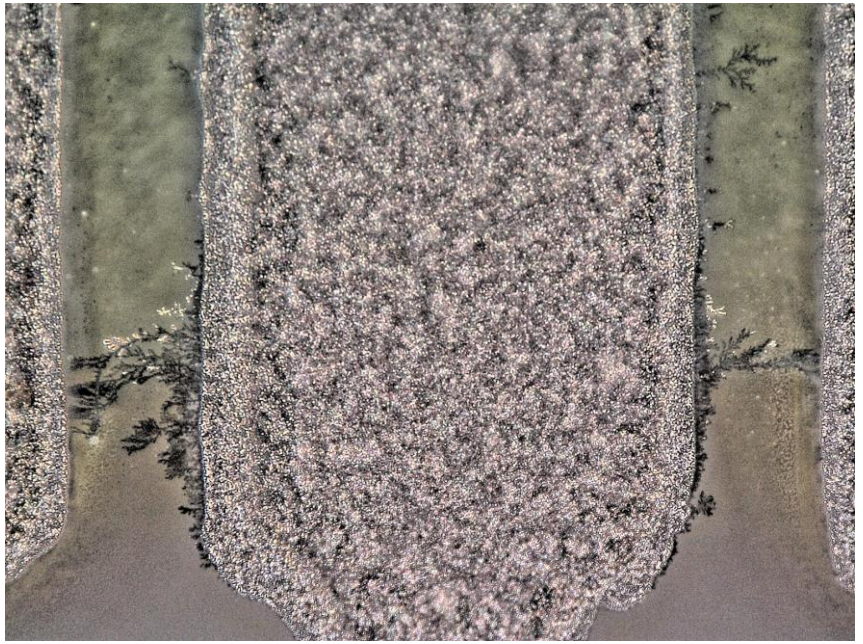
Reliability through cleaning – challenges



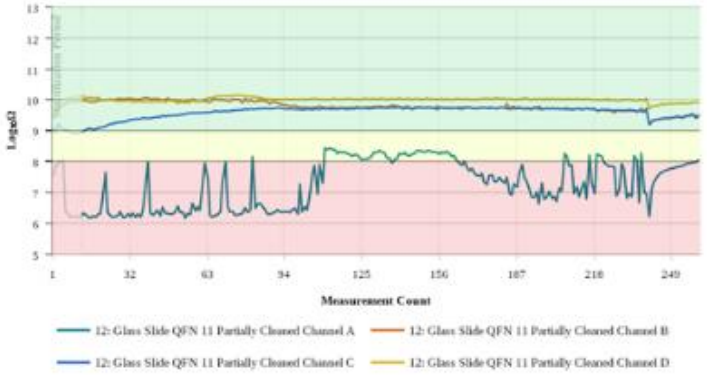
Consequences of uncomplete cleaning



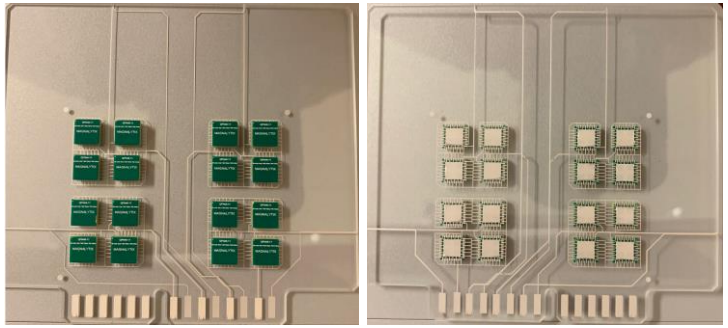
Leakage current

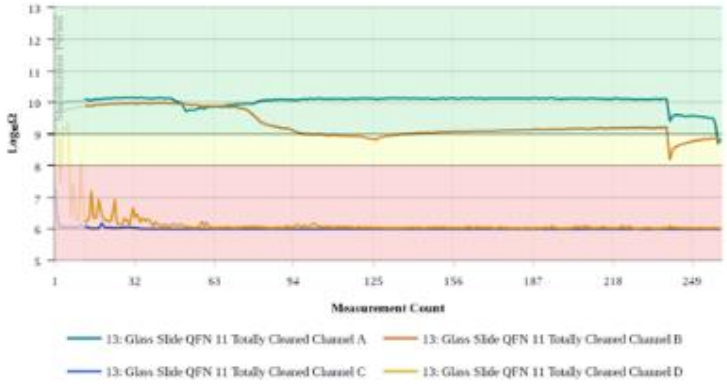


Shortage by dendrite

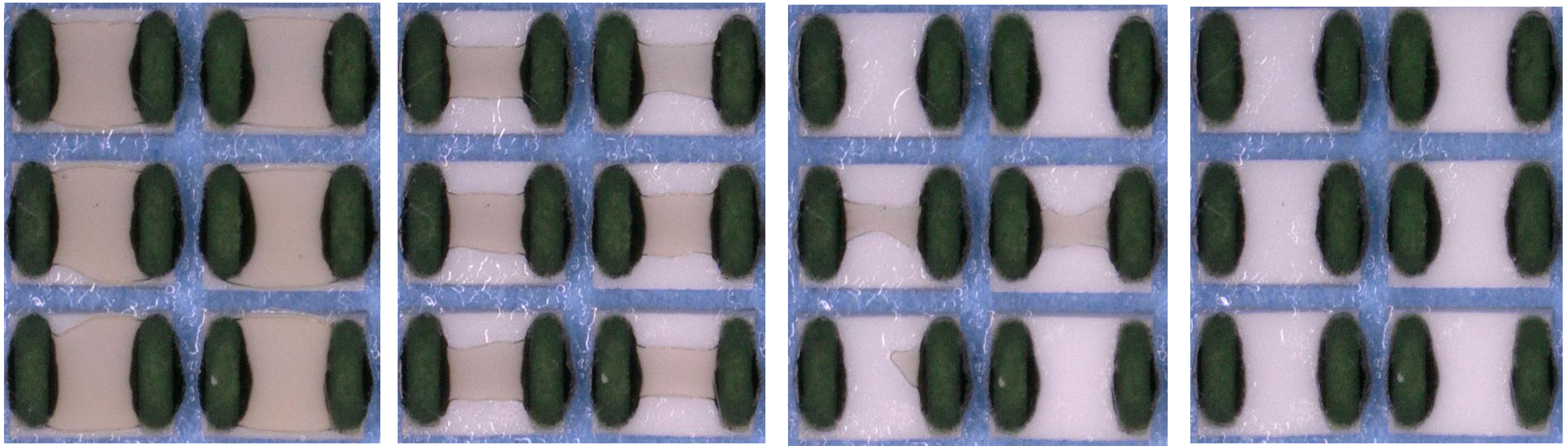


Pictures made by MAGNALYTICS inc.
Glass test boards by PBT Works s.r.o.





Typical progress in washing the gap



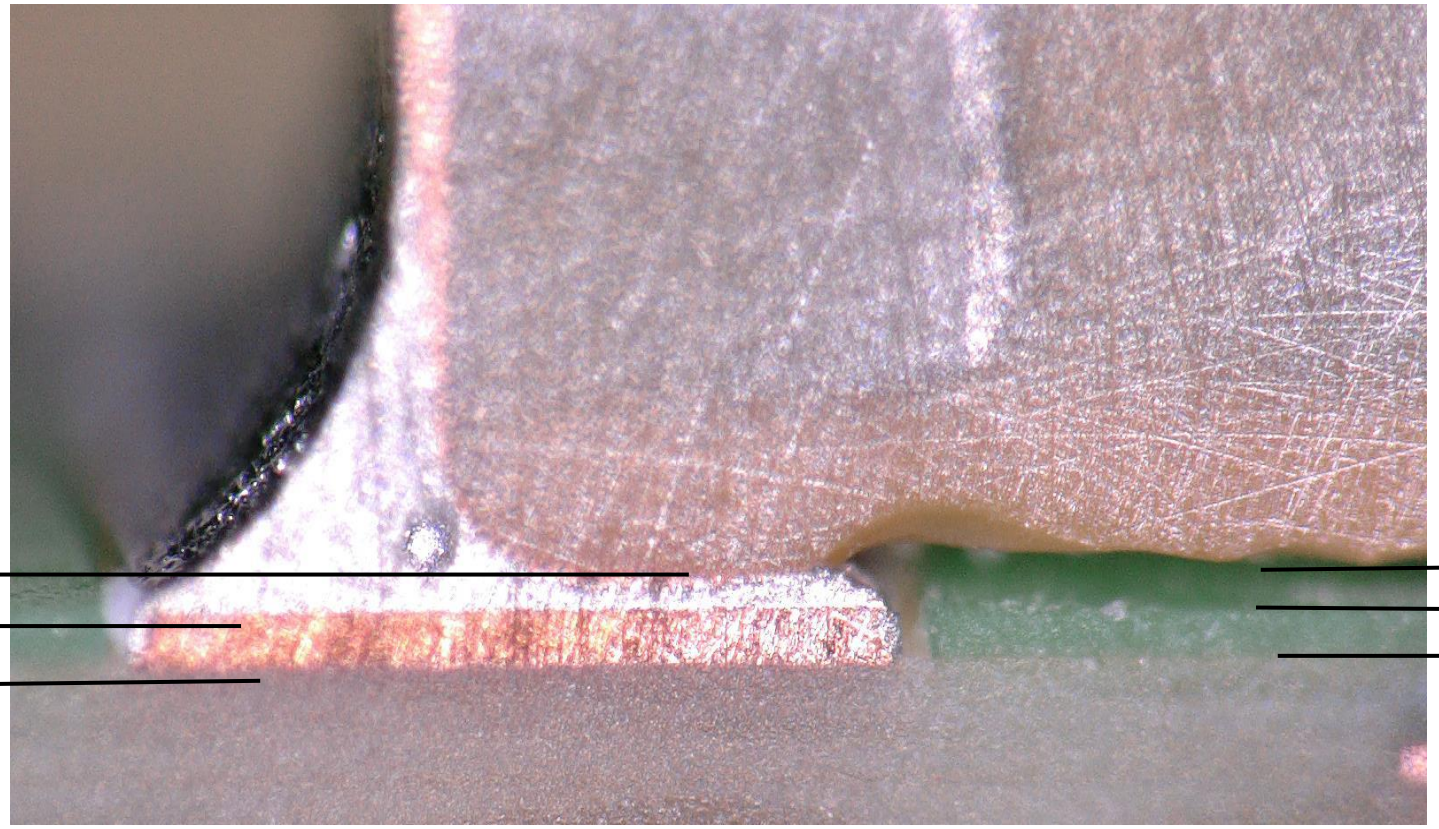
Typically, gaps are 100% filled with flux residues

Spray-in-air technology – direct spray against the surface

Washing speed factors:

- Solubility flux/ cleaner
- Temperature, flow/ pressure, concentration, saturation (NVR), alkaline reserve
- **Gap geometry** – kinetic energy transfer efficiency.

