iNEMI

International Electronics Manufacturing Initiative

Creep Corrosion Project

Finished in Q4 2012

Project leaders: Xiaodong Jiang (Alcatel-Lucent), Mason Hu (Cisco) and Simon Lee (Dow)

iNEMI Staff: Haley Fu

Advancing manufacturing technology

Thrust Area: Miniaturization

TIG: Board Assembly

Creep Corrosion Project

Phase 3: Investigation of Factors That Influence Creep Corrosion

Apr-13

Goal: **Phase 3: Understand the sensitivities of the identified factors to Creep Corrosion. Correlate experimental test conditions to environment classification standards.**

Strategy

- Survey of the occurrence of creep corrosion in the industry
- Inclusive of global applications
- Investigation of environmental conditions related to creep corrosion (temperature, relative humidity, atmospheric concentration of sulfide)
- Investigation of the surface finishes related to creep corrosion
- Investigation of manufacturing factors related to the incidence of creep corrosion (e.g. flux, processing, operations)

Project Lead: Xiaodong Jiang, Alcatel-Lucent

Project Co-Lead: Mason Hu, Cisco; Simon Lee, Dow

Issues

- Due to RoHS transition, the SnPb based PWB finish will move to Pb-free compatible finishes
- Corrosion of electronics in many areas in Asia
- However, there is very little agreement on the test methods and conditions
- This project seeks to establish a standard test methodology to facilitate further investigation of this problem.

Graphics

Tactics

- Phase 1 Survey to collect the data on creep corrosion failures and related factors in the electronics industry
- Phase 2 Use the output of Phase 1 to analyze and understand the root cause of creep corrosion
- Phase 3 Understand the sensitivities of the identified factors to Creep Corrosion

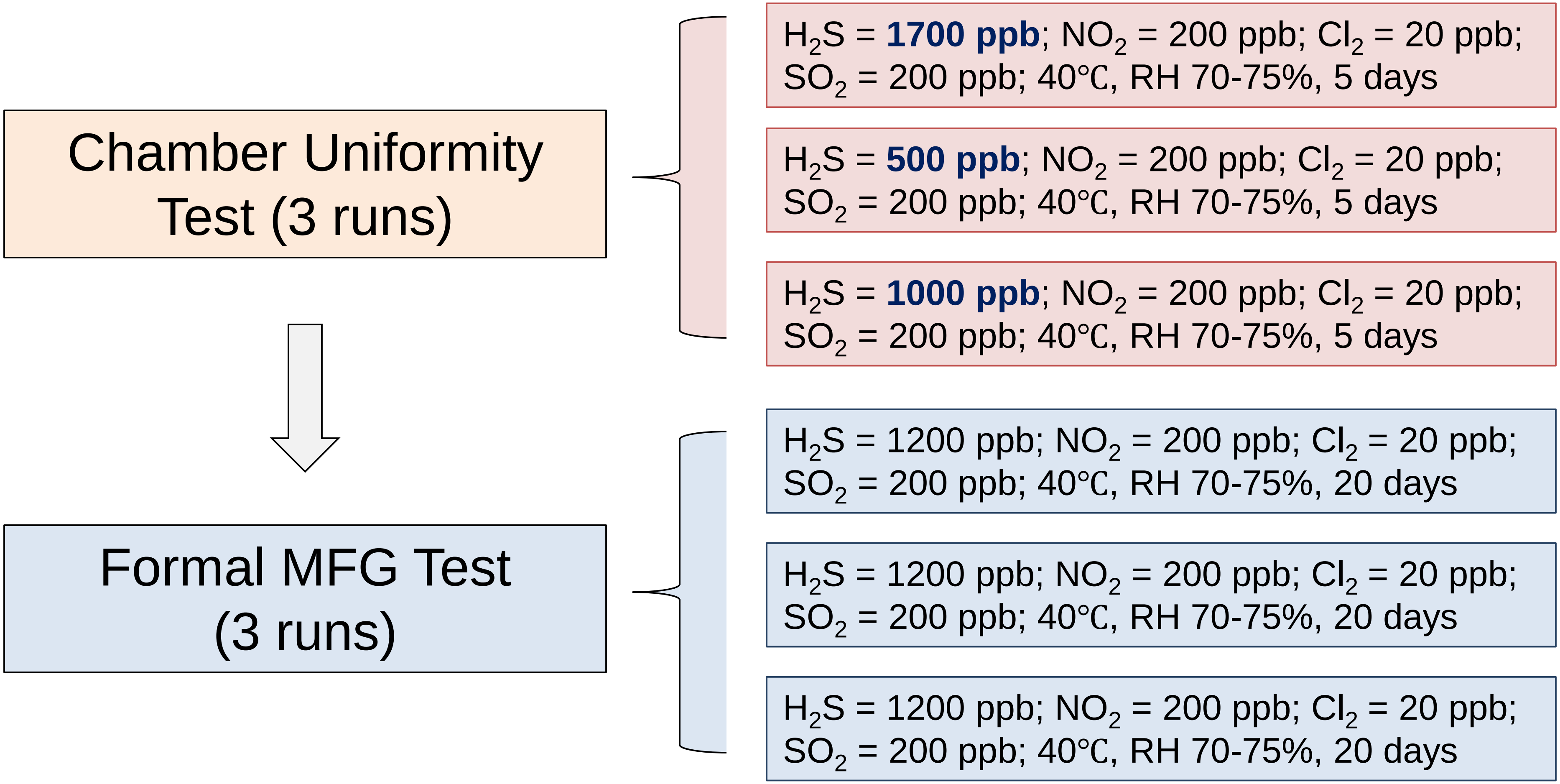
Milestones and/or Deliverables	Plan	Actual
Phase 1 Survey	May ‘10	Done
Phase 2 Identify factors & establish experimental plan	Nov ‘10	Done
Phase 3 Experiments to Investigation of Factors That Influence Creep Corrosion	Jan ‘12	Aug ‘12

