How to tailor Immersion tin plating for IC substrate applications

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Introduction

Introduction

Surface finishes and IC substrates

Task of the surface finish:

- Protect the copper surface from tarnishing and oxidation
- Maintain an active surface for various interconnect techniques
  - Soldering
  - Wire bonding
  - Pressfit (Compliant Pin)
  - Conductive Adhesives
  - Serving as a functional interface (Contact, Switches, Keypads)

Key drivers for advanced packaging evolution

- Increase functionality
- Power and performance
- Miniaturization
- Reliability

Introduction

Final finish overview

■ = very good ▲ = good ● = sufficient ▼ = limited ◆ = not possible

	Finish type	ENIG	EPAG	ENEPIG	Immersion Sn	HT-OSP
Soldering	Multiple soldering (more than 3 soldering steps)	■	■	■	▲	●
	Solder joint reliability	▲	■	■	■	■
Wire bonding	Al-Wire	■	■	■	◆	◆
	Au-Wire	▼	■	■	◆	◆
	Pure Cu-Wire	◆	▲	▼	◆	◆
	Cu-Pd-Wire	◆	■	▲	◆	◆
Fine line	Fine pitch	▼	■	▼	■	■
Planarity	For SMD	■	■	■	■	■
High frequency capability	HF applications	●	■	●	■	■
Shelf life	Shelf life before assembly	≥12 months	≥12 months	≥12 months	12 months	6-12 months

Introduction

Immersion tin process flow

Bath Names	Temp.°C	Time (min.)
Acidic Cleaner	35 - 45	3 - 8
MicroEtch	25 - 35	1 - 2
Cold tin bath	20 - 30	1 - 2
Hot tin bath	65 - 73	9 - 15
Reduction of IC	60 - 65	1 - 2
Prevention of discoloration	20 - 30	5 – 25 sec

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Solder joint reliability

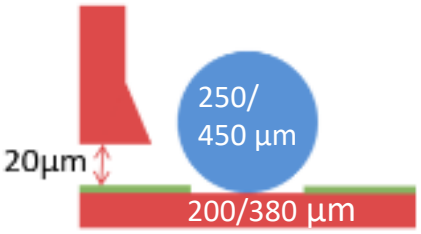
Solder joint reliability

High Speed Shear Test SAC 305 - conditions

Alloy	SAC 305
Ball diameter	250/450 µm
Flux type	Kester Tacky Flux TSF 6502
Reflow profile	TSF 6052 Leadfree Linear Profile
Reflow atmosphere	N_2
PCB type	SFTB1 SMD BGA SRO 380

	OSP	Sn	Ni	Pd	Au
OSP	0.3 µm				
ISn		1 µm			
ENEPIG			7 µm	0.04 µm	0.06 µm

Mode 1	Pad pull-out
Mode 2	Intermetallic fracture < 5%
Mode 3	Intermetallic fracture < 25%
Mode 4	Intermetallic fracture < 95%
Mode 5	Intermetallic fracture > 95%

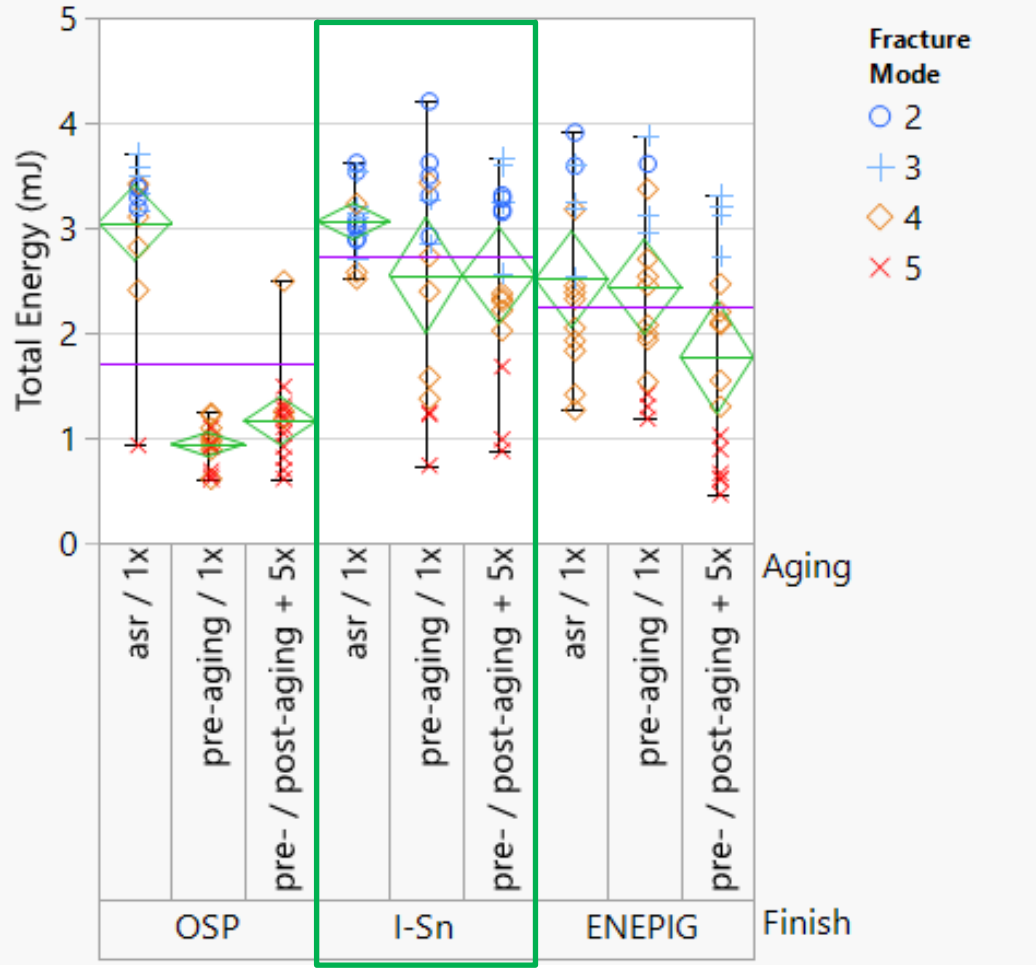


SAC 305:
0.8 m/s (250µm)
0.9 m/s (450µm)

