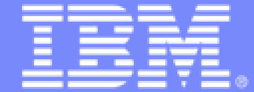
Integrated Supply Chain



IBM PCB Pb-free Transition

Marie Cole and Jeffrey A Taylor
Matt Kelly, Brett Krull, Kaspar Tsang, PS Hou, Brian Carlson, Granit Wang, Dave Braun, Kevin Splittstoesser

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- **EU RoHS Regulatory Update**
- **IBM Pb-free Transition Roadmap**
- **Pb-free Assembly Requirements for PCBs**
- **PCB Pb-free Qualification Approach and Status**
- **PCB Pb-free On-going Work**
- **Summary**

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EU RoHS Requirement Background

- **EU RoHS exemption review in progress**
  - Consultant recommended Server exemption expiry in 2014
  - Finalization expected in 2010, coincident with RoHS recast
  - Net: IBM roadmap plans for 2014 expiration
- **Recent discussion includes halogen-free requirements**
  - Future target for restriction
  - Details unclear: compounds, levels, applications, etc
- **IBM to continue close monitoring of regulatory requirements**

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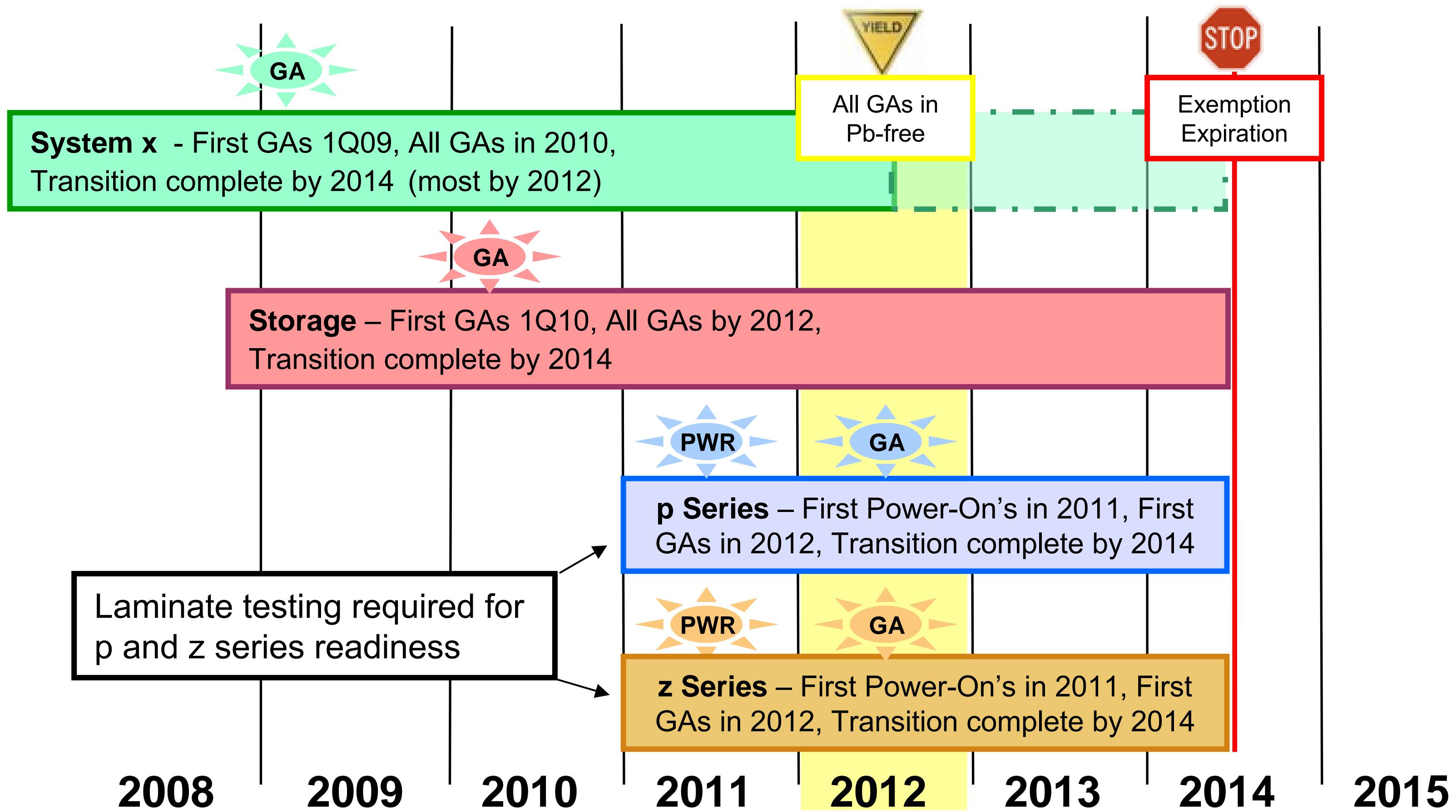
IBM Pb-free Transition Roadmap