Chamber setup for mixed-flowing gas test (MFG)

Phase 3: Investigation of Factors That Influence Creep Corrosion

- Perform laboratory-based experiments to investigate the affects of:
  - surface finish,
  - flux,
  - solder mask geometry,
  - solder paste coverage,
  - reflow and wave soldering and
  - mixed-flowing gas test conditions.

Test Plan



Chamber Uniformity Test (3 runs)

- H_2S = **1700 ppb**; NO_2 = 200 ppb; Cl_2 = 20 ppb; SO_2 = 200 ppb; 40℃, RH 70-75%, 5 days
- H_2S = **500 ppb**; NO_2 = 200 ppb; Cl_2 = 20 ppb; SO_2 = 200 ppb; 40℃, RH 70-75%, 5 days
- H_2S = **1000 ppb**; NO_2 = 200 ppb; Cl_2 = 20 ppb; SO_2 = 200 ppb; 40℃, RH 70-75%, 5 days

Formal MFG Test (3 runs)

- H_2S = 1200 ppb; NO_2 = 200 ppb; Cl_2 = 20 ppb; SO_2 = 200 ppb; 40℃, RH 70-75%, 20 days
- H_2S = 1200 ppb; NO_2 = 200 ppb; Cl_2 = 20 ppb; SO_2 = 200 ppb; 40℃, RH 70-75%, 20 days
- H_2S = 1200 ppb; NO_2 = 200 ppb; Cl_2 = 20 ppb; SO_2 = 200 ppb; 40℃, RH 70-75%, 20 days

Pause the test every 5 days to check the TV status and record the results. One formal test run lasts for 20 days.

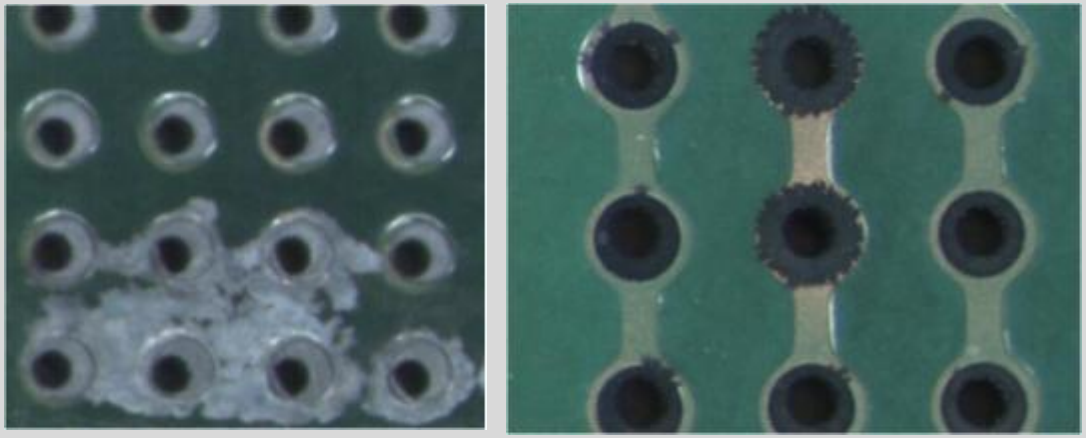
Definition

Creep Corrosion:

Copper creep corrosion is when the corrosion products spread onto the solder mask beyond the edge of the pad or via.

