

# Halogen Free Solder Paste

## A Truly Zero Halogen Approach

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# Contents

- What is a halogen?
- Impact on the environment
- Halides and halogens
- Halides in electronics
- Halogens in electronics
- Definition of halogen free
- Technical challenges to remove halogen
- Current 'State of the Art'
- Summary and conclusions

# What is a halogen?

- The elements occurring in Group 17 of the periodic table (fluorine, chlorine, bromine, iodine & astatine)
- Widely used in all manners of industrial and consumer applications

- Toothpaste
- Disinfectants
- Lighting
- Film photography
- Drug manufacturing
- Food production
- Etc.....

hydrogen 1 H 1.0079	beryllium 4 Be 9.0122																	helium 2 He 4.0026					
lithium 3 Li 6.941	boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180																	argon 18 Ar 39.948
sodium 11 Na 22.990	aluminum 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	potassium 19 K 39.098	calcium 20 Ca 40.078	scandium 21 Sc	titanium 22 Ti	vanadium 23 V	chromium 24 Cr	manganese 25 Mn	iron 26 Fe	cobalt 27 Co	nickel 28 Ni	copper 29 Cu	zinc 30 Zn	gallium 31 Ga	germanium 32 Ge	arsenic 33 As	selenium 34 Se	bromine 35 Br	krypton 36 Kr
rubidium 37 Rb	strontium 38 Sr	yttrium 39 Y	zirconium 40 Zr	niobium 41 Nb	molybdenum 42 Mo	technetium 43 Tc	ruthenium 44 Ru	rhodium 45 Rh	palladium 46 Pd	silver 47 Ag	cadmium 48 Cd	indium 49 In	tin 50 Sn	antimony 51 Sb	tellurium 52 Te	iodine 53 I	xenon 54 Xe						radon 86 Rn
cesium 55 Cs	barium 56 Ba	lanthanum 57 La	hafnium 72 Hf	tantalum 73 Ta	wolfram 74 W	reynoldsium 75 Re	osmium 76 Os	iridium 77 Ir	platinum 78 Pt	gold 79 Au	mercury 80 Hg	thallium 81 Tl	lead 82 Pb	bismuth 83 Bi	polonium 84 Po	astatine 85 At	radon 86 Rn						
francium 87 Fr	radium 88 Ra	actinide series 89-102 * * *	lutetium 71 Lu	hafnium 72 Hf	tantalum 73 Ta	wolfram 74 W	reynoldsium 75 Re	osmium 76 Os	iridium 77 Ir	platinum 78 Pt	gold 79 Au	mercury 80 Hg	thallium 81 Tl	lead 82 Pb	bismuth 83 Bi	polonium 84 Po	astatine 85 At	radon 86 Rn					

\* Lanthanide series

lanthanum 57 La	cerium 58 Ce	praseodymium 59 Pr	neodymium 60 Nd	promethium 61 Pm	samarium 62 Sm	europium 63 Eu	gadolinium 64 Gd	terbium 65 Tb	dysprosium 66 Dy	holmium 67 Ho	erbium 68 Er	thulium 69 Tm	ytterbium 70 Yb
actinium 89 Ac	thorium 90 Th	protactinium 91 Pa	uranium 92 U	neptunium 93 Np	plutonium 94 Pu	americium 95 Am	curium 96 Cm	berkelium 97 Bk	californium 98 Cf	einsteinium 99 Es	fermium 100 Fm	mendelevium 101 Md	nobelium 102 No