Gap size under component is essential

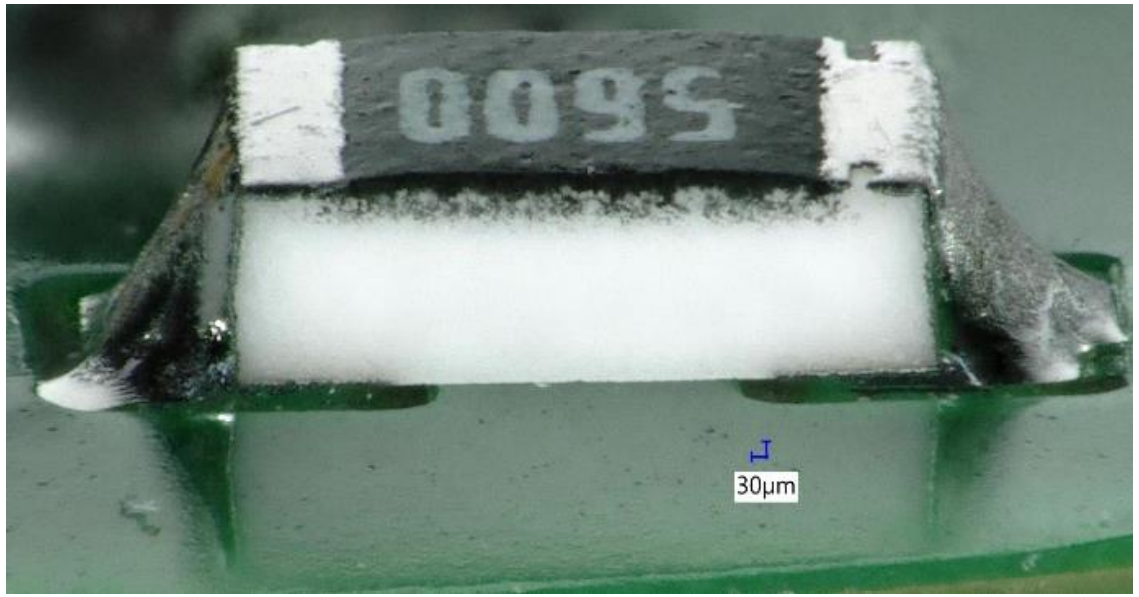


Pad thickness ≥ Solder mask thickness

Solder thickness ≈ Printed solder thickness /2 - reduction by weight of the component

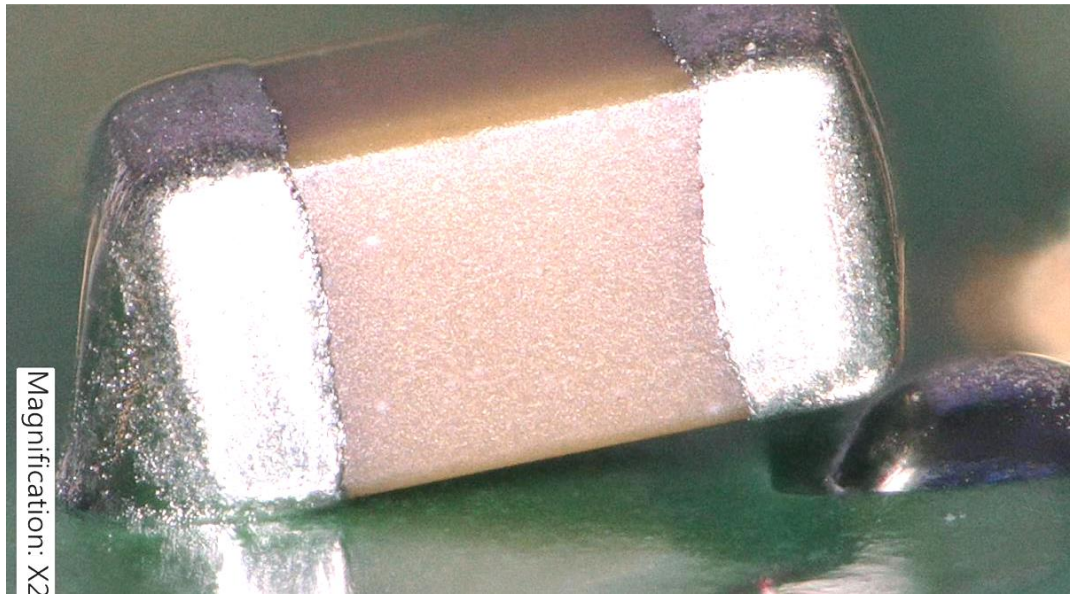
Ceramic and metal housings reduce solder thickness

Too thick solder mask



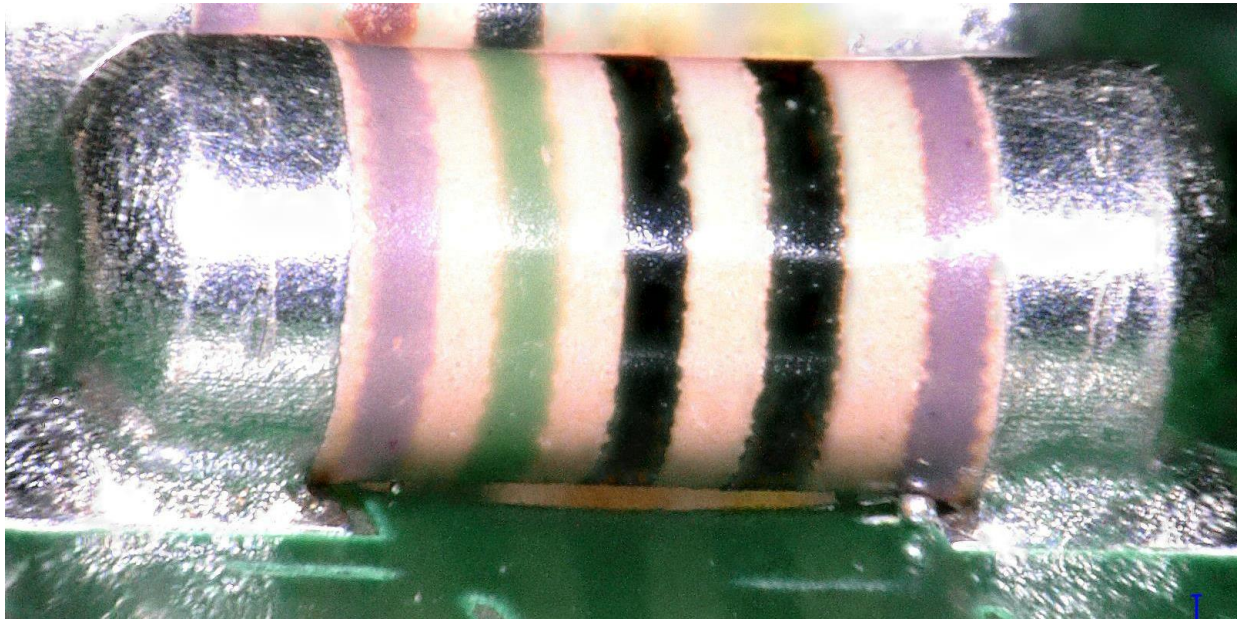
Gap reduced to zero !

Not cleanable with any process !

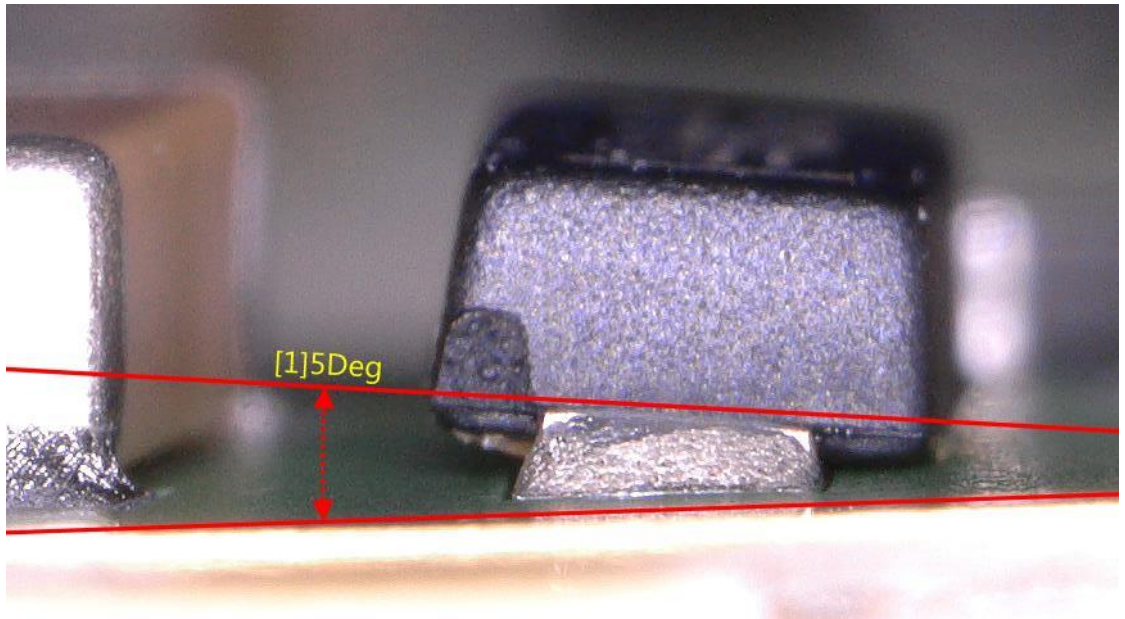


Tombstone caused by too thick solder mask

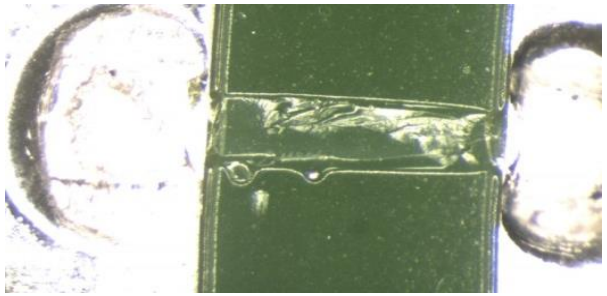
Reduced solder thickness



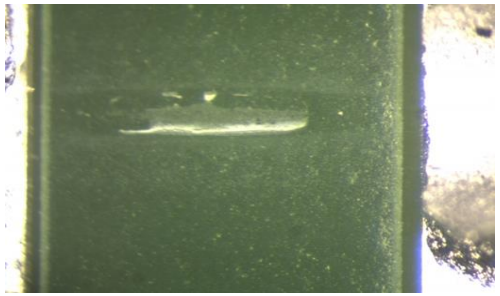
Rounded terminals are critical
– package „ dives“ more deeply into the solder



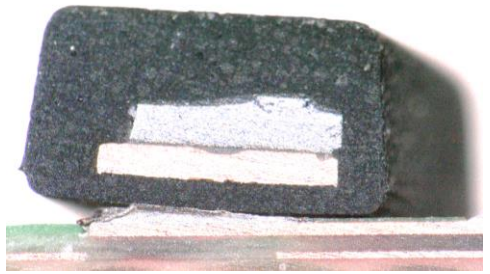
Tilted SOD123FL – package not astable due to narrow terminal and high point of gravity