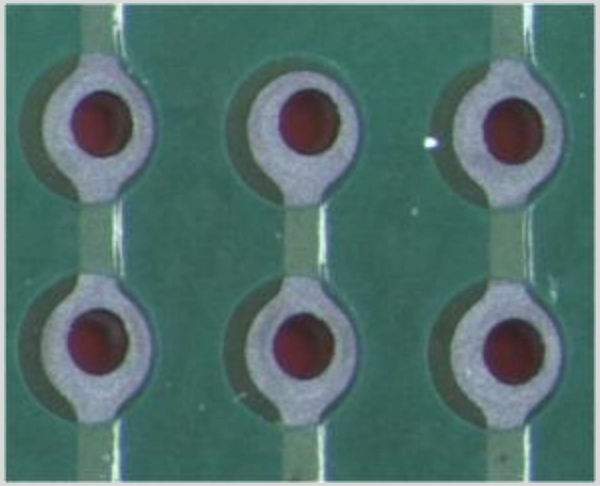
Heavy Creep (left picture) - Massive spread of corrosion products shorting signals.

Light Creep (right picture) - Onset of creep signatures on the solder mask interface.



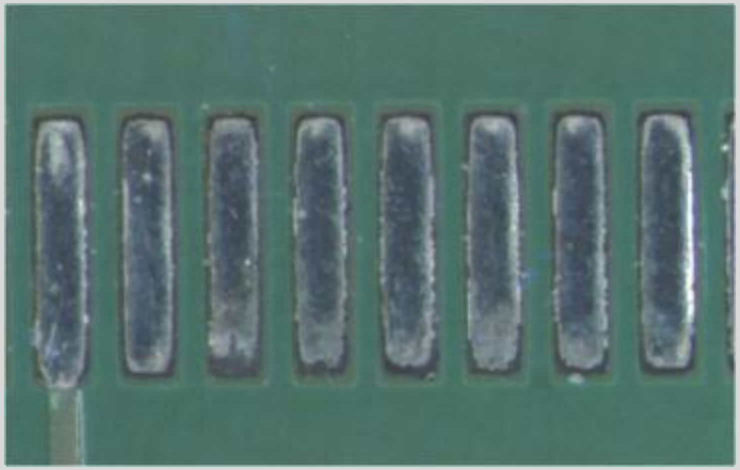
Corrosion:

Corrosion product on the surface of the pad or via. But no spread of the material onto adjacent surfaces.



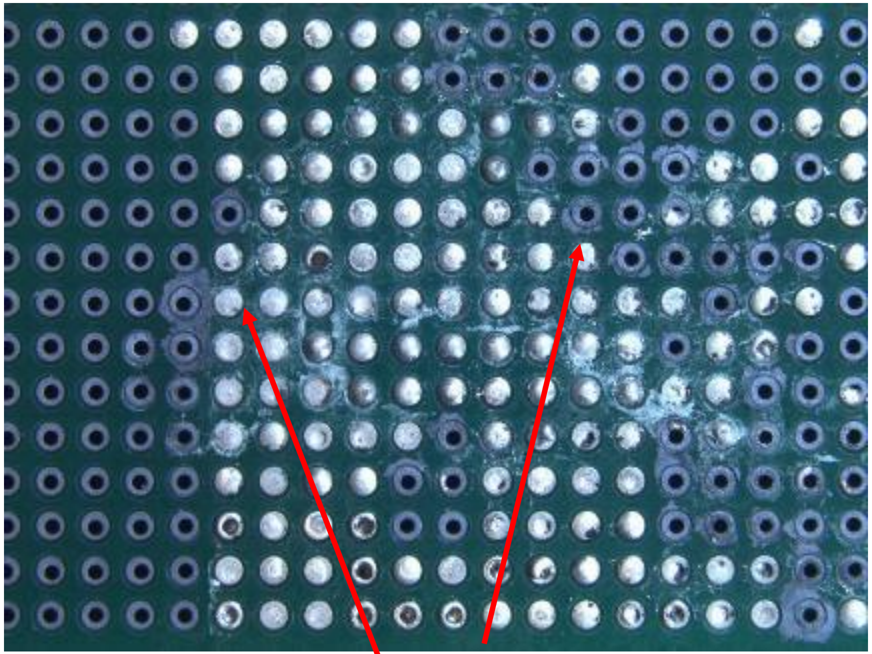
Edge Corrosion:

Corrosion products only along the edge of the pads.