	Aging conditions
ASR	Ball attach + 1 reflow ▶HSS
Pre-aging	2h@175°C▶hot rinse, air dry▶ball attach + 1 reflow▶HSS
Pre-/post aging	2h@175°C▶hot rinse, air dry▶ball attach + 1 reflow ▶120h@60°C/60%RH + 5xreflow▶HSS

Solder joint reliability

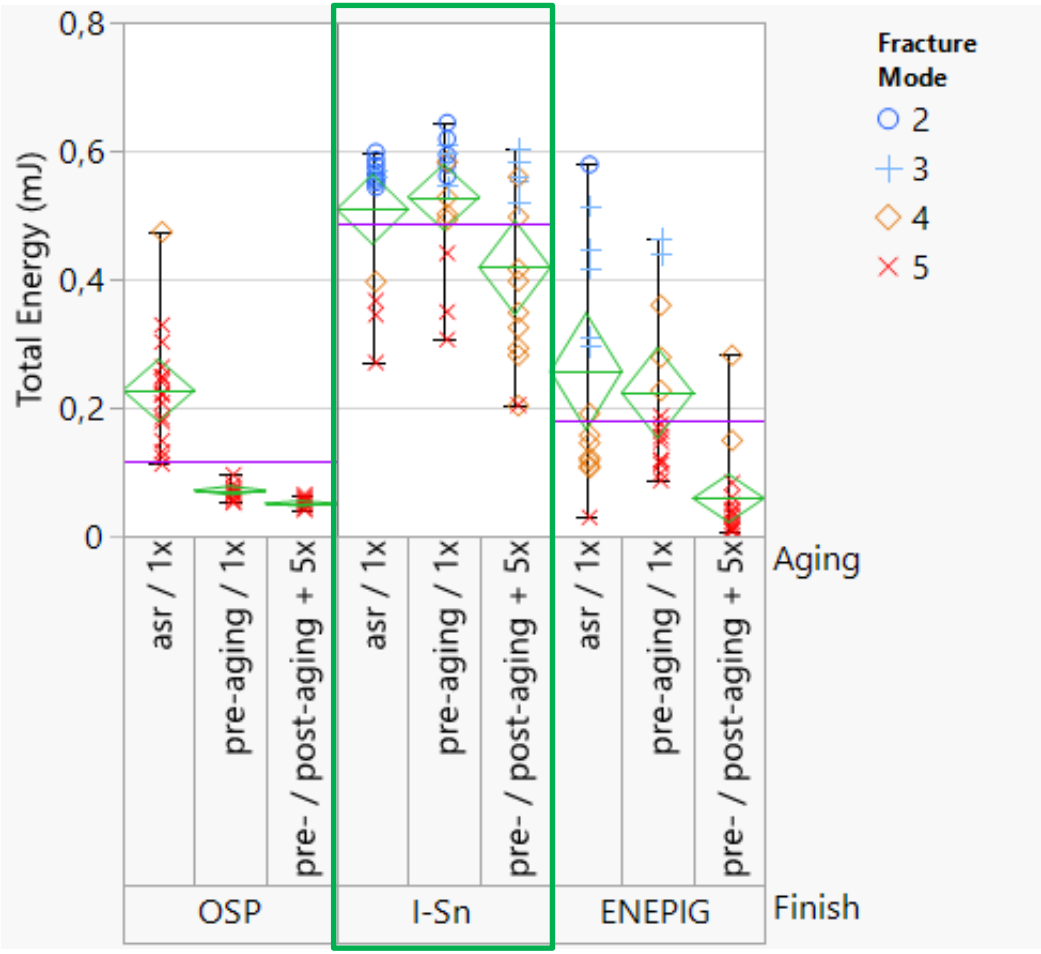
High Speed Shear Test – results 450µm solder ball



I-Sn performs consistently well compared to OSP and ENEPIG

Solder joint reliability

High Speed Shear Test - 250µm solder ball



For smaller ball diameter difference to OSP gets more pronounced

Solder joint reliability

High Speed Shear Test LF35 - conditions

Alloy	LF 35
Ball diameter	250/450 µm
Flux type	Kester Tacky Flux TSF 6502
Reflow profile	TSF 6052 Leadfree Linear Profile
Reflow atmosphere	N_2
PCB type	SFTB1 SMD BGA SRO 380