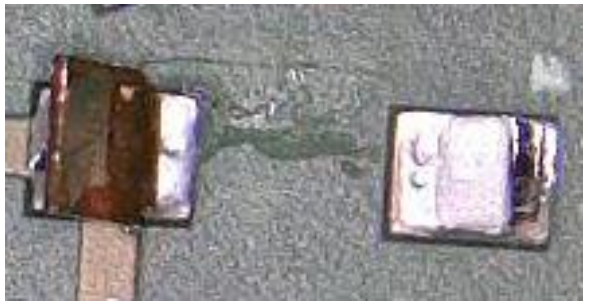
Before cleaning



After cleaning

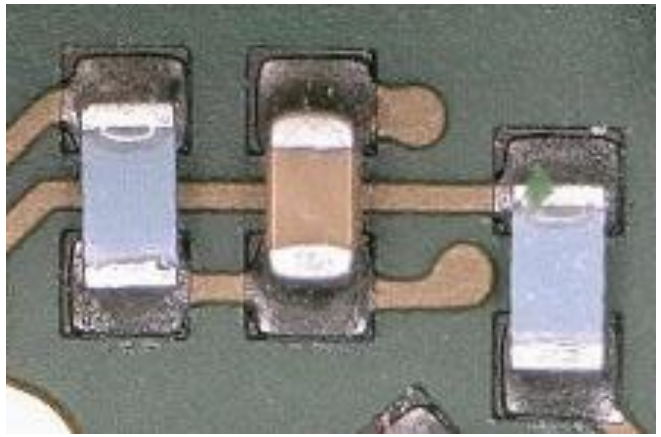


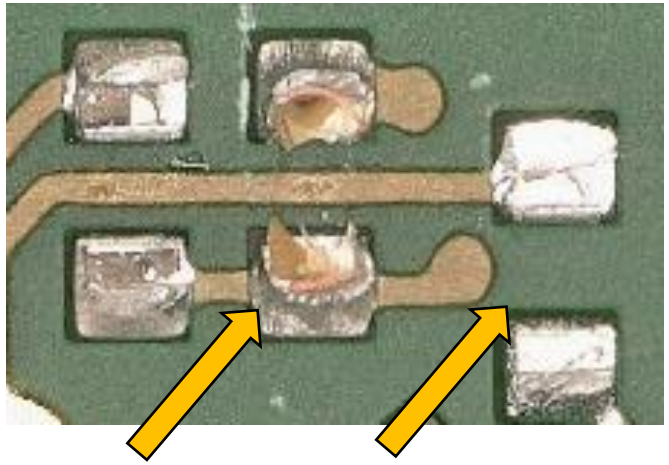
Gap reduced to < 10um



After cleaning

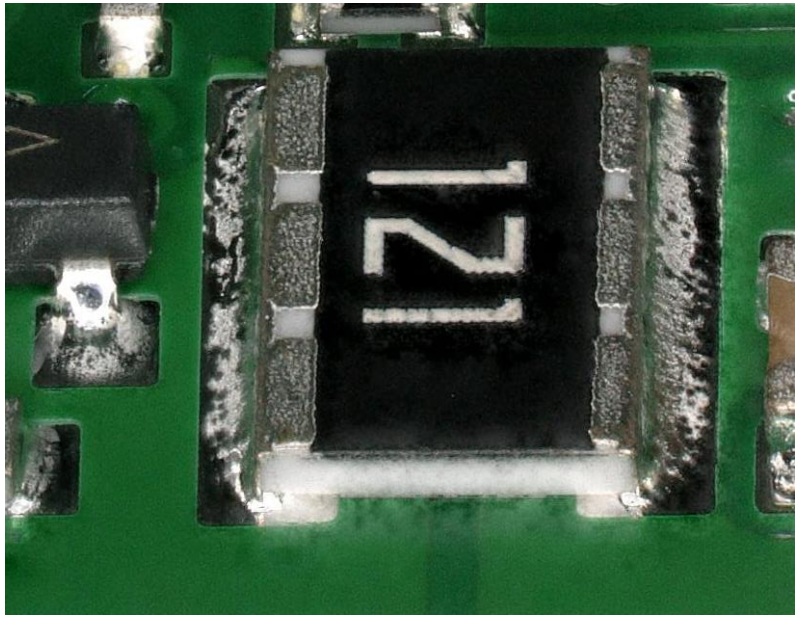
Design induced obstacles



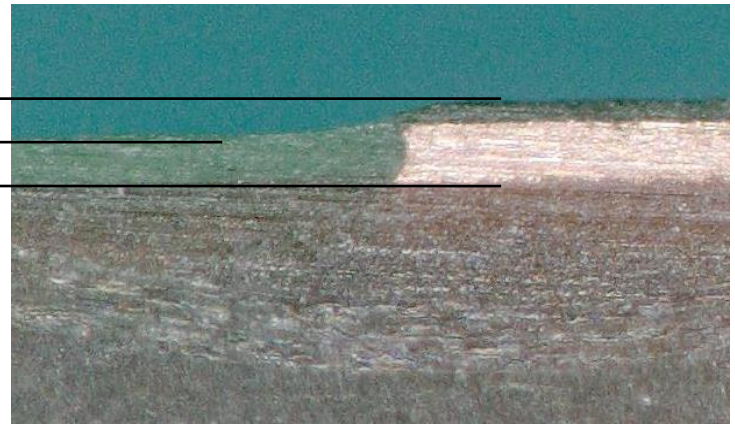


50 min to clean

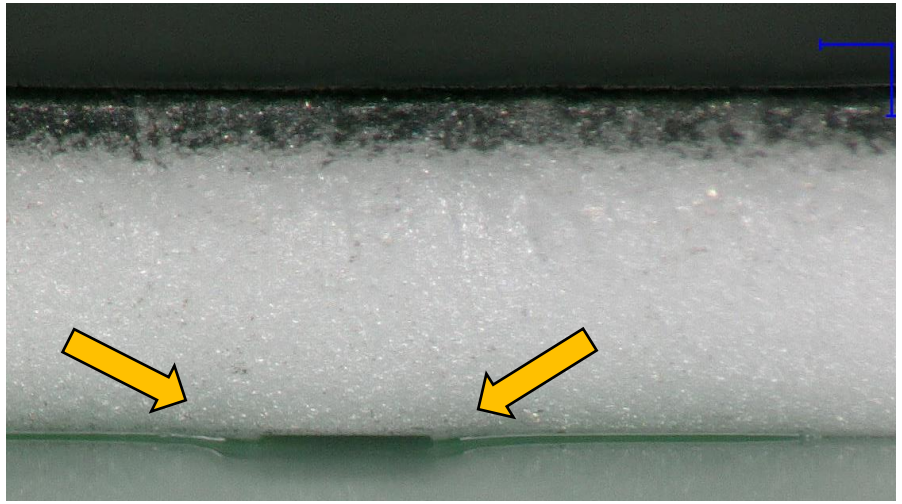
20 min to clean



1,5 – 2x
Solder mask
thickness.

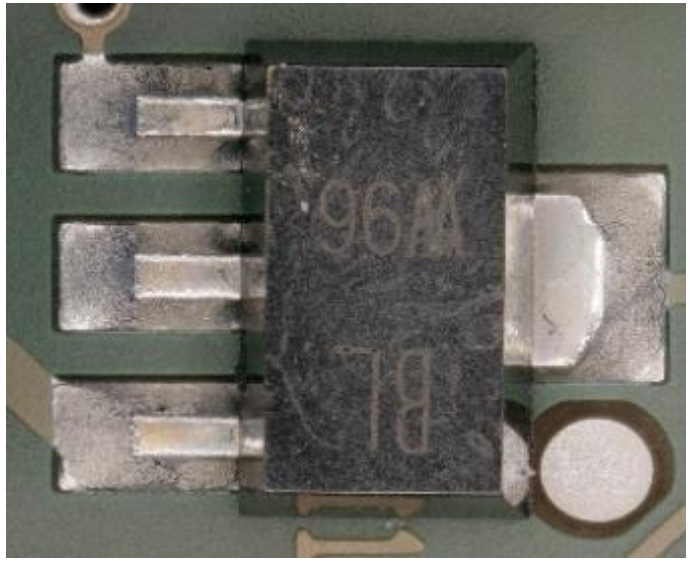


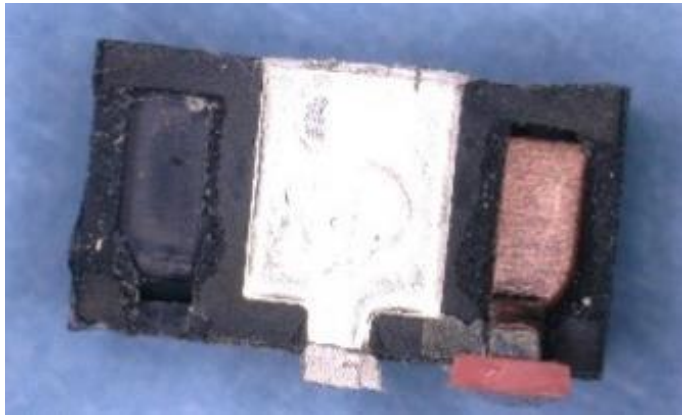
Line under component makes cleaning difficult.



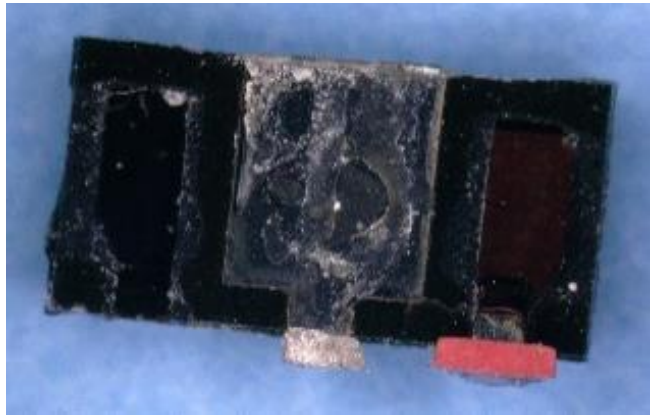
Total reduction of gap by two broad lines.