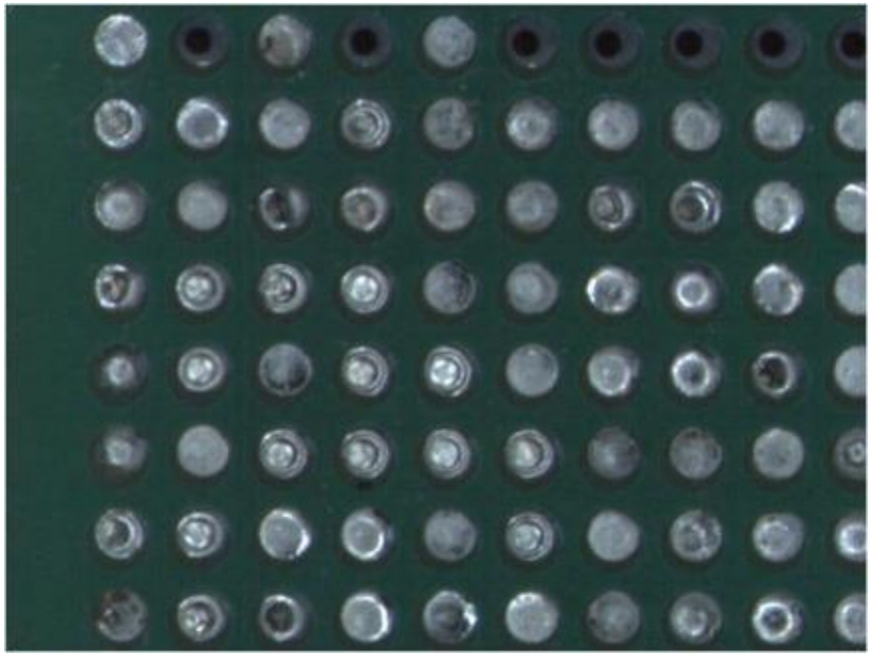
ImAg, 20 Days MFG

Organic acid flux



Creep corrosion in the soldered and boundary areas

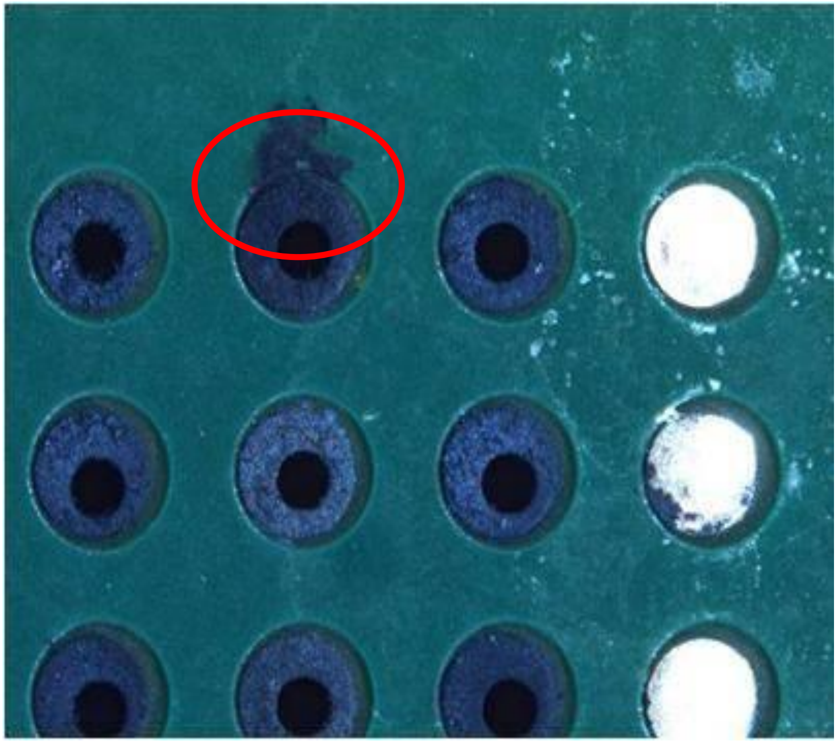
Rosin Flux



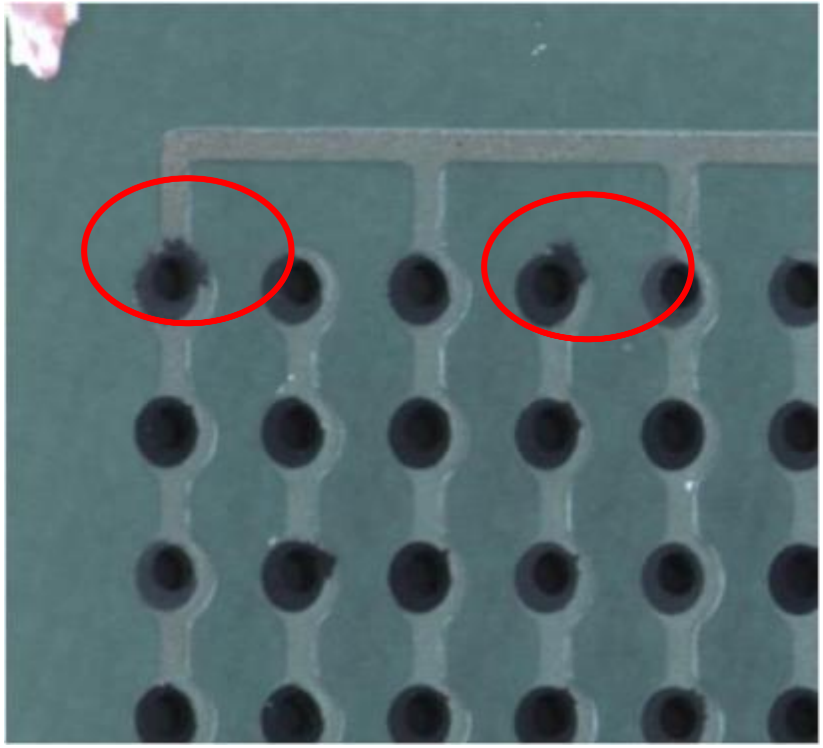
No significant creep corrosion. General tarnish.