	OSP	Sn	Ni	Pd	Au
OSP	0.3 µm				
ISn		1 µm			
ENEPIG			7 µm	0.04 µm	0.06 µm

Mode 1	Pad pull-out
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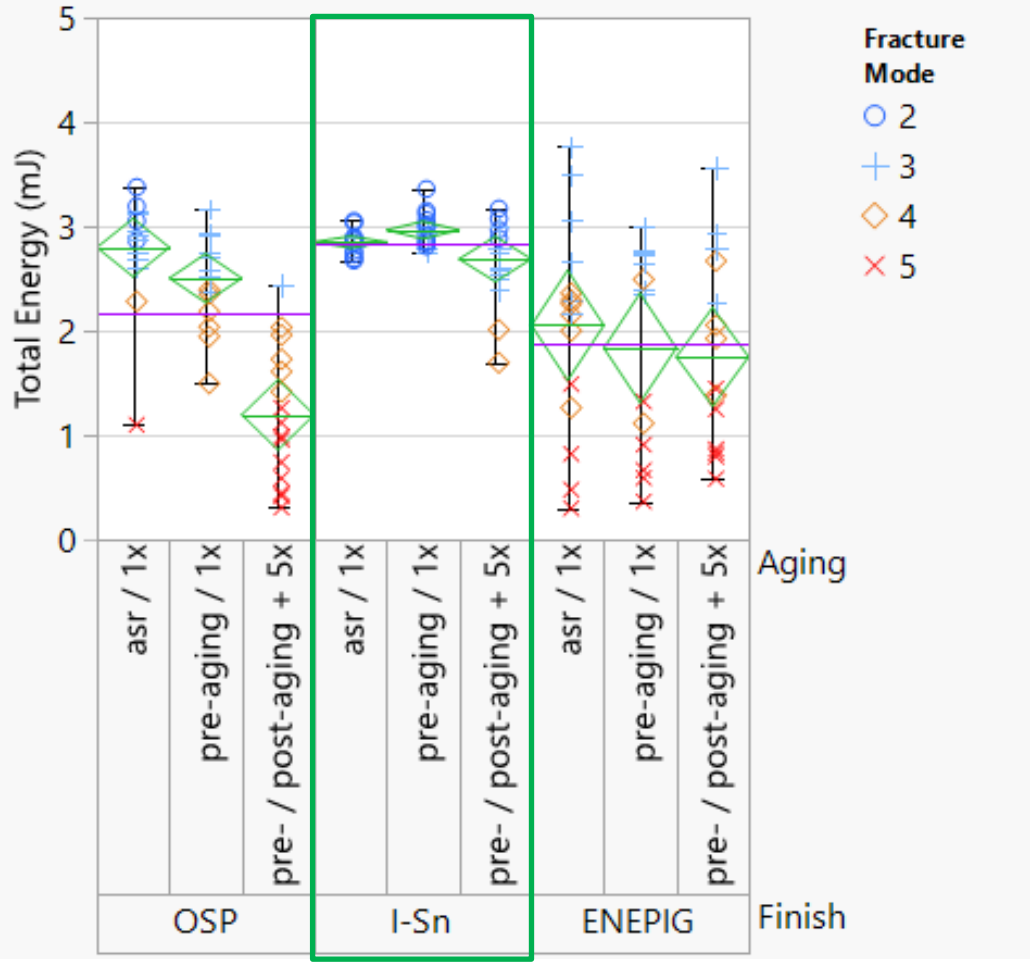
Solder joint reliability

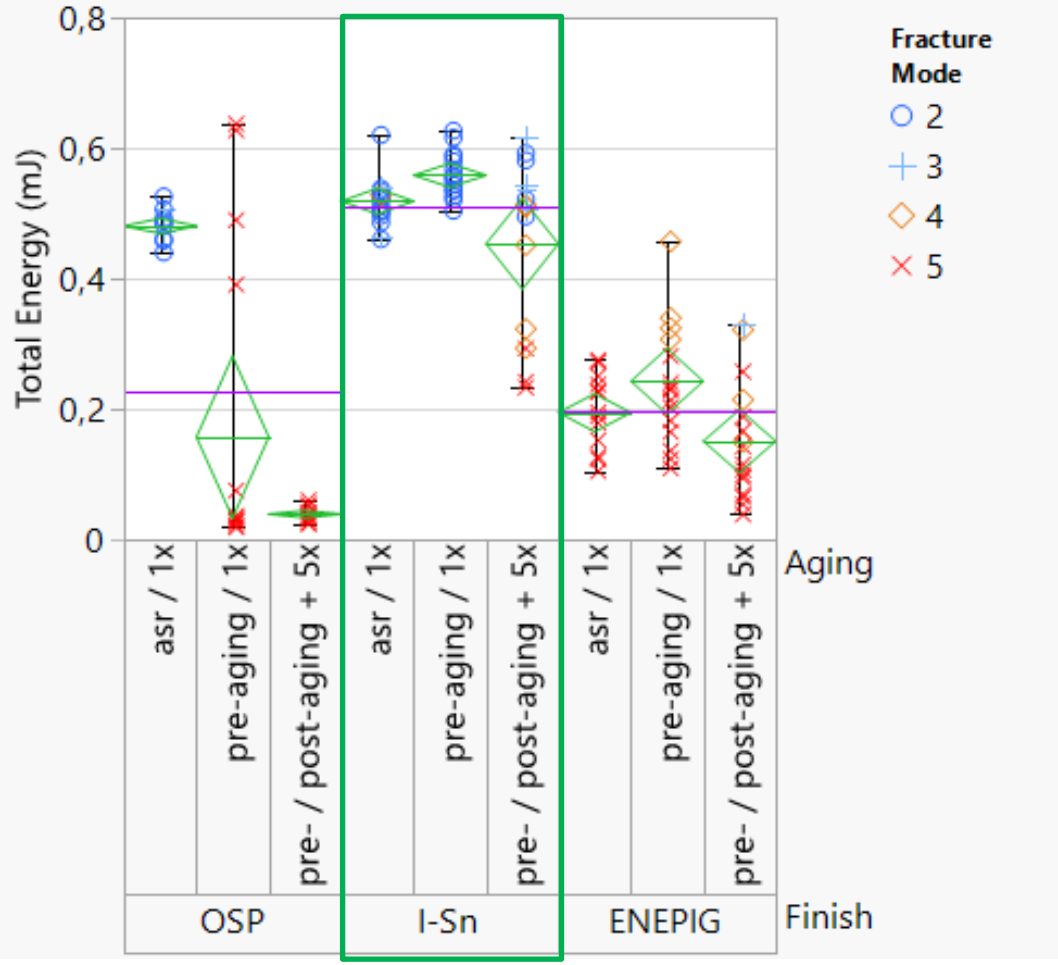
High Speed Shear Test – results 450µm solder ball