Design failure – pads do not match with component terminals

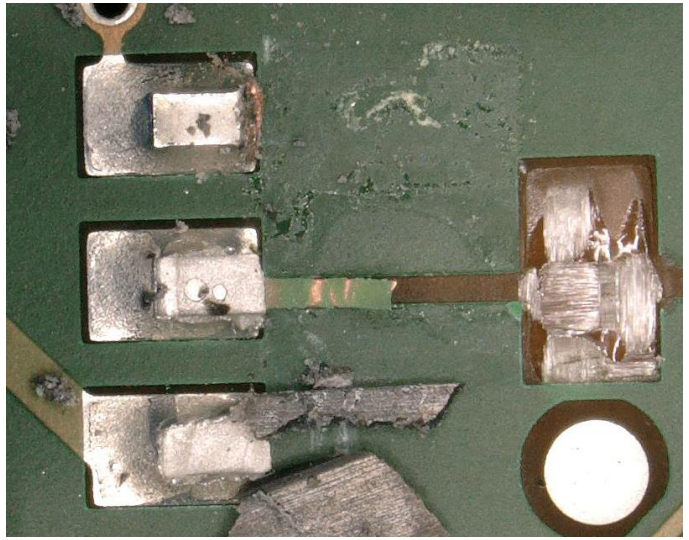


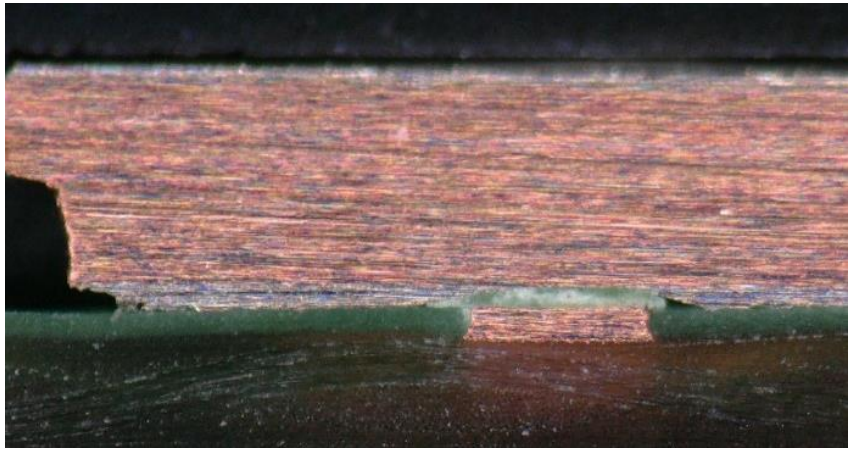


Bottom of SOT223



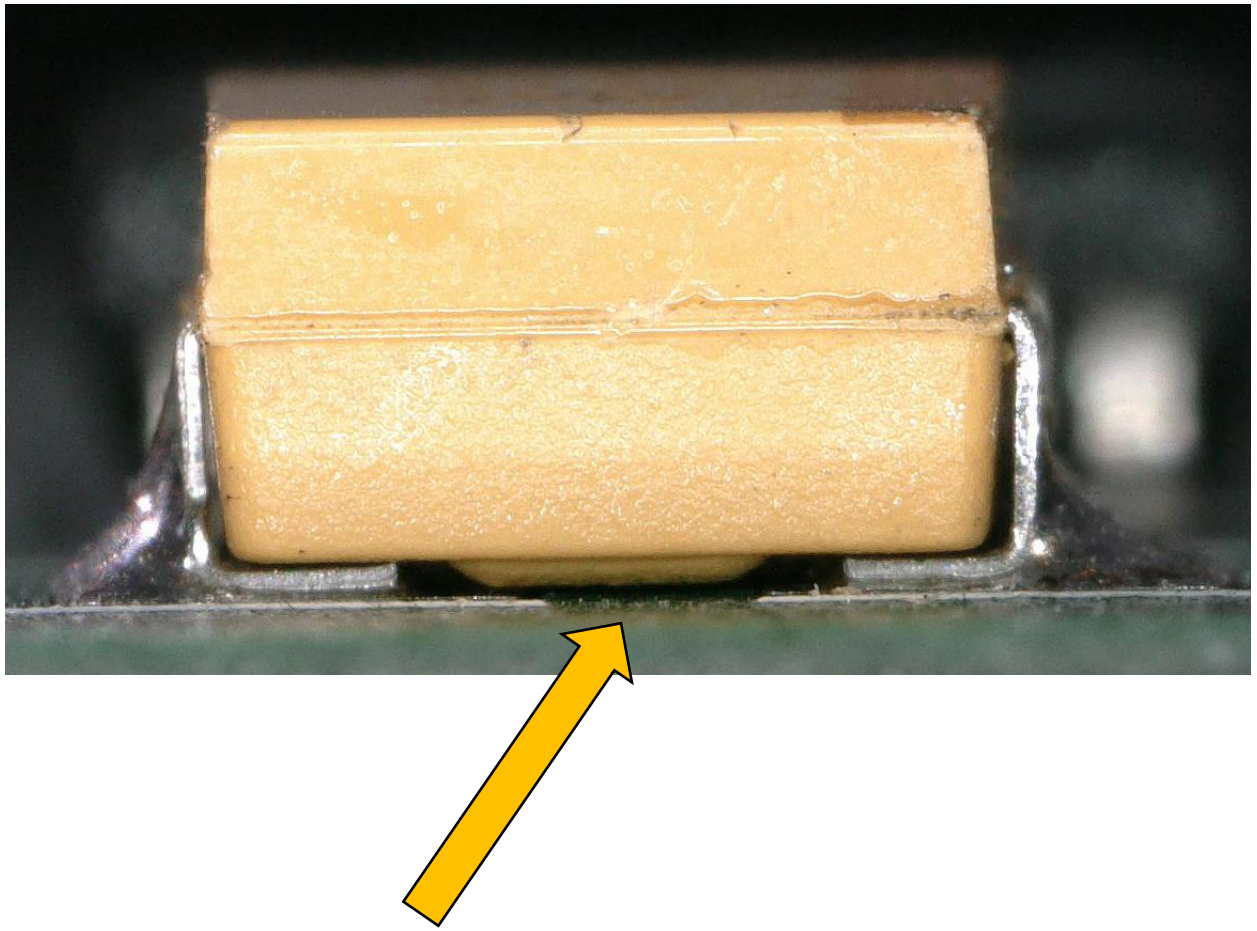
In polarised light – flux residues



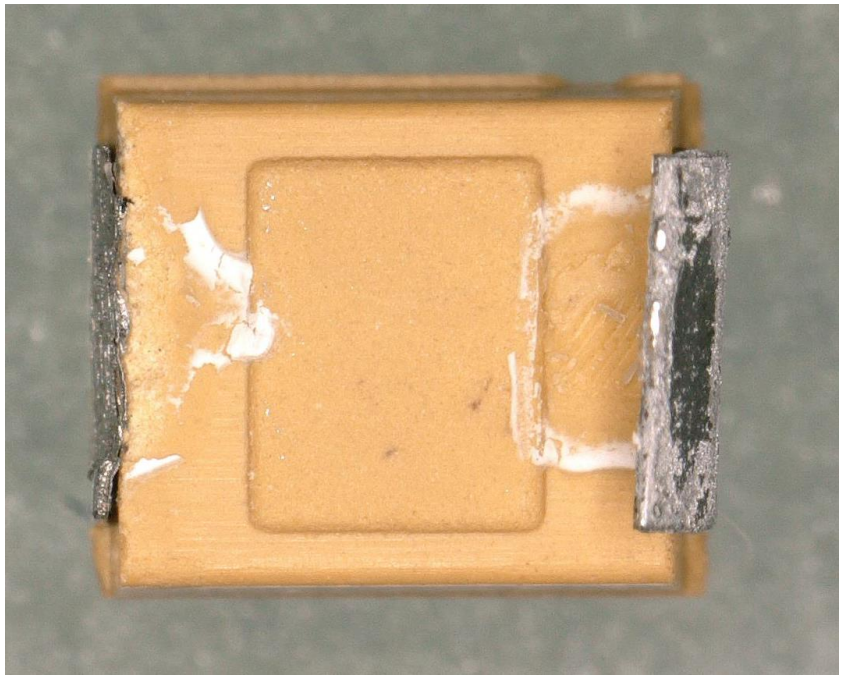


Solder wicks along the lug, but does not wett the solder mask

Cleaning obstacles on the package



Protrusion for assembly by SMT glue
Today, mostly not needed.
Lowers the gap for 80% !

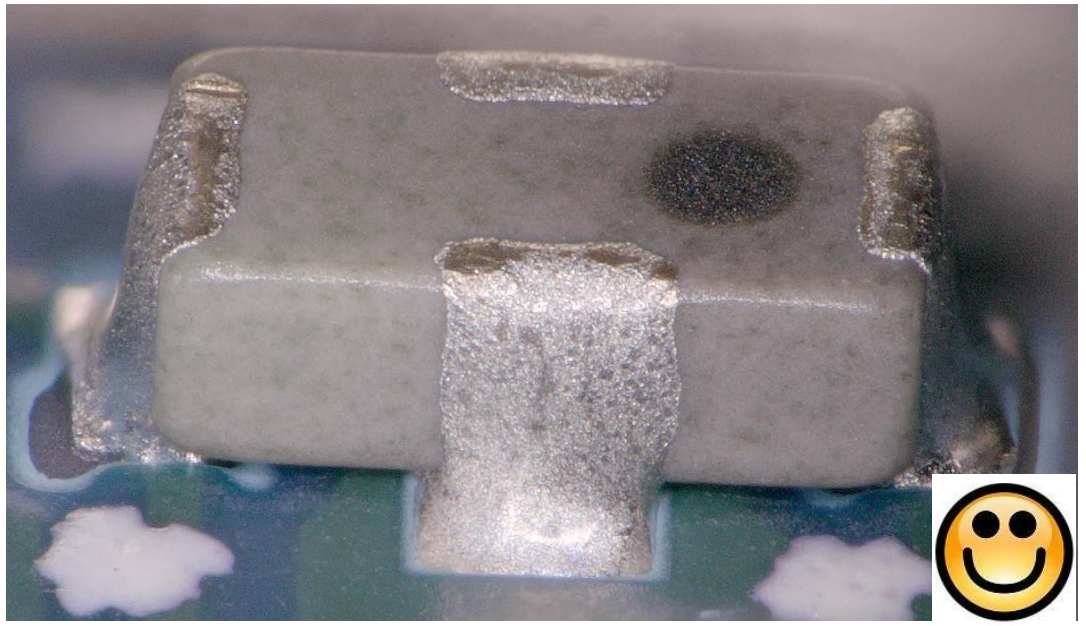


Gap between terminal and bottom
<10um - difficult to clean

For smaller tantalum capacitors with continuous flux spot between poles
- challenge for cleaning

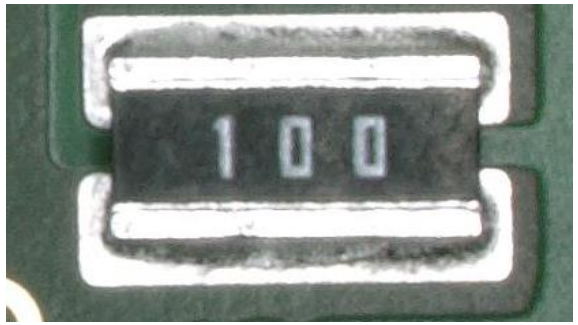
Capacitors with central side terminal

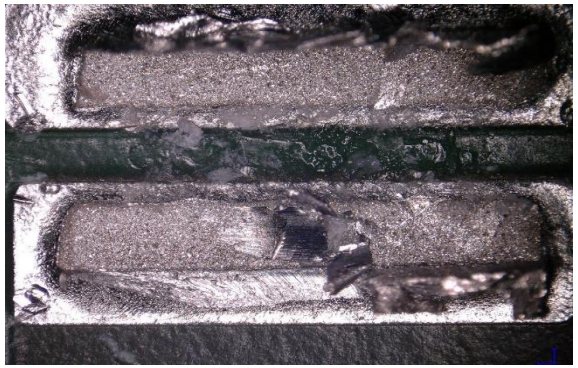
Challenged for cleaning

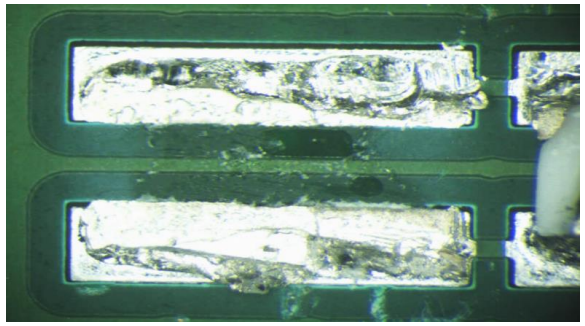


Good for cleaning !