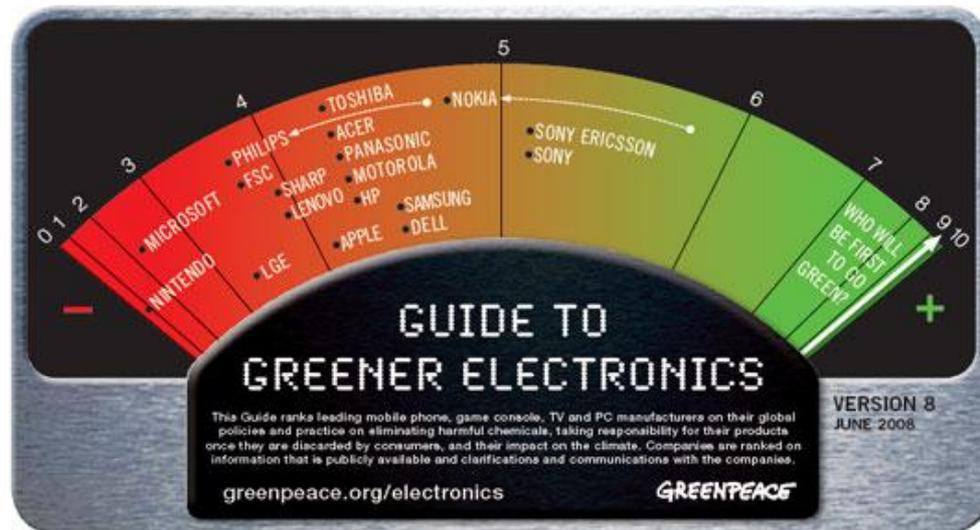
\*\* Actinide series

# Impact on the Environment

- CFC's and ozone layer depletion
- Certain brominated flame retardants (RoHS directive)
- Persistence in the environment
- Potential to form dioxins
- The complete removal of halogens is currently not legislation driven

# Impact on the Environment

- Halogens do not cause harmful effects to humans in the forms used in electronics manufacturing
- The concern is the unregulated disposal of waste electronics and electrical equipment via incineration
- This can potentially release harmful (to human health and the environment) by-products



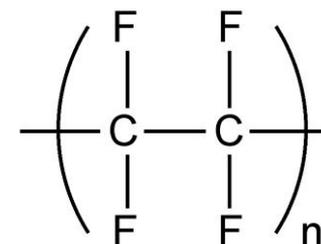
# Halides and Halogens

- **Halides**

- Ionically (weakly) bonded 'salts'
- Negatively charged halide neutralised by a positively charged cation
- Generally hydroscopic and under certain conditions electrically conductive
- E.g. NaCl (table salt)

- **Halogens**

- Covalently (strongly) bonded halogen in an organic molecule
- No ionic charge when bonded into the molecule
- Structure will determine the ease of evolution of the halide
- E.g. Teflon



# Halides in Electronics (Solder)

	Halide Free			Halogen Free	
<b>Drivers for Classification</b>	High reliability interconnects International standards			REACH Non-government organisations (NGOs)	
<b>Definition</b>	No flux corrosivity or dendritic growth detection Specific requirements to give ROL0 classification			No intentional halogens added to flux Comply to international standards (see below)	
<b>Test Procedures</b>	Well-established Chloride and Bromide halide test measured by titration			New – O <sub>2</sub> bomb on flux Ion chromatography on flux	
<b>International Standards</b>	IPC J-STD-004B IPC-TM-650	Fluoride Test	None detectable	JPCA-ES-01-1999	Bromine 900ppm max Chlorine 900ppm max Total halogen 1500ppm
		Chlorides and Bromides	<0.005%	IEC 61249-2-21	
				IPC-401B	

# Halogens in Electronics (Bis-A Resins)

- The main use of halogens in the electronics industry is flame retardants in laminate manufacturing
  - Polybrominated biphenyls and polybrominated diphenyl ether have been largely covered by the RoHS directive
  - Careful disposal of electronics (limiting impact of TBBPA) has also been covered by the WEEE directive in Europe
- Halogens are added to fluxes (cored solder wire, liquid fluxes, solder pastes) to improve solder performance