Less brittle fractures compared to SAC, aging impacts OSP performance

Solder joint reliability

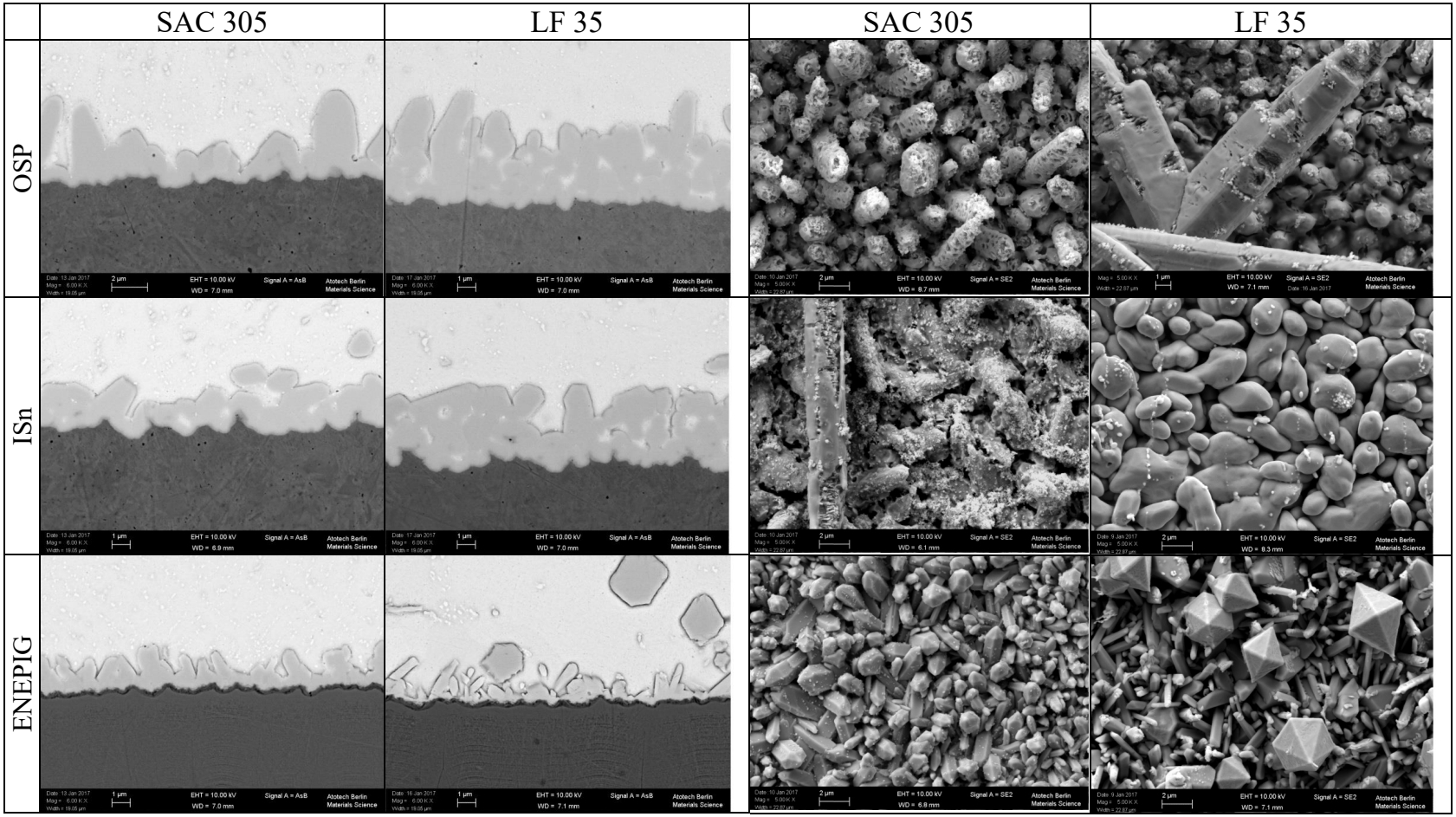
High Speed Shear Test - 250µm solder ball