OSP, 20 days MFG

Organic acid flux



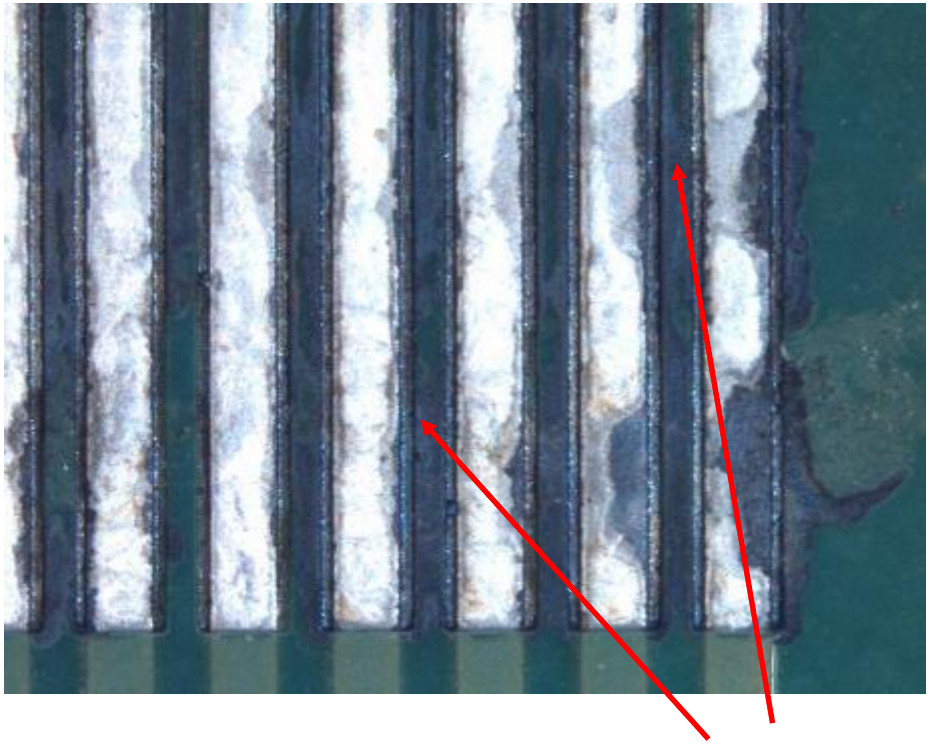
Rosin Flux



Minor creep corrosion, non solder or flux location

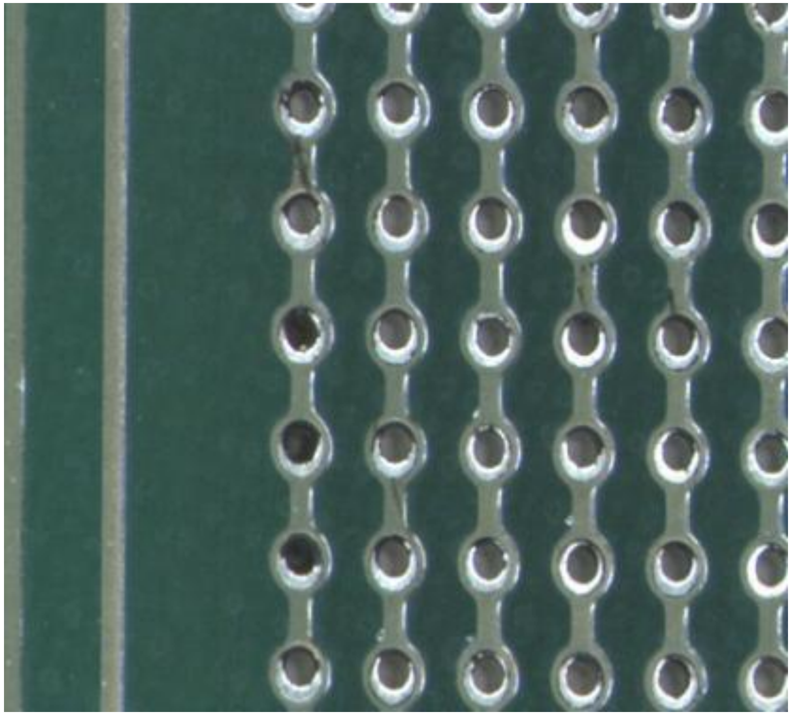
Pb-free HASL, 20 Days MFG Testing

Organic acid flux



Creep corrosion and edge corrosion due to poor HASL coverage

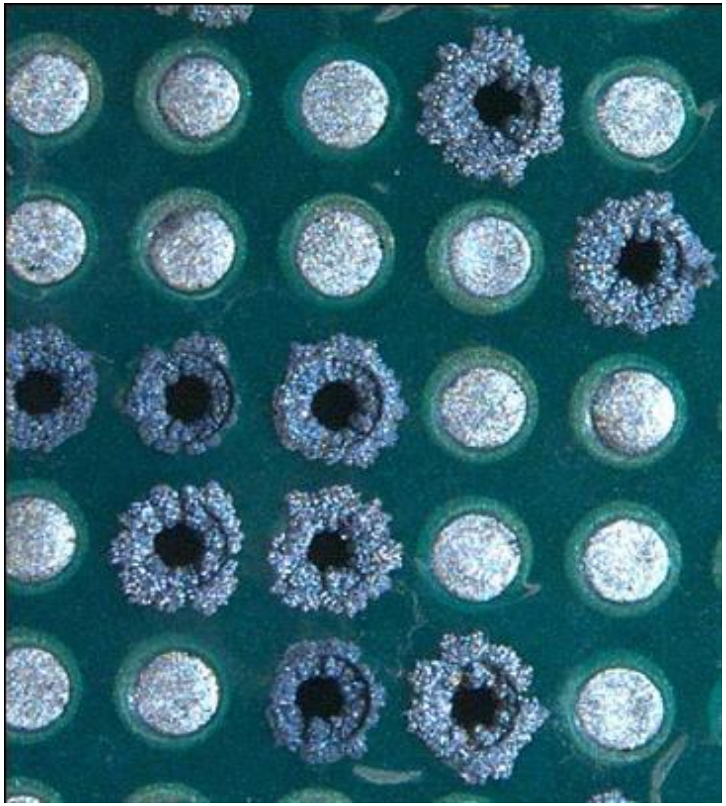
Rosin Flux



No creep corrosion

ENIG, 20 days MFG

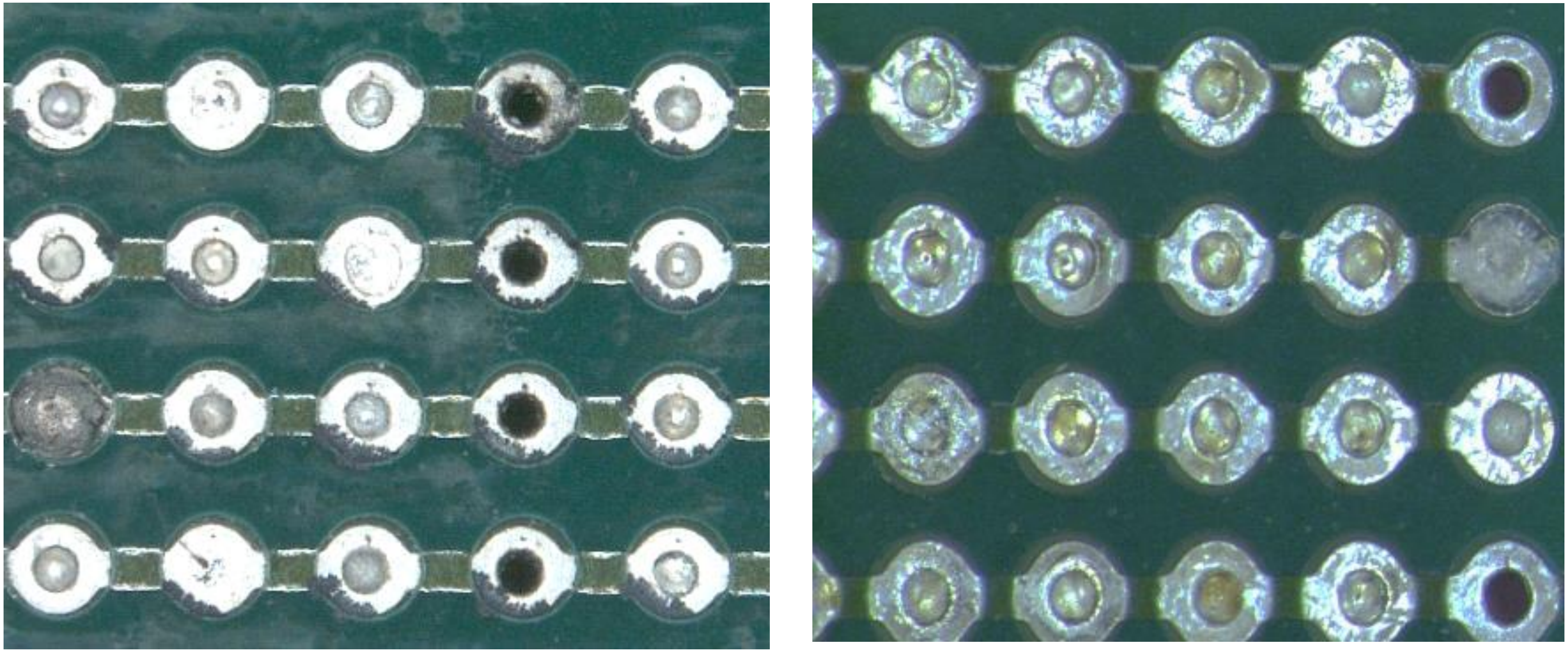
Organic Acid flux



Rosin Flux