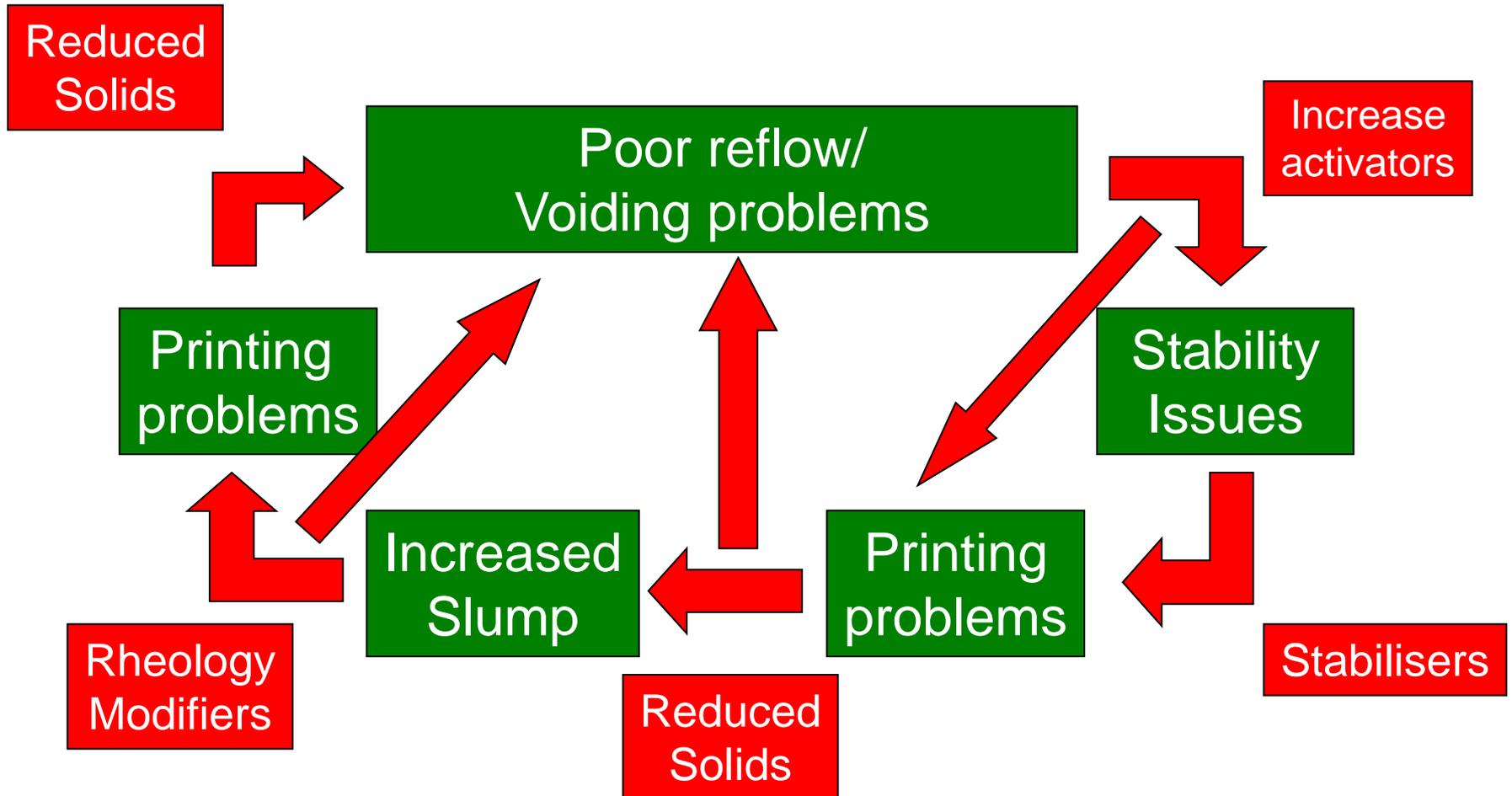
# Halogens in Electronics

- Greenpeace initially pushed the effort
- Consumer (handheld) producers have lead the way
- Automotive now following with demand for Halogen free solder paste

# Definition of Halogen Free

- Current definitions (JPCA, IEC, IPC) are all very similar
  - <900ppm Chlorine
  - <900ppm Bromine
  - <1500ppm combined (total) halogens
- The term halogen free does not necessarily mean **zero** halogen
  - Is it technically possible to go zero halogen?