Smaller ball diameters confirm previous trends

Solder joint reliability

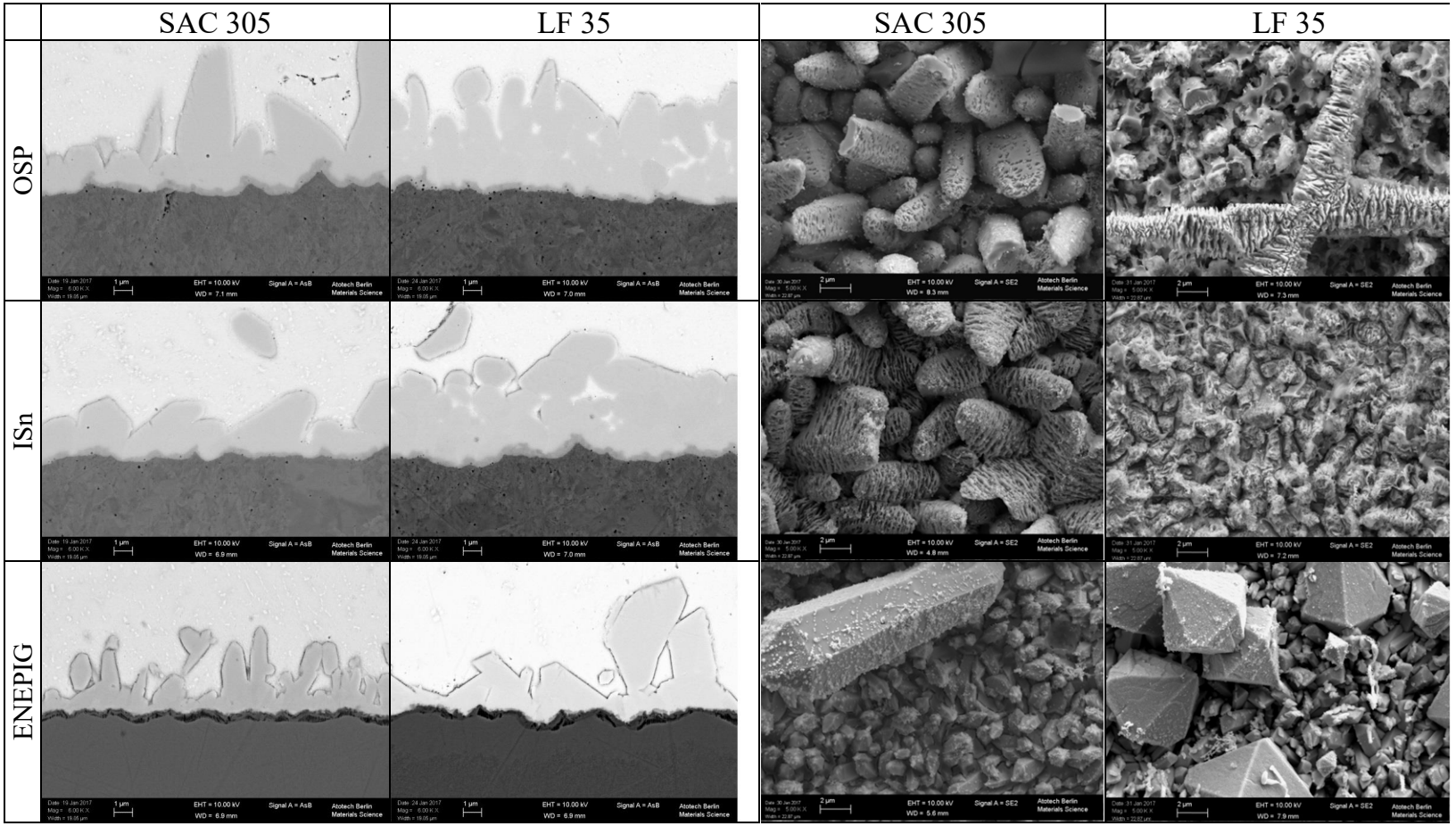
IMC evaluation after 1x reflow



LF35 IMC exhibits smaller crystal structures compared to SAC 305

Solder joint reliability

IMC evaluation after after pre/post aging 5x reflow



Increased IMC thickness, continuous and dense in particular for ISn

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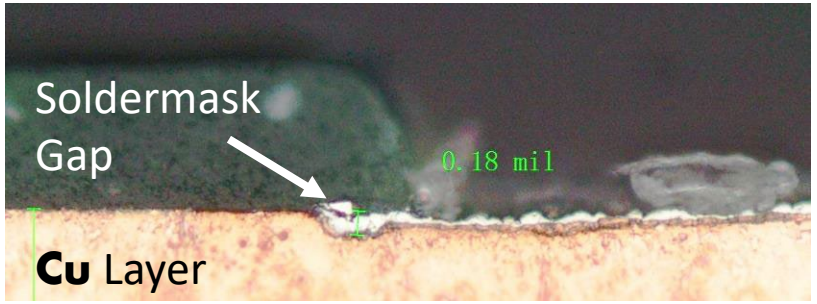
Plating solution and equipment

Plating solution and equipment

Mouse Bite - background



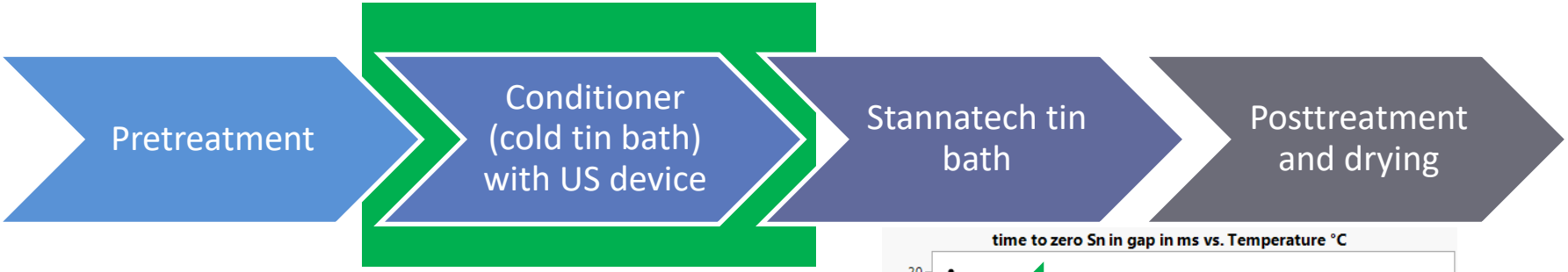
Schematic drawing of Undercut

During the plating low in the undercut (Reaction 1) → Tin is consumed very fast
Less Sn deposition

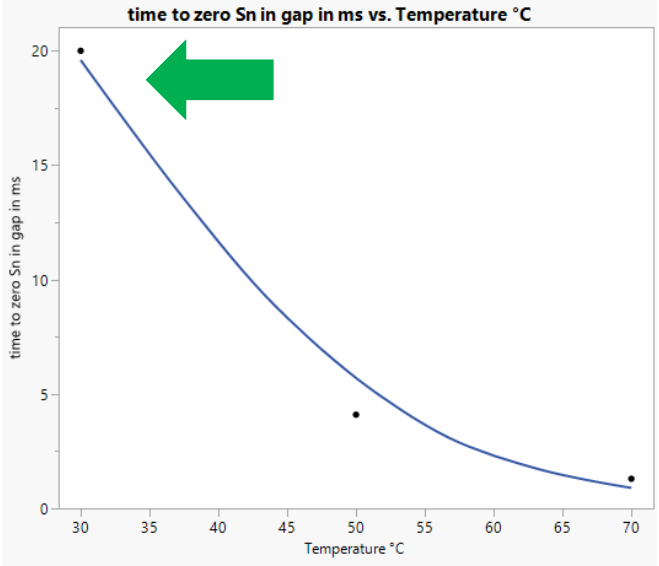
Plating of Sn and dissolving of Cu at different locations (Reaction 2) → Without a protective Sn layer in the mouse bite area increased Cu dissolution