High creep corrosion

Lead Free HASL, 20 days MFG

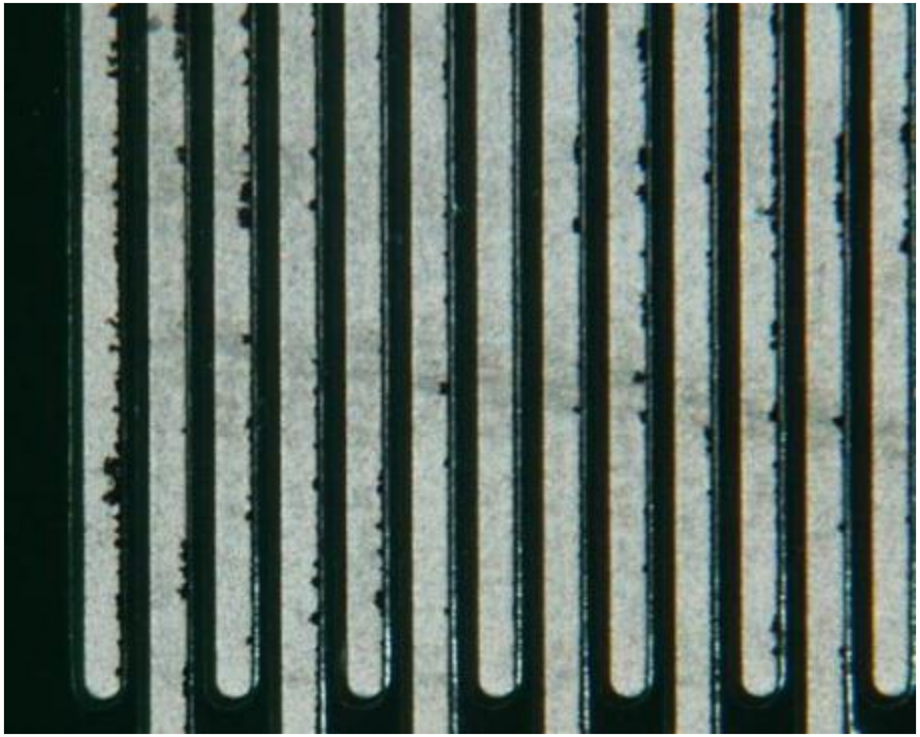

Organic Acid flux

Rosin Flux

Light creep corrosion on organic acid flux sample, no creep corrosion on rosin flux sample

ImSn - No Creep Corrosion

- **Only small amount of edge corrosion on organic acid flux sample**
- **Sn is more anodic with respect to copper than gold is on ENIG**
- **Sn based alloy has low reactivity in sulfur rich environment**



Project Summary

- MFG test conditions of all 3 runs were chosen to reach the target of about 500nm/day copper corrosion rate.

- Creep corrosion was observed on 4 of 5 finish types tested (ImAg, OSP and Pb-free HASL and ENIG):
  - Most severe creep corrosion was observed on ImAg boards with organic acid flux.
  - Pb free- HASL with Rosin flux experienced no creep corrosion. However edge corrosion was commonly seen on these boards
  - ImSn showed the least creep corrosion tendency