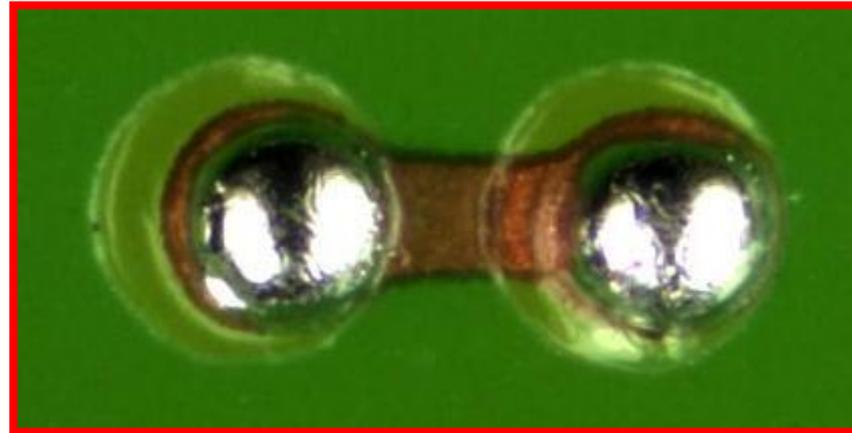
# Technical Challenges



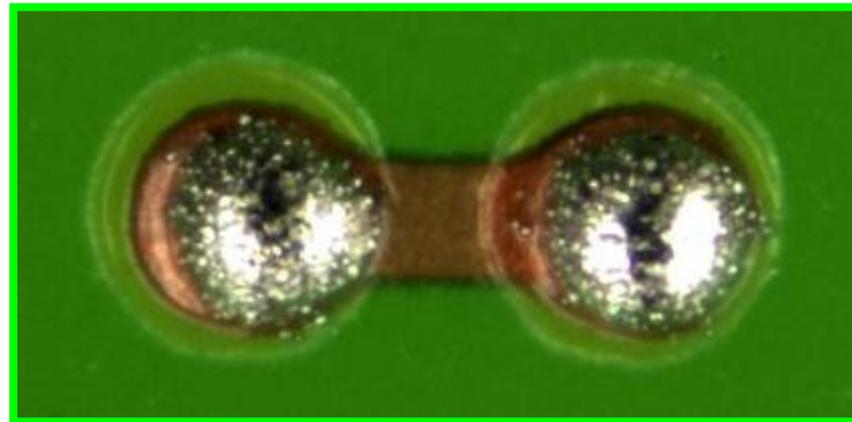
# Technical Challenges

## Reflow

- The removal of halogen from a flux formulation is not simple
- Halogens are exceptionally efficient at removal of oxide from solder surfaces
- Fluxes have to be formulated from first principles



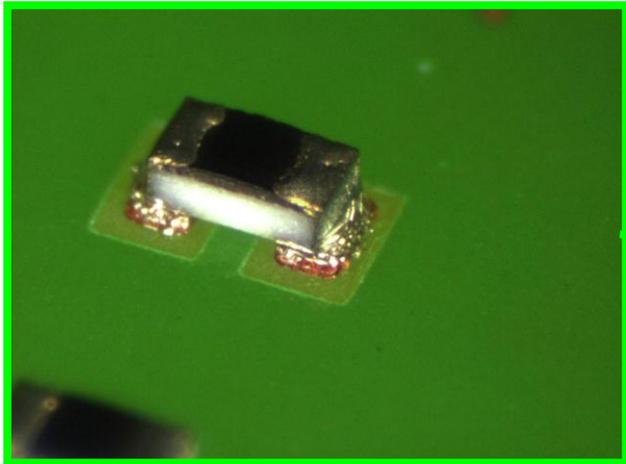
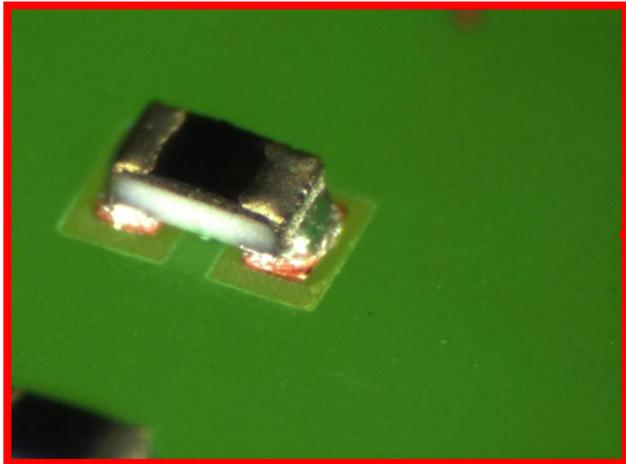
Typical halogen containing formulation