Plating solution and equipment

Mouse Bite – the Solution



Temperature in °C	Time to zero Sn in gap in ms
70	1.3
50	4.1
30	20



Low temperature → More time for solution exchange

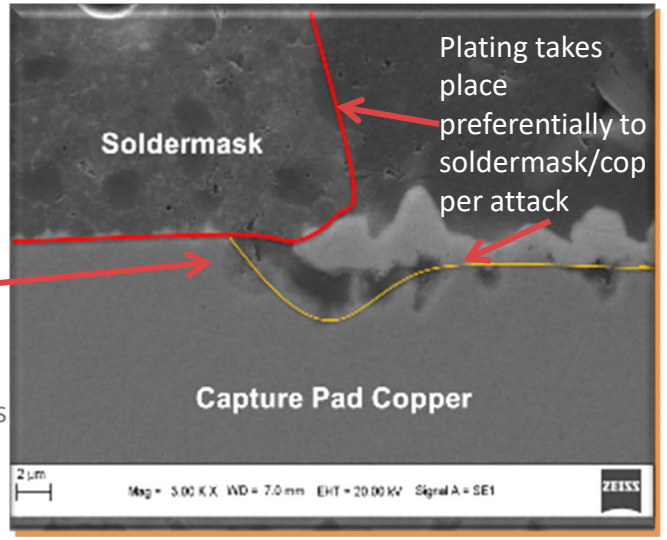
Ultra sonic → Increase/improve the solution exchange

Plating solution and equipment

Reduced Viscosity

	ISn for PCB	ISn for ICS
Viscocity (mPas)	11.2	**6.4**
Density	1.23	1.25

- A reduction in viscosity optimizes solution exchange
- The similar densities reflect the optimizations in metal ion supply

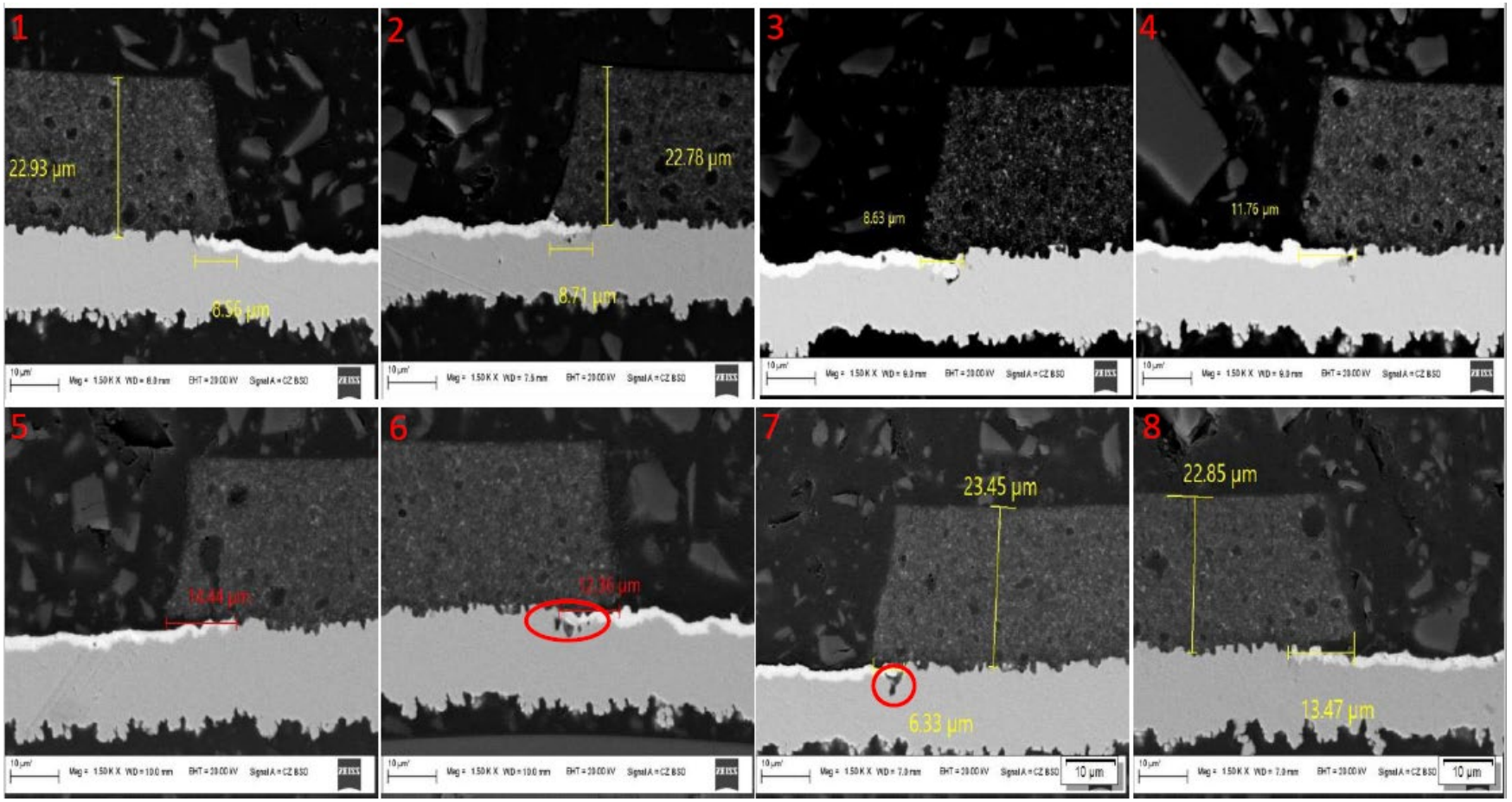


Higher metal content induces the filling of micro structures under low exchange conditions