PCB raw card must be available for Power-On and qualified for GA (including 260°C)

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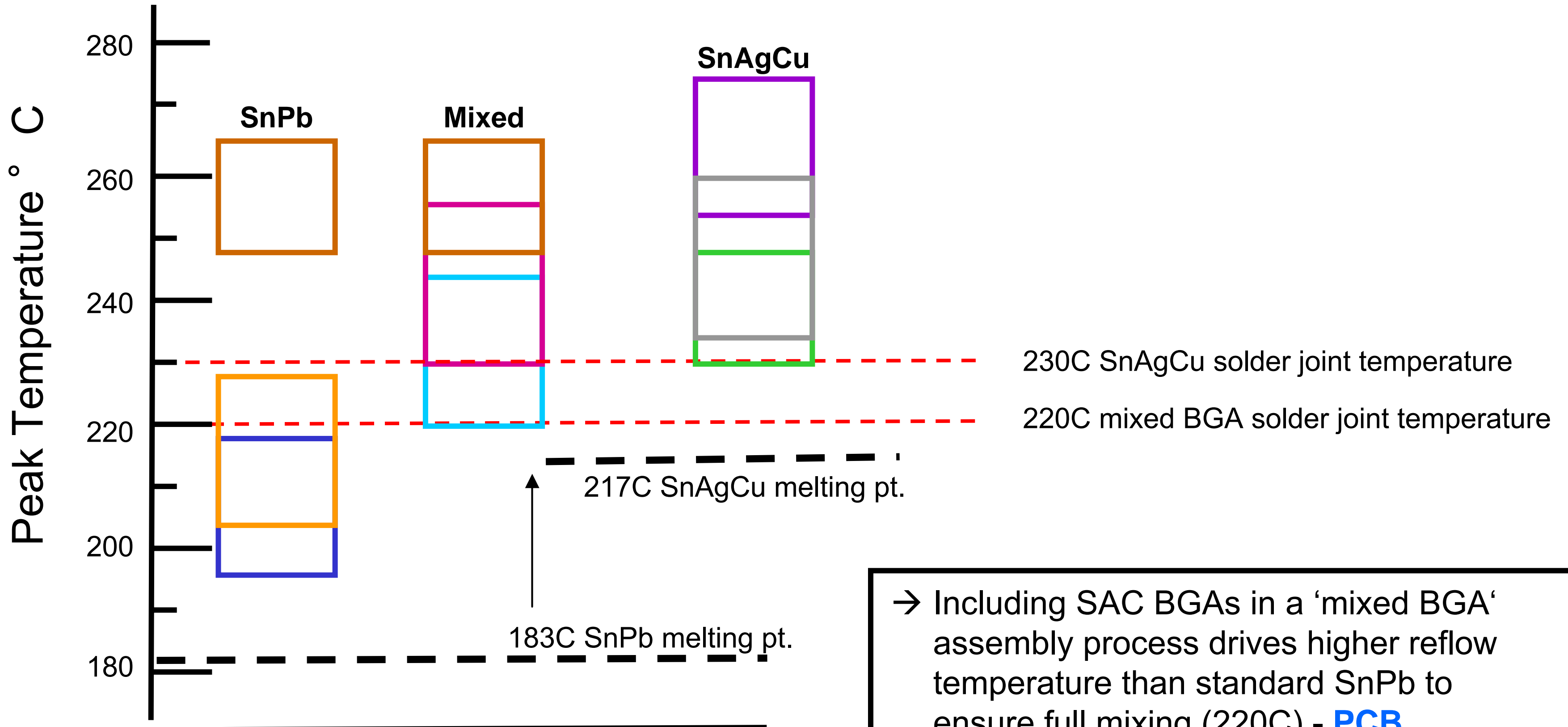
Elevated Solder Processing Temperatures



→ Including SAC BGAs in a 'mixed BGA' assembly process drives higher reflow temperature than standard SnPb to ensure full mixing (220C) - **PCB requirement of 245C.**

→ Full Pb-free assembly drives minimum 230C solder joint temperature – **PCB requirement of 245-260C**.