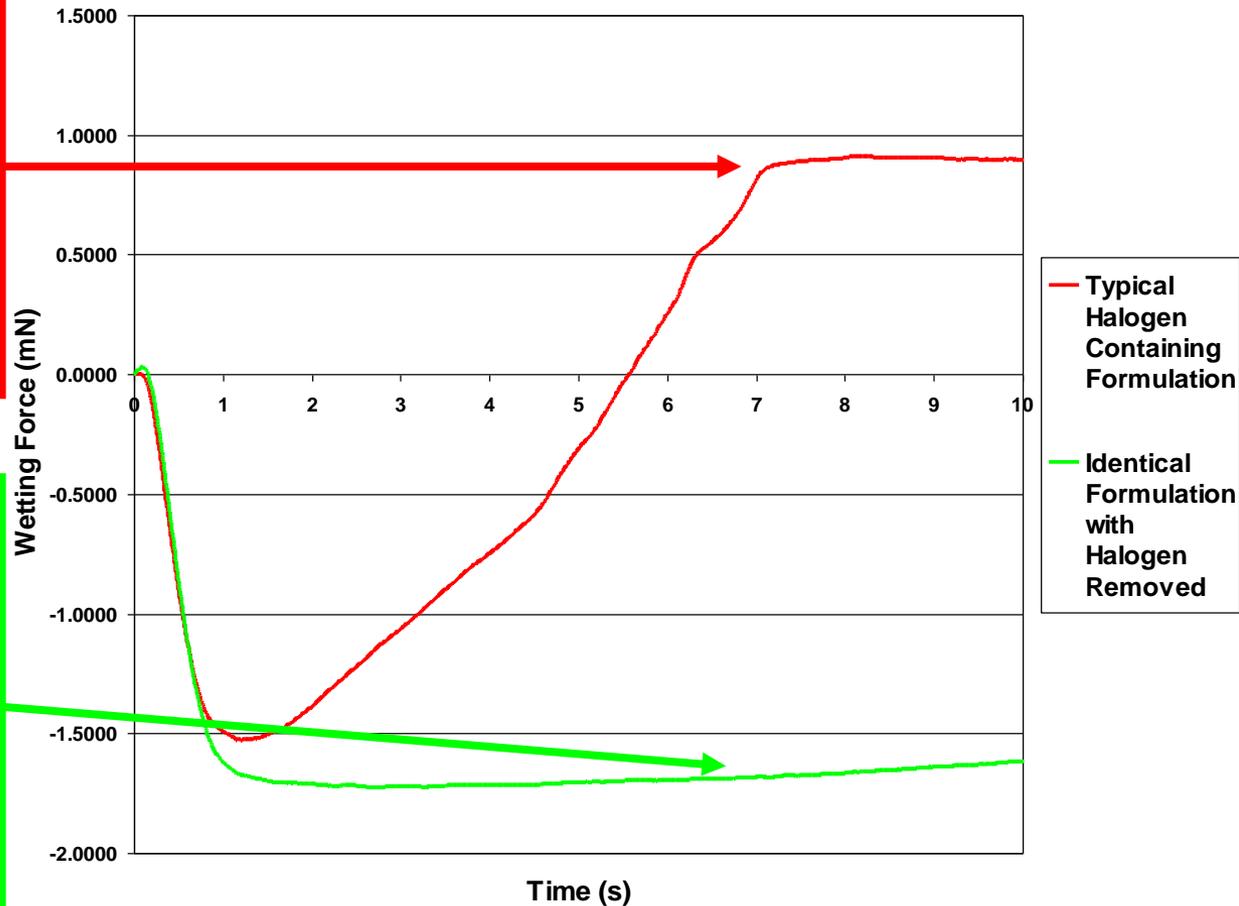
Identical formulation with halogen removed