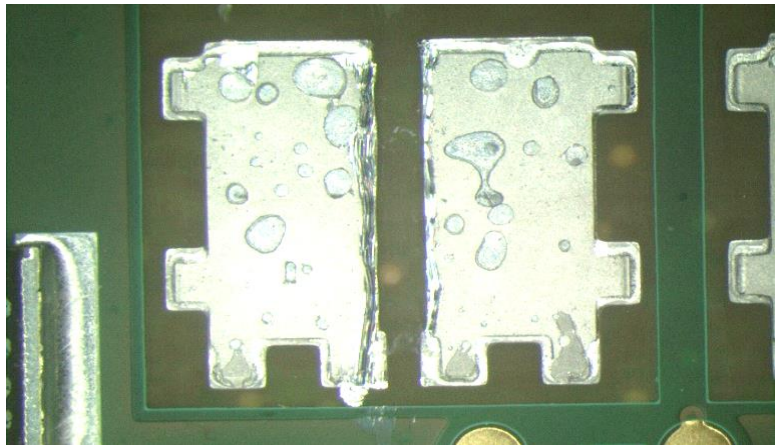
Reverse format chips



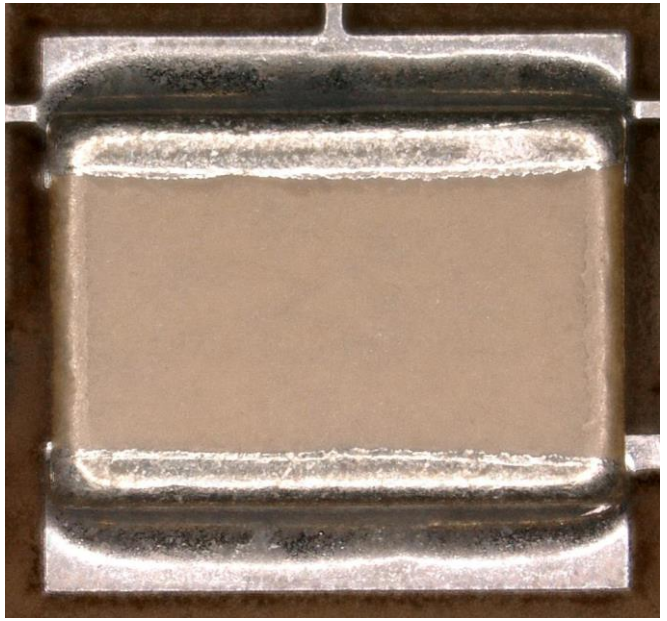


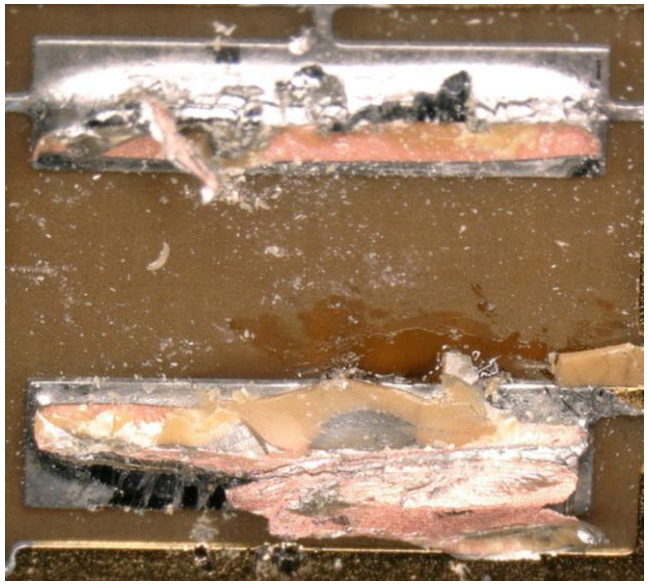


Reverse geometry combined with the line under the chip



Skipping solder mask can help…

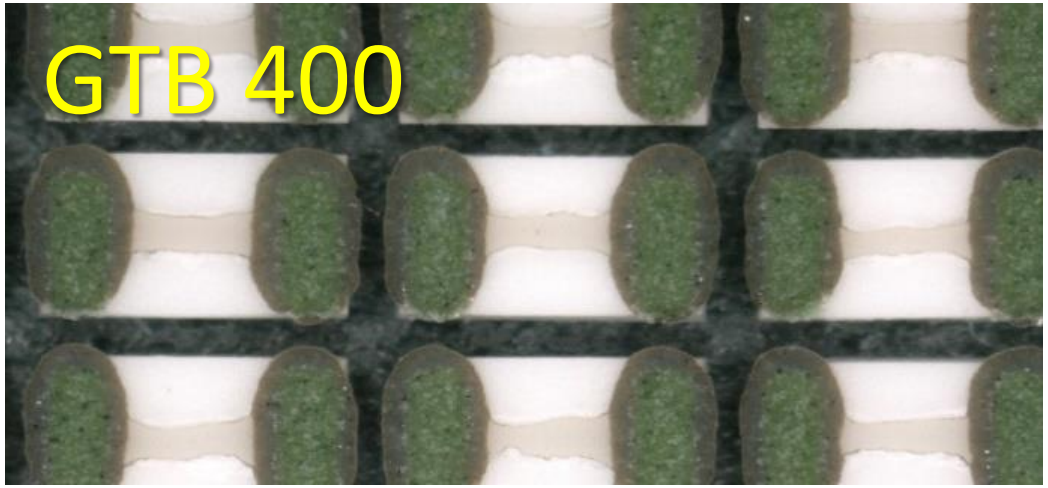


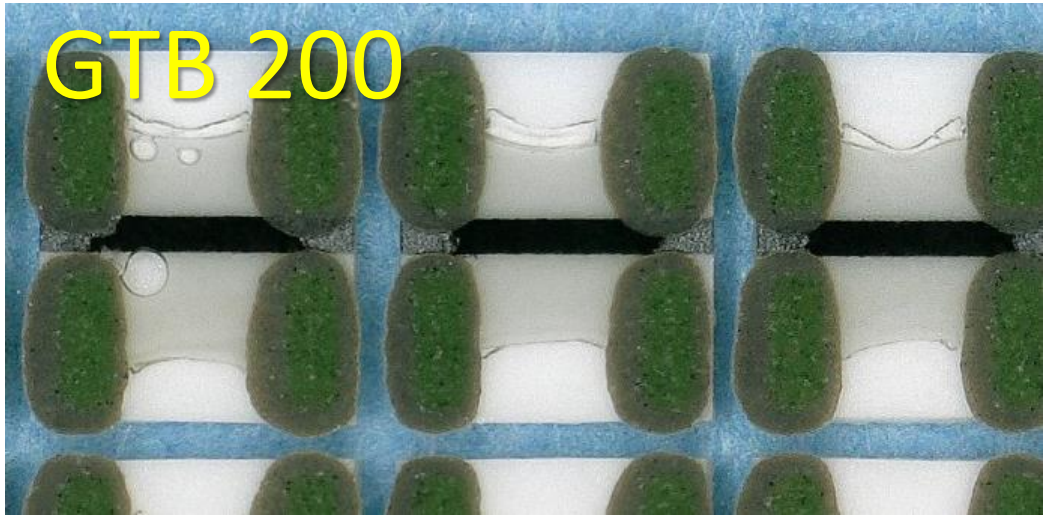


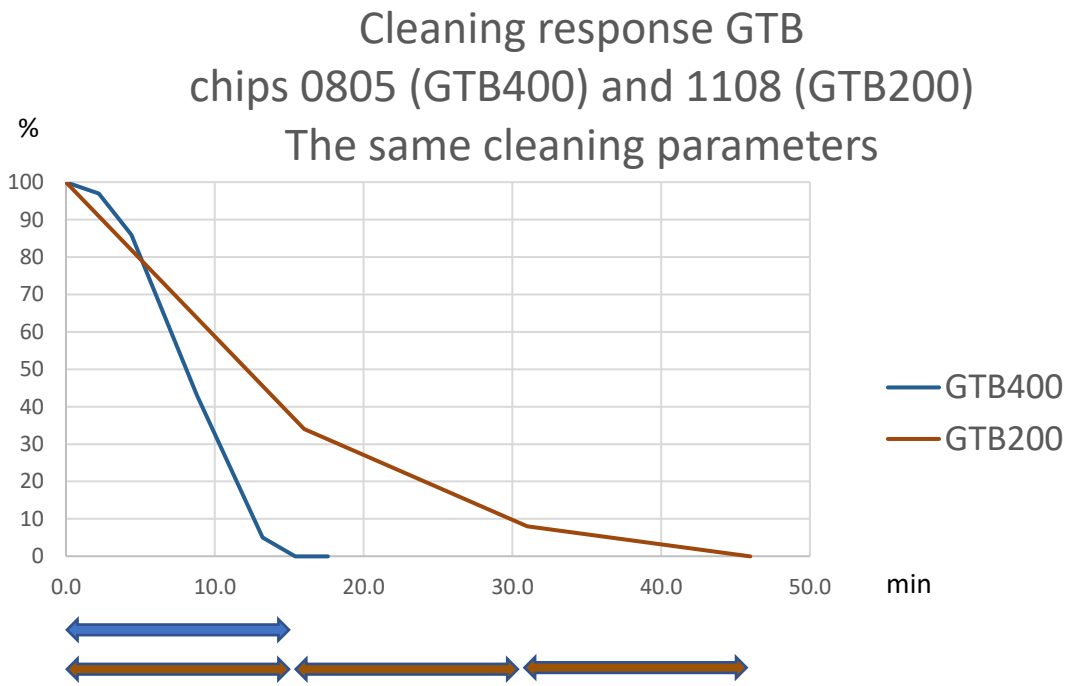
…but, not at all circumstances

Shape of the gap is important

- Simulation on glass test boards



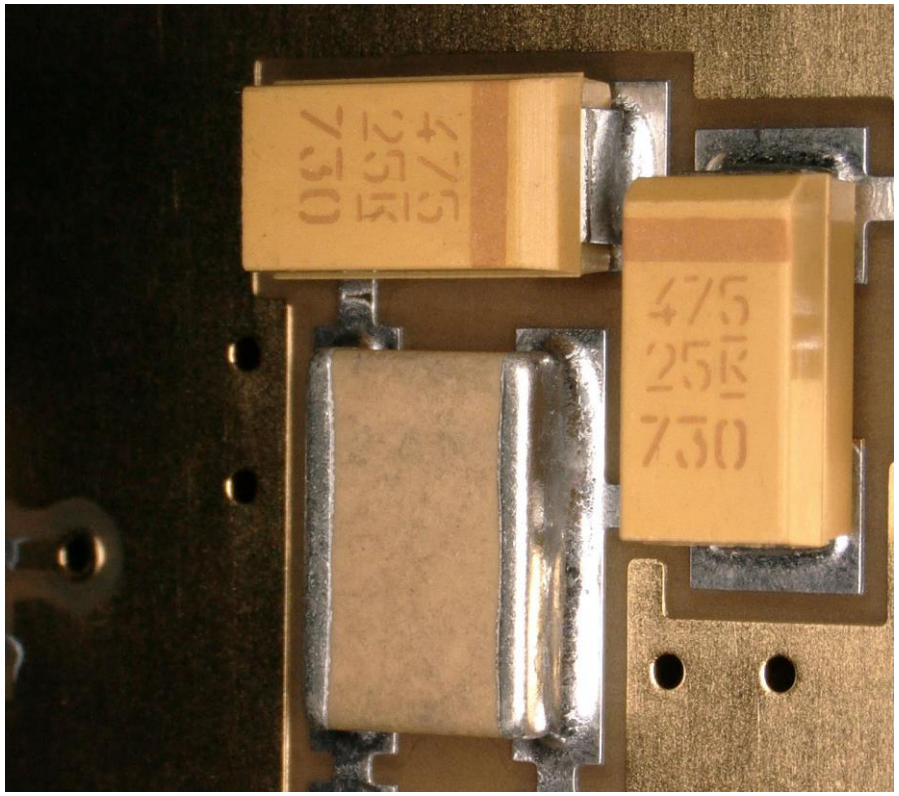


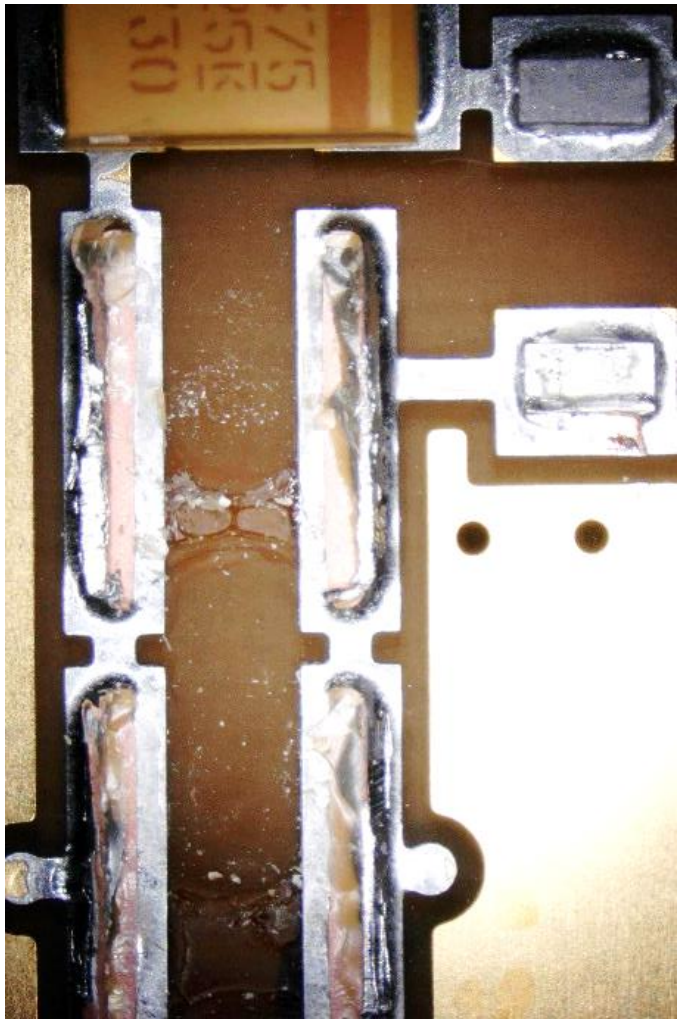


The same thickness of the gap
The same width of the gap

2x longer gap
3x longer cleaning time needed !

Shadowing by components





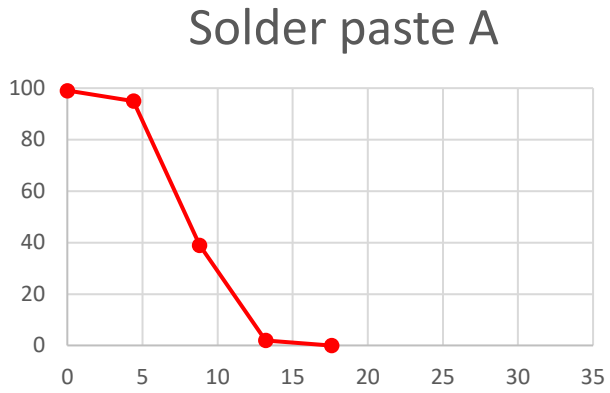
Components placed closely together reflect some portion of the spray beam by the top side of the package.

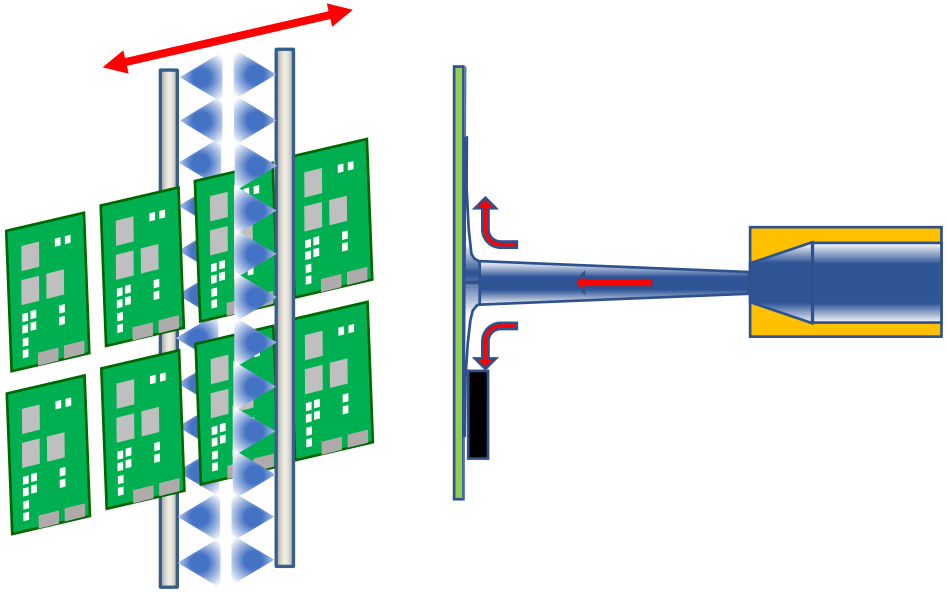
This energy is missing for cleaning the gap.