Low velocity = high solution exchange in vertical processes

Plating solution and equipment

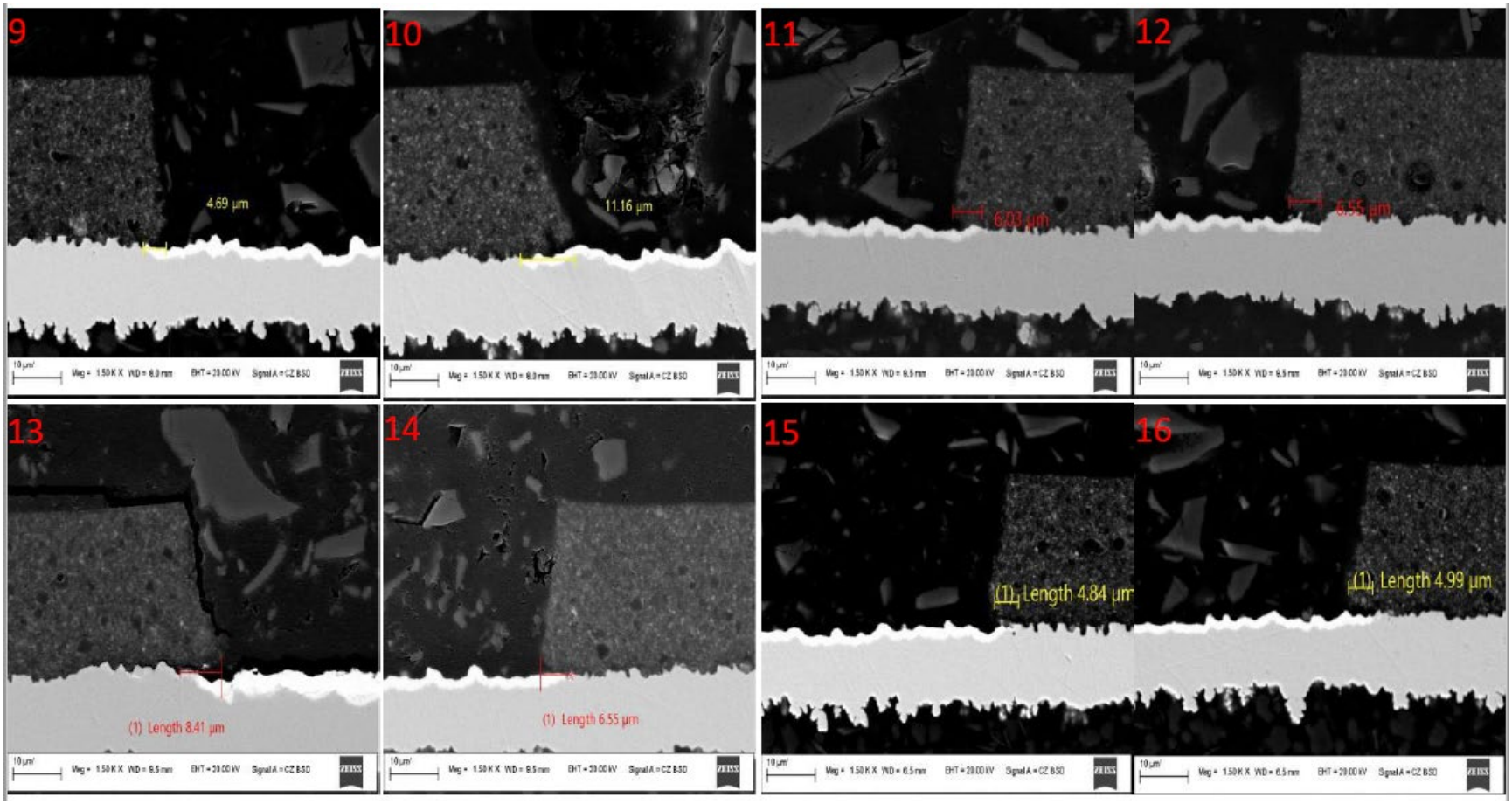
C4 undercut ISn for PCB



Some corrosive attack and underplating observed

Plating solution and equipment

C4 undercut ISn for ICS

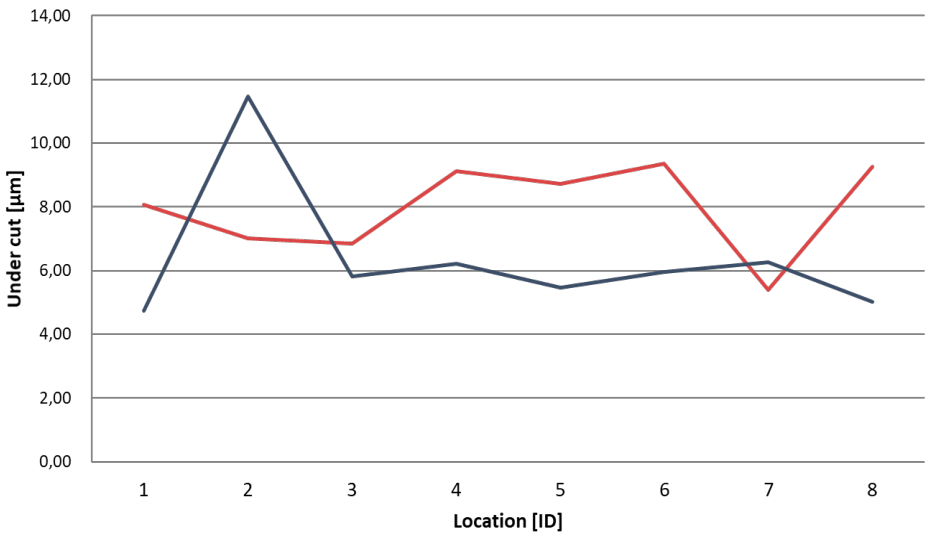


Reduced underplating, no corrosive attack

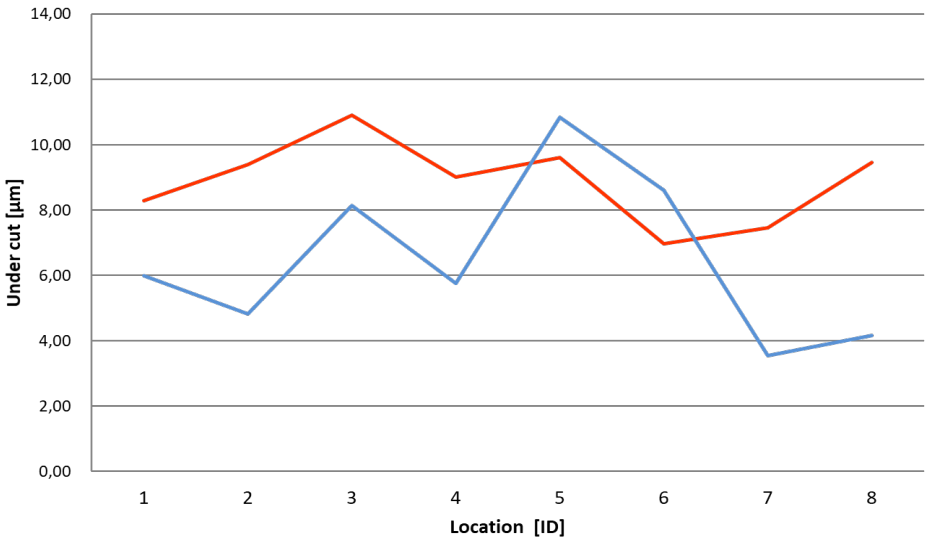
Plating solution and equipment

Underplating

C4 side



BGA side



ISn for PCB

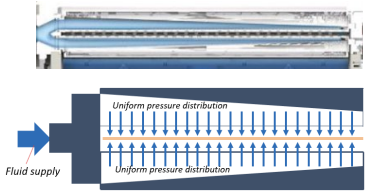
ISn for ICS

Significant better performance with reduced solution viscosity

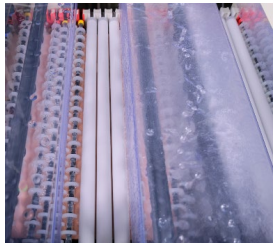
Plating solution and equipment

High-end immersion tin system suited for automotive and IC substrates

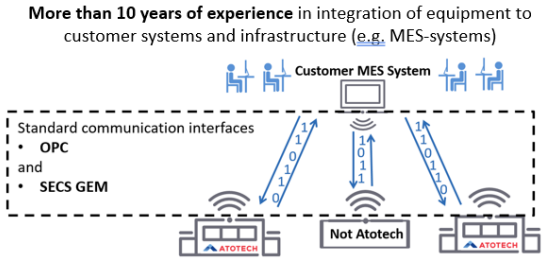
Auxiliary equipment
extending chemistry life time, process stability and provide a sustainable production



Patented flood bar
for uniform solution exchange



spray bar
High quality spray nozzles and effective pressure performance



Digital solutions
for process control, real time monitoring and repetitive results