# Technical Challenges Wetting

- Wetting properties of the fluxes are also affected by the removal of halogens



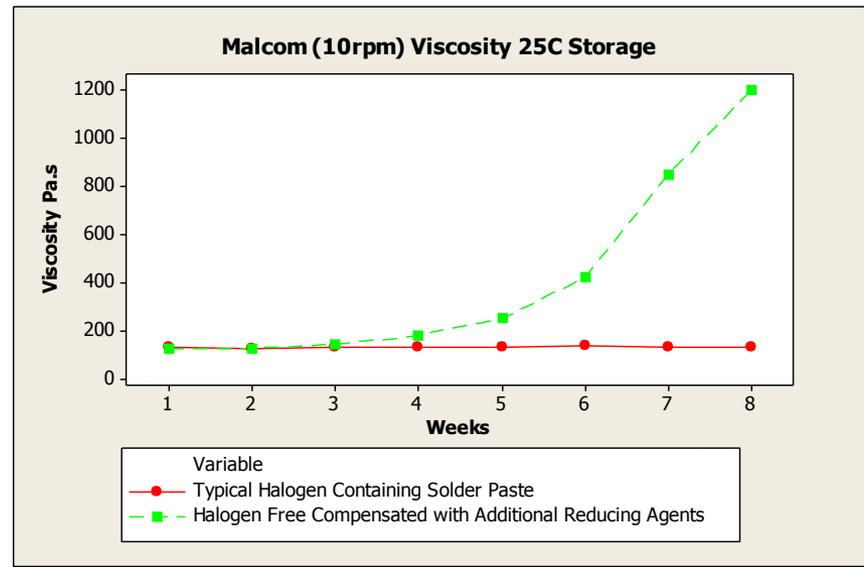
Wetting Balance Curves OxCu



# Technical Challenges

## Stability

- Compensating for the removal of halogen requires the addition of other materials that have reducing properties with regards to metal oxides
- This can also in some cases have a detrimental affect on stability of the product

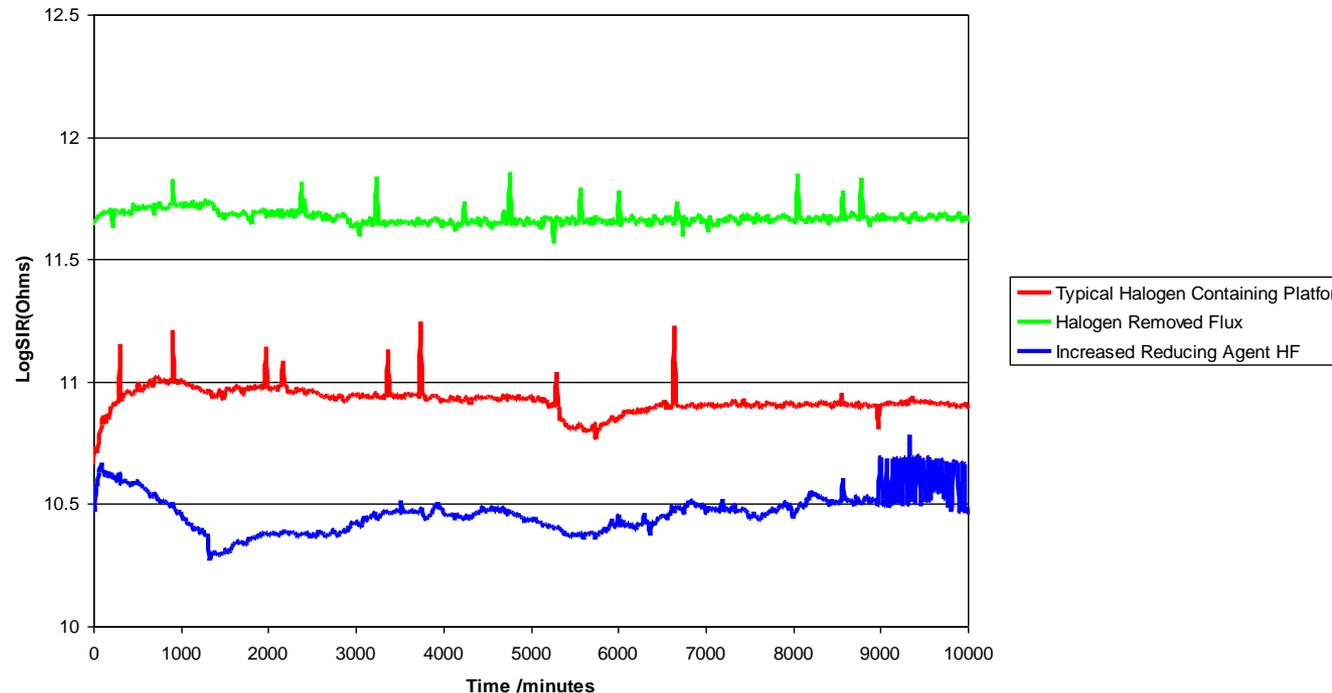


# Technical Challenges

## Reliability

- Increasing the non-halogen reducing agents can also compromise reliability
- The removal of halogen typically improves electrical reliability
- It's a balance