Cleaning such configuration takes much longer

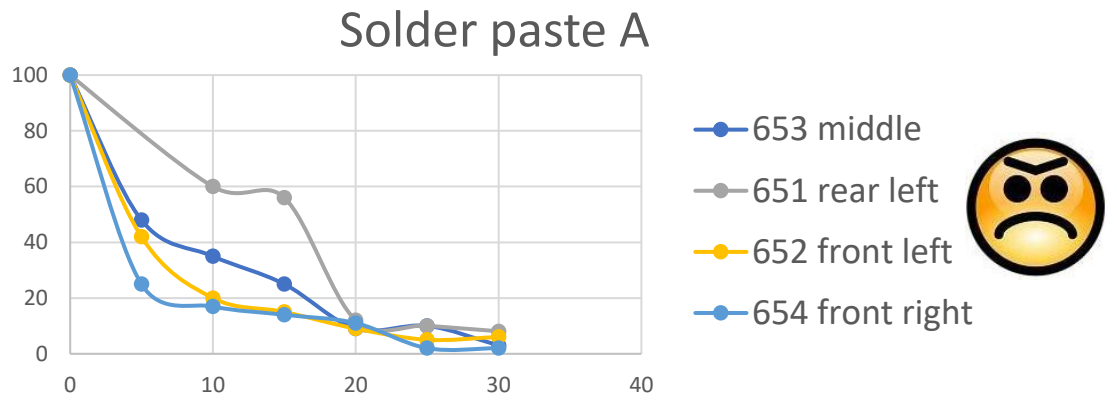
The shadowing effect can be suppressed

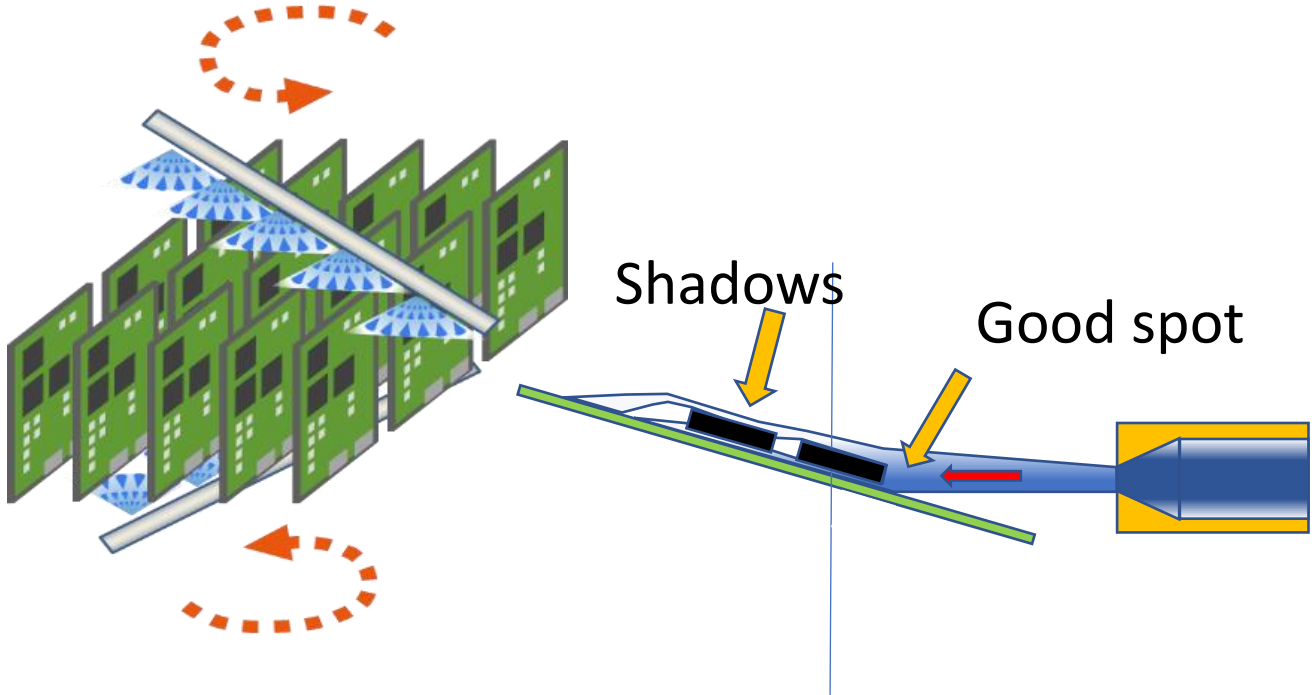
Direct spray against surface
– bidirectional (cleaning progress on the GTB)



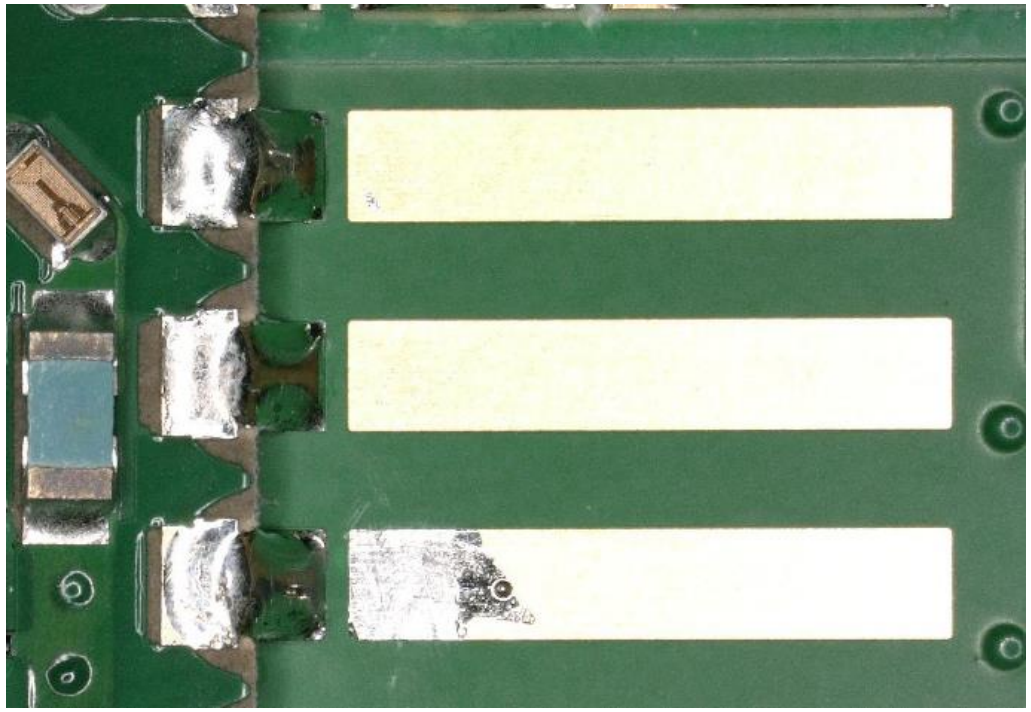


Tangential spray
– single direction spray (cleaning progress on the GTB)

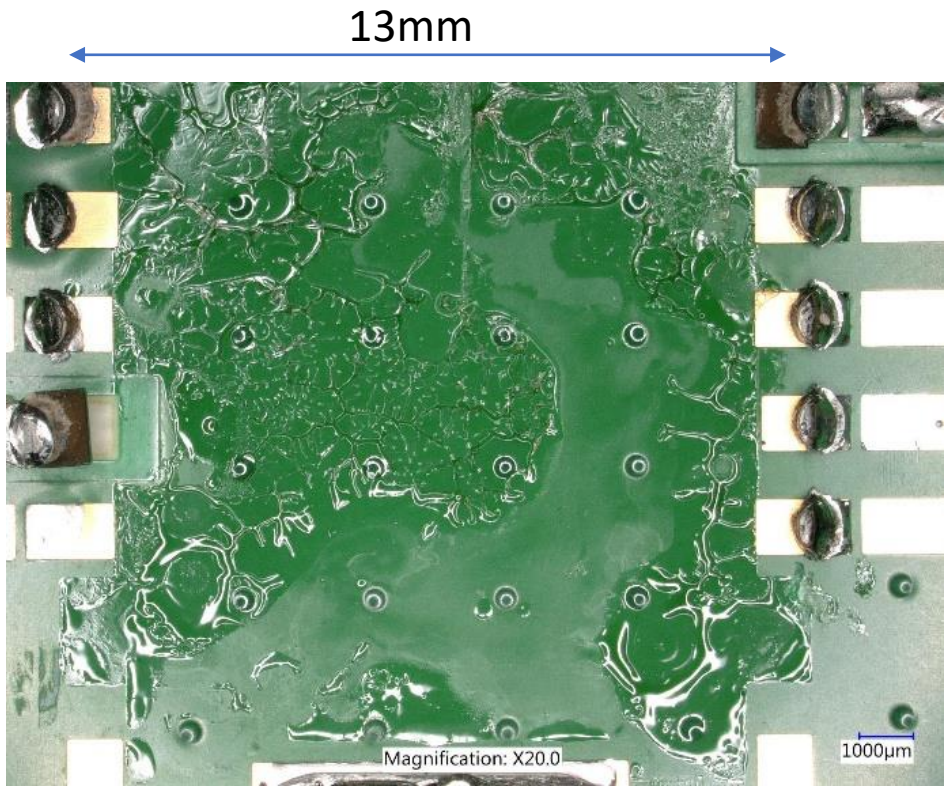




Large area gaps – doughter boards (modules)

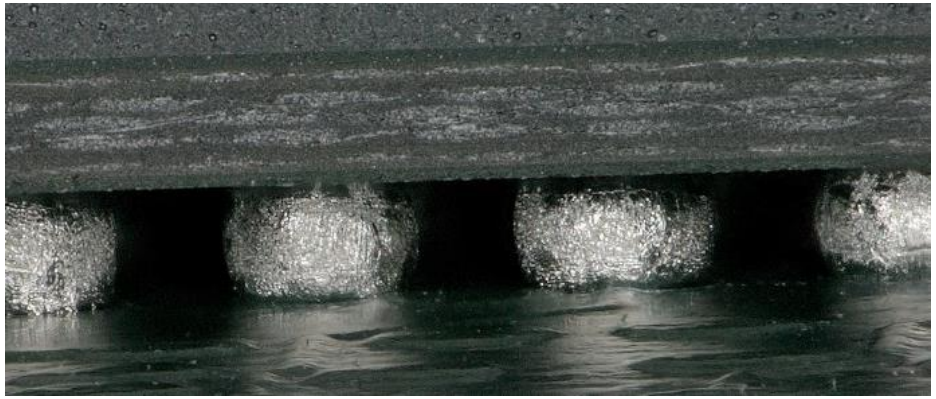


Minimum gap size for daughter board
Our experience:
gap - 5% of the largest dimension