Horizontal equipment systems can easily be combined with ISn for ICS. This approach fuses high end equipment with optimized utility chemistry.

Horizontal ISn plating for PCB

- More than 20 years of experience
- Highest corrosion resistance compared to other surface finishes
- Anti whisker additive for whisker prevention

Horizontal ISn plating for ICS

- Suitable for high frequency
- Suitable for fine L/S
- Reliable CuSn solder joints formed

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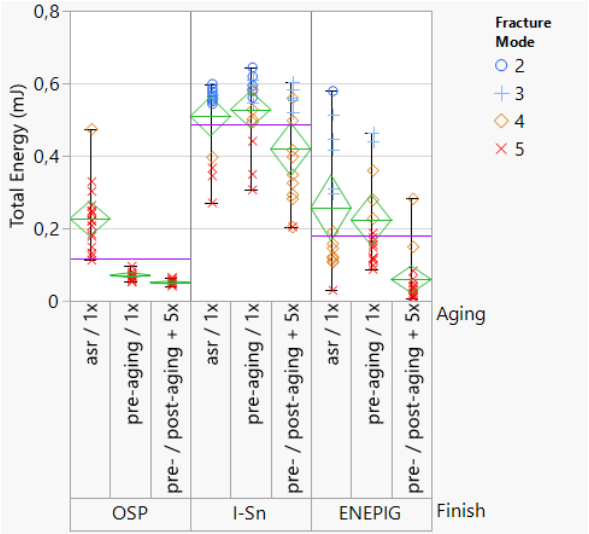
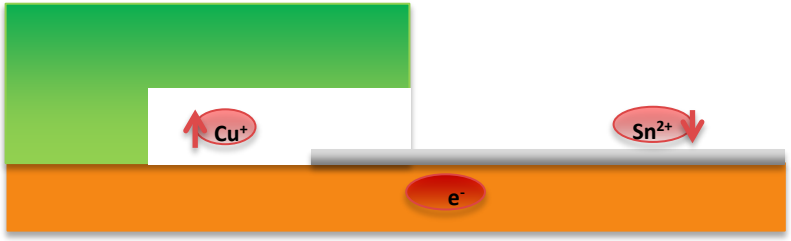
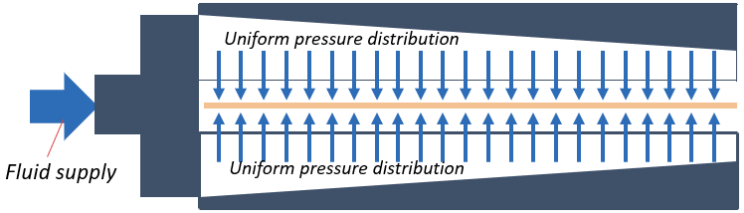
Summary

Summary – take away message

- ISn exhibits excellent solder joint reliability compared to OSP or ENEPIG with cost benefits over ENEPIG
- High solder joint ductility can be achieved even in aged conditions
- ISn tailored electrolytes can overcome limitations caused by high plating solution viscosity such as corrosive undercut
- Horizontal plating equipment can ensure constant plating performance and full process control and panel tracking







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Thank you

for your attention!

Contact

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