Comparative HF SIR results

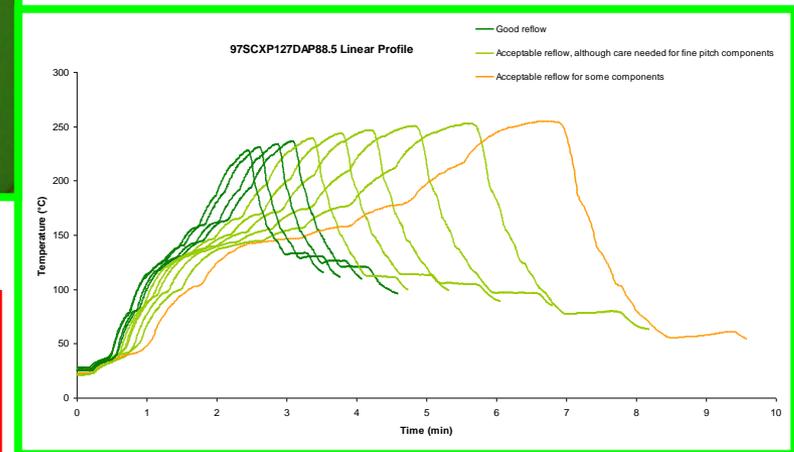


# Current 'State of the Art'

- Extensive resource has been dedicated to the development of completely halogen free solder paste formulations
- Production of electronics assemblies is now possible with consumables containing **no intentionally added halogens**

# Current 'State of the Art'

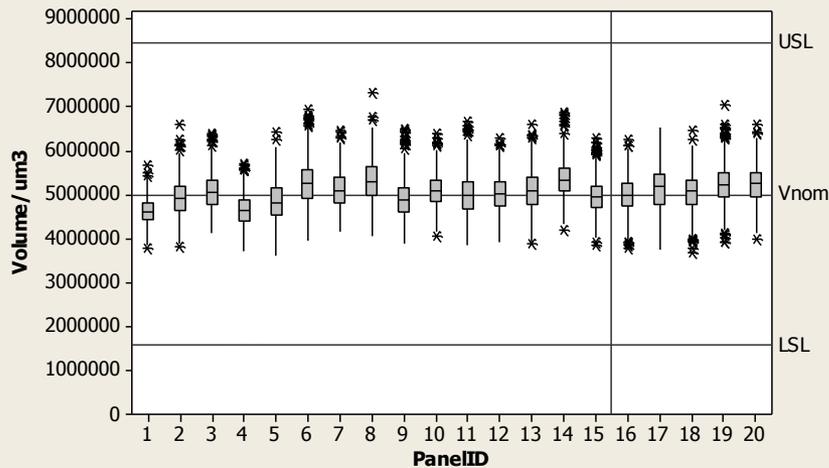
- Reflow Performance



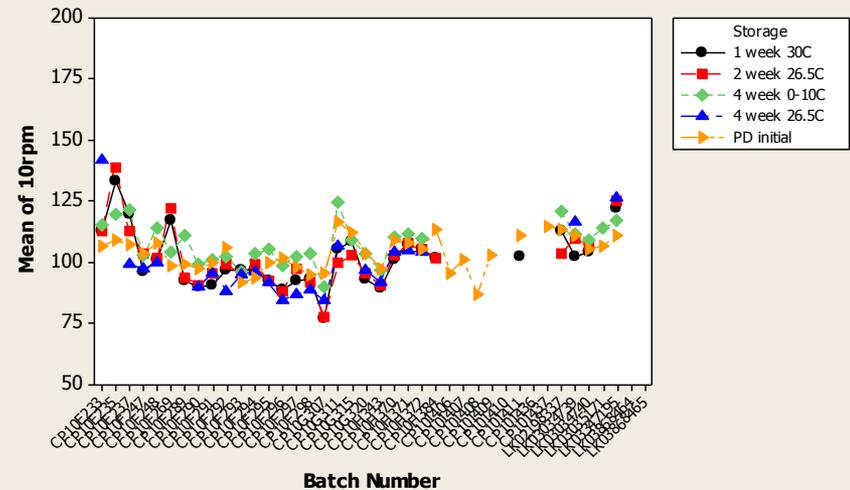
# Current 'State of the Art'