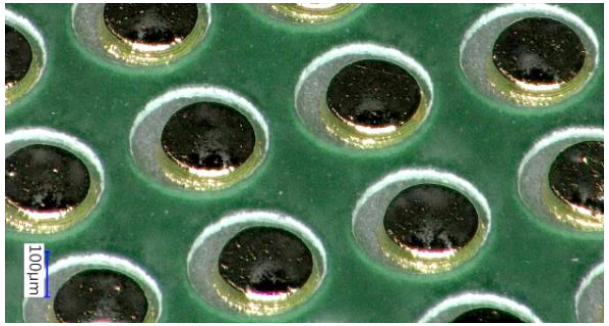


Result of too small gap height
Daughter board size 13mm, gap 60um

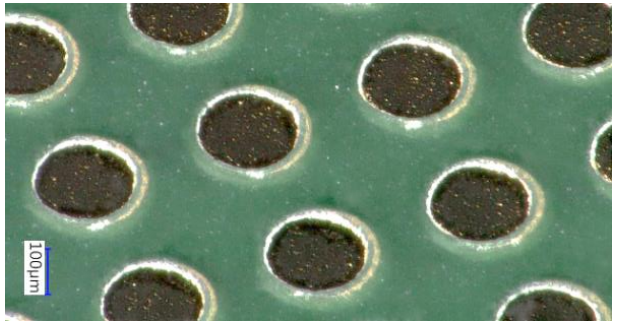
BGA, CSP, flip – chip



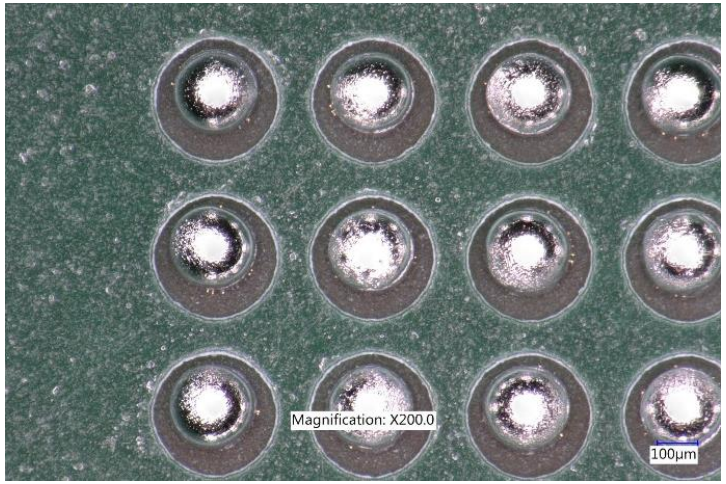
BGA does not compromise cleaning



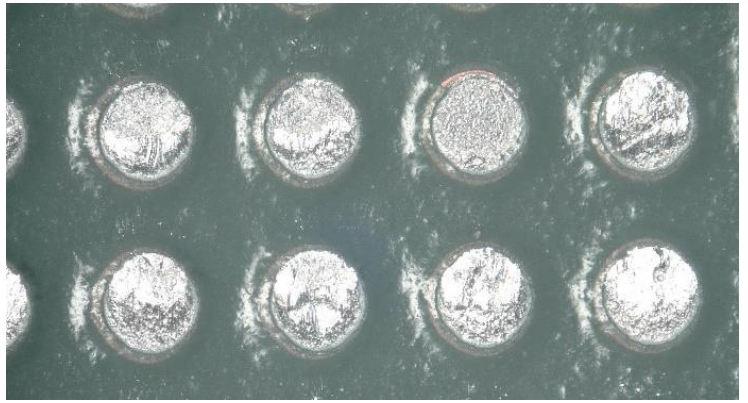
NSMDP - non solder mask defined pad



SMDP - solder mask defined pad

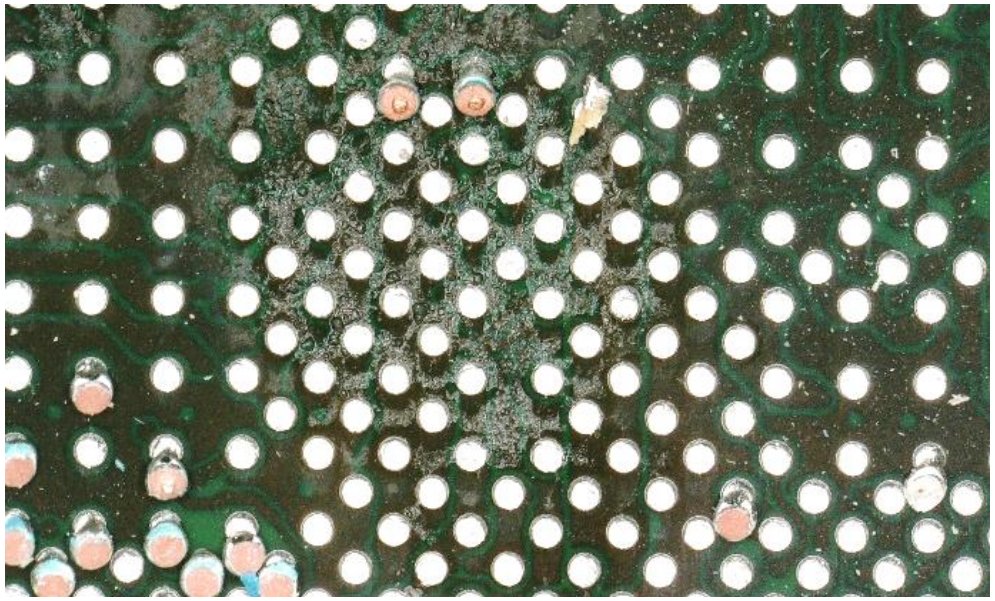


CSP cleaned – ball size 150um

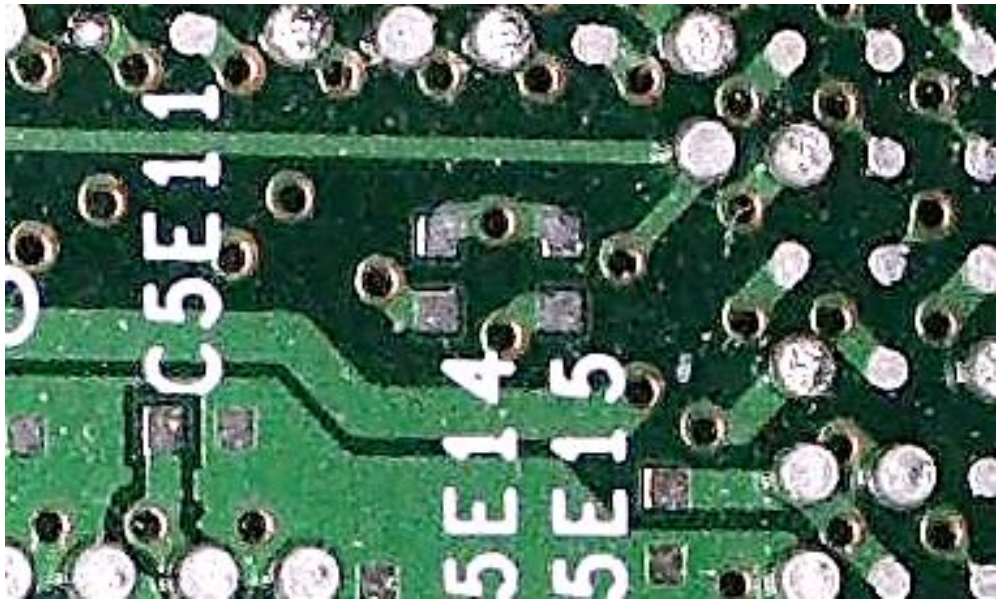


SMDP helps to lift the chip.
It makes cleaning easier

BGA with irregular ball matrix



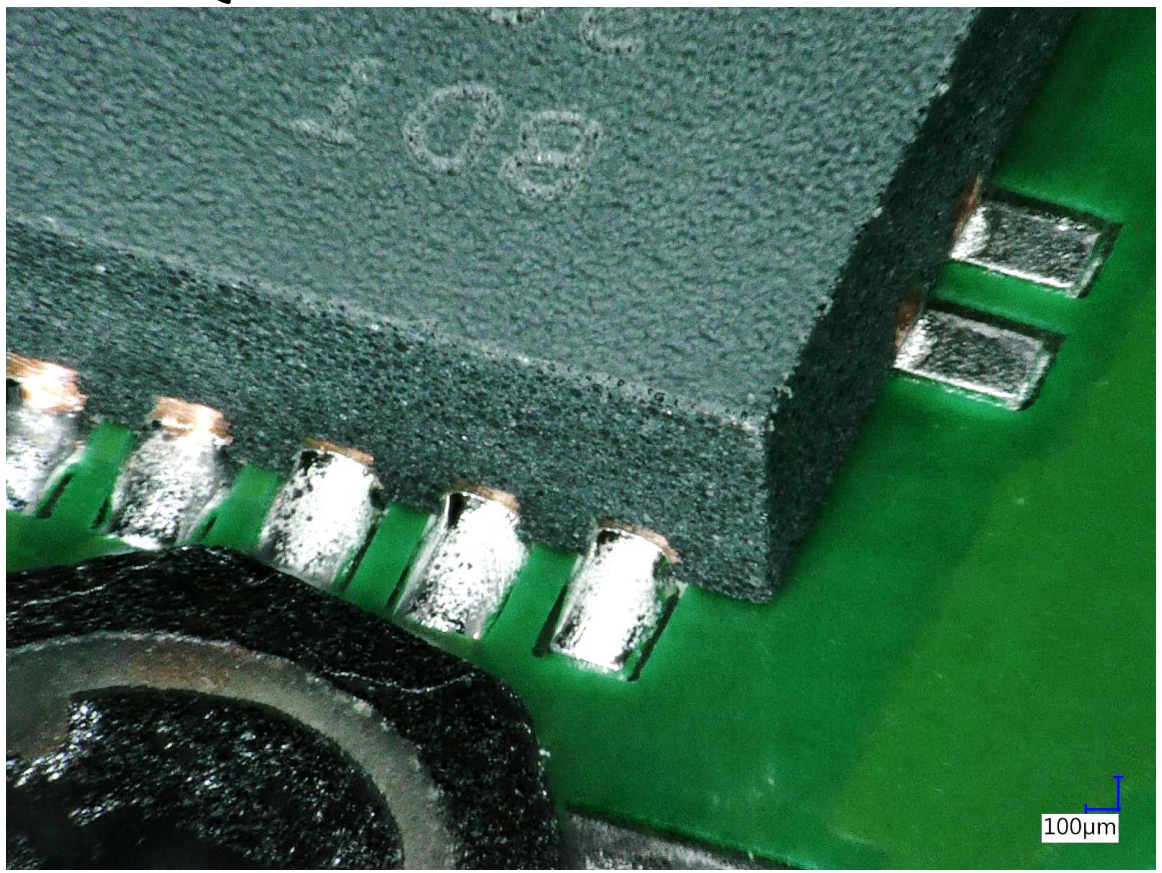
Residues between too dense placed terminals

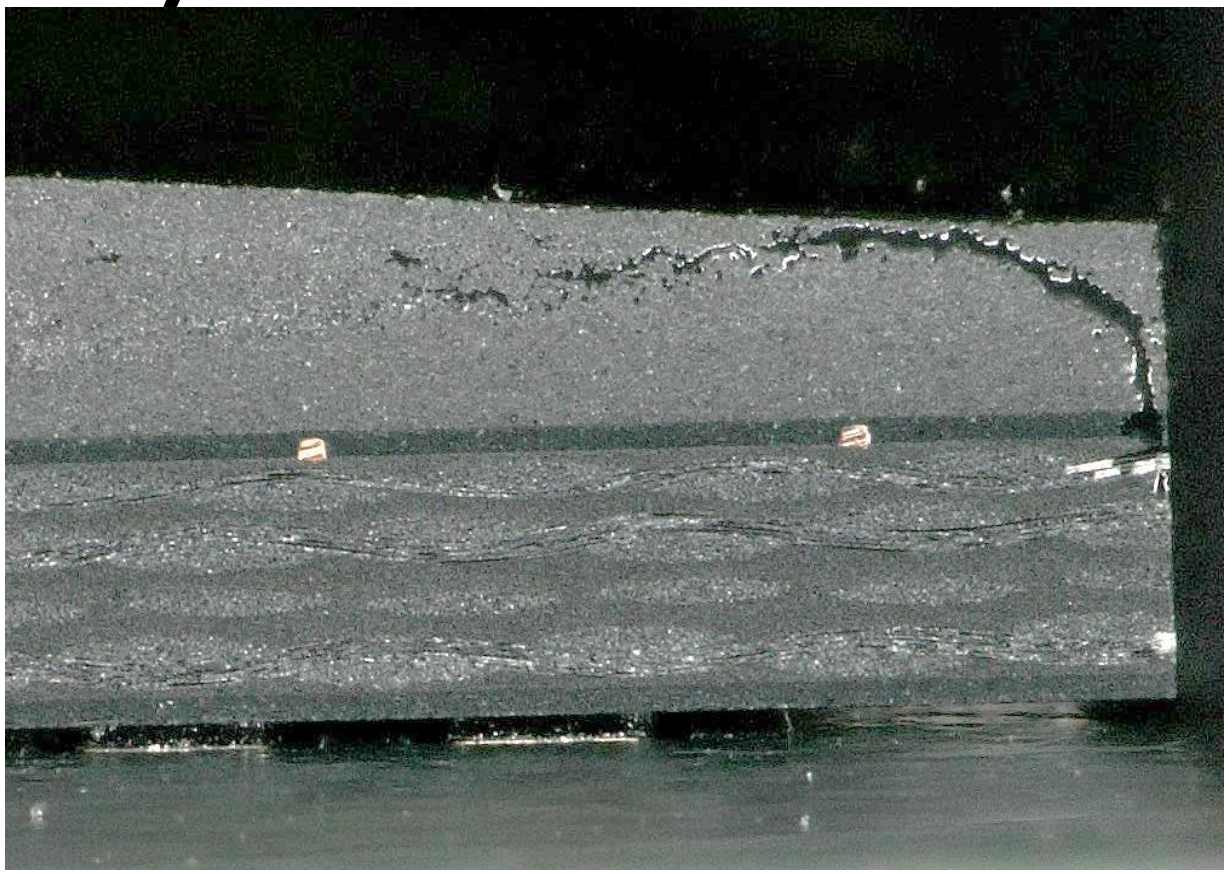


Chips under BGA – cleaning challenge

Irregularities in ball placement disturb liquid flow under BGA.
Kinetic energy drops down.
Results in uncomplete cleaning of residues (white residues)