Project Summary – continue

- Organic Acid vs. Rosin Flux
  - Organic acid fluxed boards showed more creep corrosion than rosin fluxed boards.
  - On boards processed with organic acid fluxes the worst creep corrosion was seen in the regions adjacent to wave soldered locations.
- Excess rosin flux residue
  - Reduced creep corrosion on ImAg board, but increased creep corrosion in ENIG samples. This observation needs to be verified with further experiment. This could also be due to the difficulty of controlling the distribution of flux residues (perhaps also other surface contamination) on solder mask.
- Rosin activity
  - Both rosin fluxes with lower and higher rosin content showed similar creep corrosion results

iNEMI

International Electronics Manufacturing Initiative

Qualification Test Development for Creep Corrosion

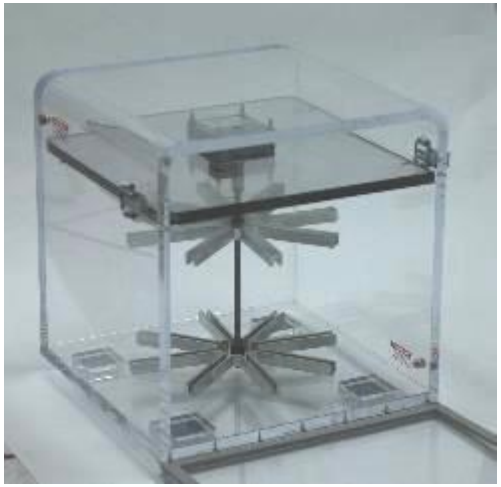
New for sign-up

Co-chair: Prabjit Singh (IBM)
iNEMI staff: Haley Fu

Advancing manufacturing technology

Qualification test development for Creep corrosion Phase 1 – Primary Investigation on Flowers of Sulfur Test (sign-up ends on April 19th)

- **The iNEMI project on creep corrosion (2009-2012) using mixed-flowing gases (MFG) was successful in in identifying the role of finishes and fluxes on creep corrosion.**
- **The challenge remains to develop a simple test that suppliers can use to prove that their products will survive reasonably clean environments.**

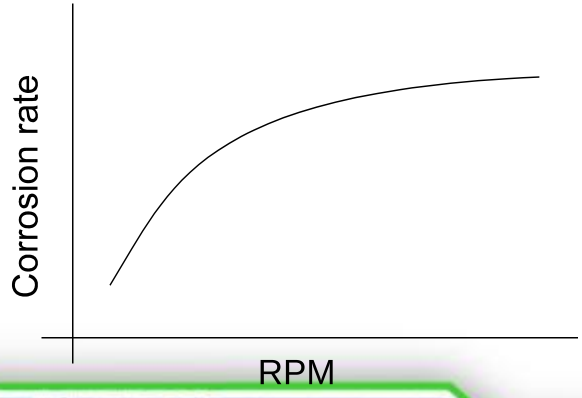


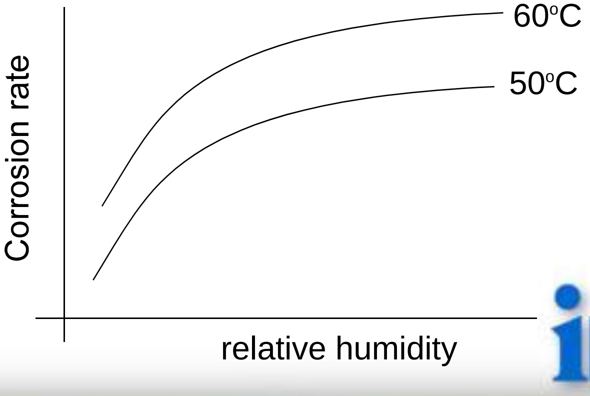
Qualification test development for Creep corrosion Overall Project Plan

	Brief description of each phase	Execution Time (months)
Phase 1	Determine the relationship of copper and silver corrosion rate with the temperature and humidity in a flowers of sulfur chamber. Determine the possibility of chloride contamination from the saturated salt solution.	6-8months
Phase 2	Determine the optimum condition of temperature and humidity to achieve reproducible creep corrosion on ImAg finished boards soldered with organic acid flux. Round robin test at multiple sites.	6-8 months
Phase 3	Evaluate the creep corrosion propensity of ImAg, ImSn, OSP, HASL and ENIG finished boards with rosin fluxes of various rosin contents. Other finishes, fluxes and PCB design features will be evaluated depending on iNEMI member interest. Compare with MFG test results.	6-8 months

Phase 1 – Primary Investigation of Flowers of Sulfur Test Proposed design of experiment

Non chloride salts	**Chloride salts**	**% relative humidity**	
		50^{o}C	**60^{o}C**
K_2SO_4		96	96
KNO_3		85	82
	KCl	81	80
	NaCl	75	75
$NaNO_3$		70	68
$NaNO_2$		59	59
Na_3PO_4		TBD	TBD





Phase 1 – Primary Investigation of Flowers of Sulfur Test

Timeline

Phase 2	Months											
Tasks	1	2	3	4	5	6	7	8	9	10	11	12
1. Test preparation	▨	▨										
Review chamber design & build instruction	X											
Purchase chambers	X											
Material sourcing		X										
Finalize DoE & resource		X										
2. Preliminary study (Corrosion rates and the effect of RPM)			X									
3. DoE test runs at multiple sites (with various salts, temperature)				▨	▨	X						
4. Summary							X					
5. Plan the 2nd phase								X				

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