- Printing and Stability

**Solder paste volume on 0.4mm CSP with pause after print 15**  
Current Halogen Free Paste Formulation

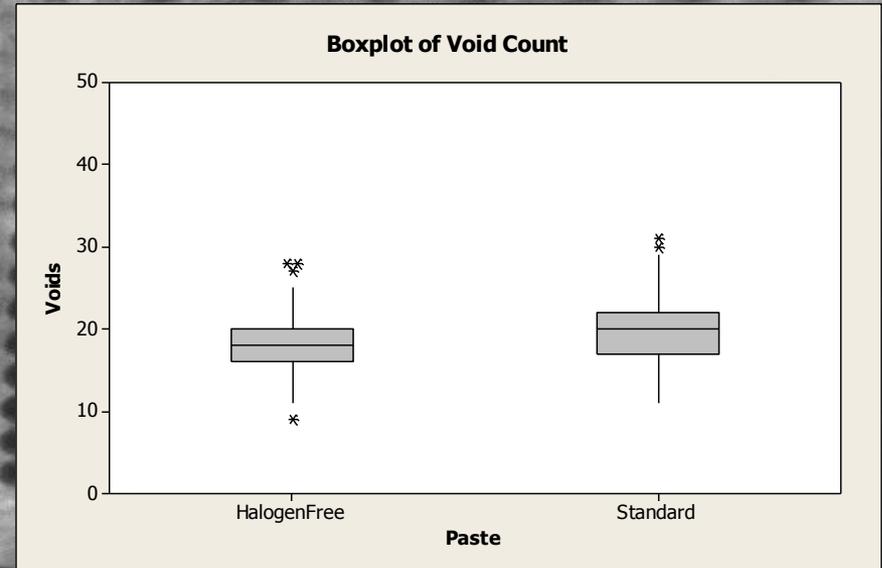
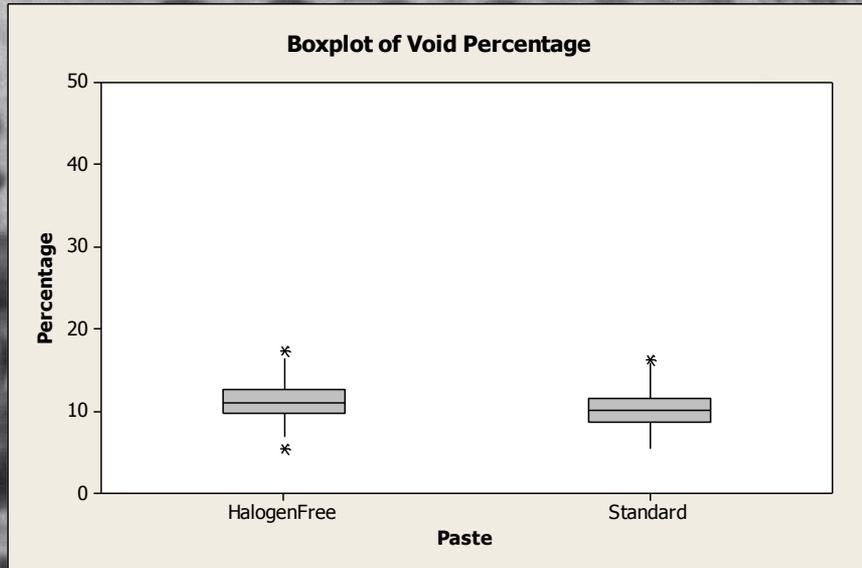


**Line Plot of Halogen Free Paste Storage (Malcom 10rpm)**



# Current 'State of the Art'

- Voiding



# Summary

- HF solder paste offers the following:
- Reduced environmental impact
- Attractive end-user perception
- Zero Halogen reduces risk
- Zero added Halogen Solder Pastes are now a technical possibility



# Thank you for Listening

## Any Questions?