QFN and similar BTC (LGA)



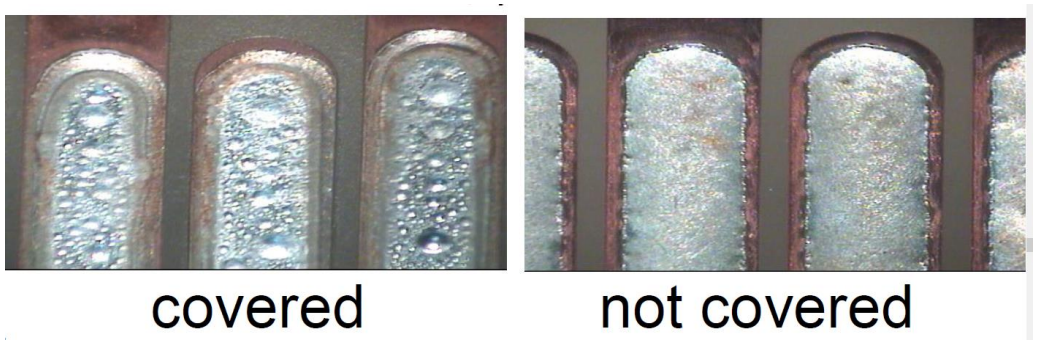


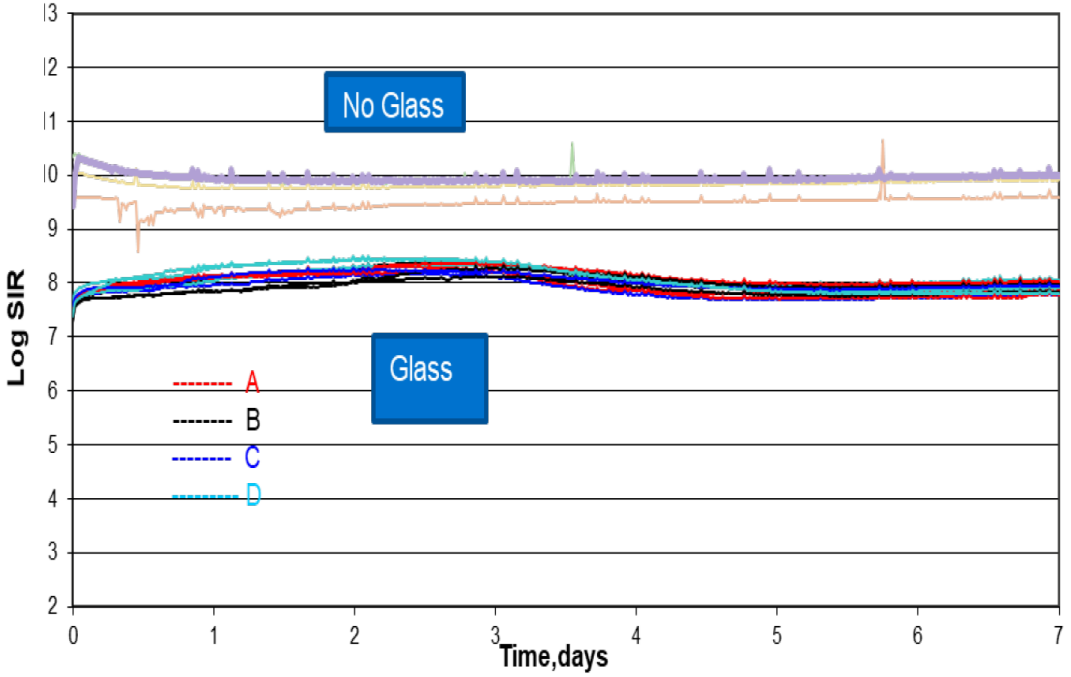
Gap size determined by amount of solder past on the termal lug - more paste – higher gap
But – more solder paste – more residues + not termally processed !

Average gaps – 20 – 40um

Residues under BTC are critical for ECM

- Residues cannot degass properly – „cubic flux“
  - Some volatile compounds remaind in the residues
  - Residues more susceptible to electrochemical migration (ECM)

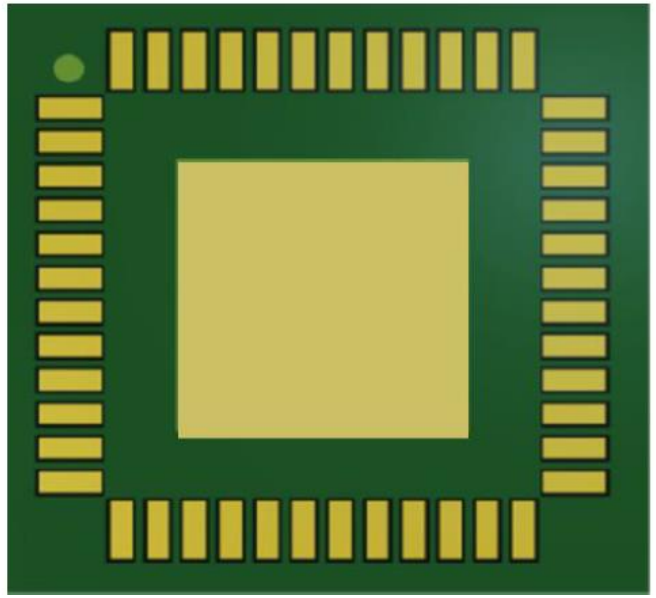




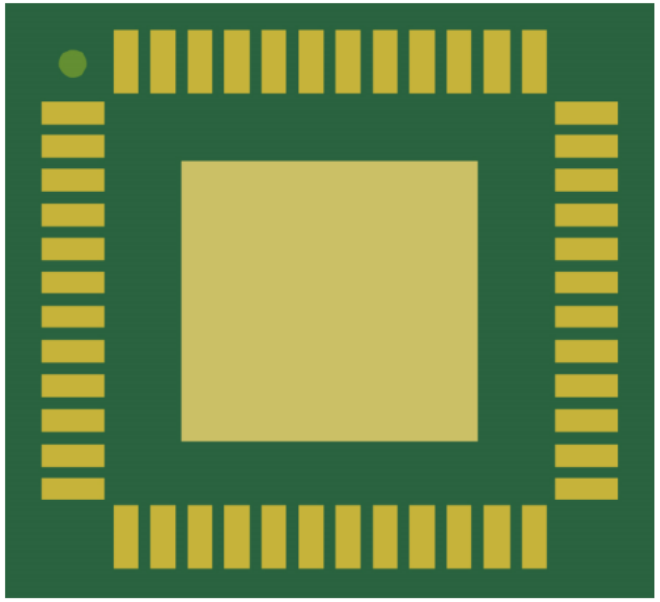
Ms. Karen Lellefsen
Presented at SMTA international, 2020

How to improve cleanability of QFN?

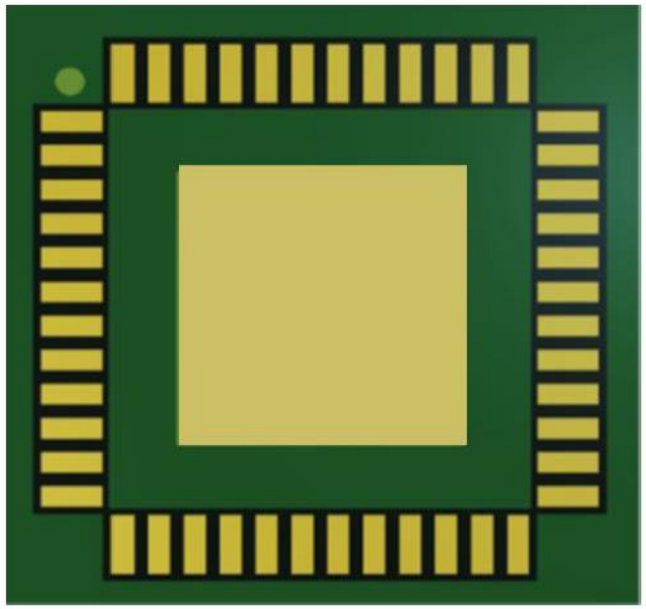
- Increasing the gap



SMDP (solder mask defined pad)
Small gap
Difficult to degas
Difficult to clean



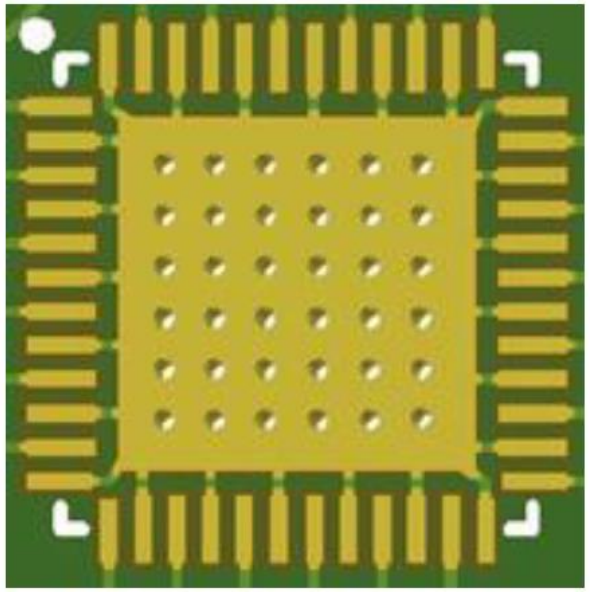
NSM (non solder mask)
Higher gap
Still difficult to degas
Easier to clean

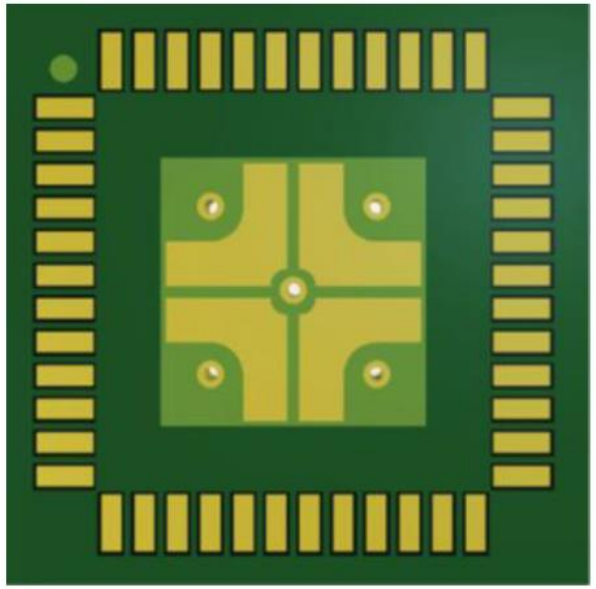


NSMDP (non solder mask defined pad)
Highest gap
Easier to degas
Easier to clean

How to improve cleanability of QFN?

- Lowering the flux residues amount
- Lifting the package





Vias in the termal lug
Good degassing (void supression)

Lowering the gap (paste goes to vias)
Pollution of other side of PCB by flux

Vias guarded by solder mask
Overprint over mask

Good degassing (void supression)
Easier cleaning

Proper design for cleaning

- Respecting rules for optimal cleaning…..
  - By PCB designers
  - By component manufacturers

- Saves cleaning time – increases cleaning capacity
- Saves energy
- Saves cleaning chemistry
- Saves deionize water consumption
- Minimize waste water treatment costs

∑ : makes assemblies more reliable for less money

QUESTIONS ?

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