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PCB Laminate Qualification Process

- **IBM Suppliers Slowly Passing Qualifications (MSA, 245 °C)**
  - Applicable to material/fab site combination
  - Limited to 1 oz. and 2 oz. copper planes

High volume	**75 mils**
Others	**100 mils**
	130 mils

- **Extend from Mixed Assembly to Entry Pb-free Assembly (245 °C)**
  - New Investigations / Additional Tests
  - PCB / Solder Joint Interaction

- **Extending Efforts for Pb-free Assembly (260°C)**
  - Increased complexity driving higher temperatures
  - Targeted PCB thicknesses
    - Blade planars, HE x ≤110 mils
    - MR/HE applications ≤130 mils
    - Midplanes, HE p, z > 130 mils
  - Include 3 oz. – 5 oz. copper planes
  - Include vapor phase processing for high end

Thickness	Temperature
<100 mils	5 x 245 °C
>100 mils	5 x 245 °C or (3 x 260 °C) + (2 x 245 °C)

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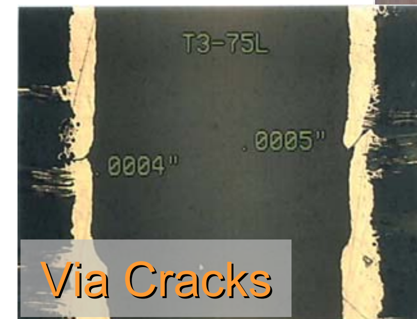
PCB Integrity Tests (5X Reflow Simulation)

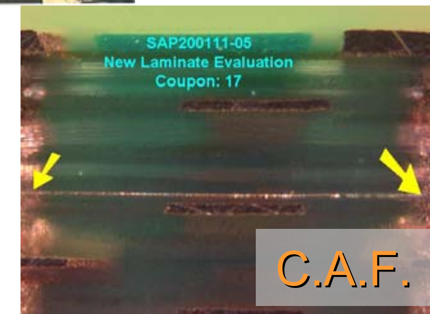
Laminate Integrity

- **Surface-Visible Delamination**
  - Usually in Featureless Areas
  - May Worsen with Storage
- **Hidden Laminate Cracks**
  - Found in Laminates down to 75 mils thick.(thus far)
  - Near Center of Stack Up, No Hint on Surface
  - In Module Sites, within the Laminate
    - At Glass-to-Resin Interface or in the Resin
    - Horizontal or Vertical Cracks



Via Reliability

- Laminate Cracks Invalidate Test
- Candidate Laminate Recipes Meeting Requirements (245°C)
- Failures Due to Various Manufacturing Defects
- Expect Greater Sensitivities as Increase Reflow Temperature



Conductive Anodic Filament Formation

- Laminate Cracks Invalidate Test
- Testing Issue: Acceleration Requires Moisture

Land-to-Barrel Interface Integrity

- More Failures Observed After Reflow than After 6x Solder Float

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PCB Supplier / Laminate Material Qualifications

Supplier (Facility / Material)	Thickness (mils)	Peak Temperature		Entry Level	Qualification Status
		245C	260C		
1 / C	75	x		x	Qualified
2 / H		x		x	Qualified
7 / B		x		x	Qualified
9 / L		x		x	Qualified
2 /G	100	x			Qualified
4 / I		x			Qualified
9 / E		x			Qualified
3 /G		x			In Progress
1 / C		x			In Progress
8 /C			x		Investigation
8 /M			x		Investigation
1 /C	110		x		Investigation
2 /G			x		Investigation
9 /L			x		Investigation
5 / J	120	x			Qualified
5 / K			x		In Progress
6 / A	130	x			Qualified
9 / L		x			Qualified
10 / A		x			Qualified
2 /D			x		Investigation
2 /F			x		Investigation
9 /D			x		Investigation

Note:
standard loss laminates

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PCB Laminate Assembly Requirements

- **Assembly temperature constraints**
  - Minimum solder joint temperatures
    - 220C required for SAC BGA in SnPb ‘mixed assembly’ process
    - 230C required for all solder joints in SAC assembly process
  - Maximum component body temperatures: typically 230C – 260C
  - Maximum PCB temperature
    - 245C for mixed assembly process
    - 245C – 260C for SAC assembly process
  - Must assure primary attach and rework processes
- **Assembly process engineer must thermocouple and monitor broad selection of locations representing these constraints**
- **Feedback loop to component and PCB engineers on required temperature compatibility to achieve acceptable assembly**

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Pb-Free Assembly Experience

- **Pb-free assembly experience over 7 years refines PCB requirements**

Test Vehicle Studies (14 TVs)	Product Vehicle Studies (6 PVs)	Product Qualifications (9 GAs)
2002 – 2009	2007 – 2009	2007 – 2009
System x and base technology evaluations	System x, Storage, pBlade and L4	OEM, Custom DIMM, High Volume System x and Blade
2010 to add pHE / z	2010 to add pHE / z	2010 to extend System x, add Storage

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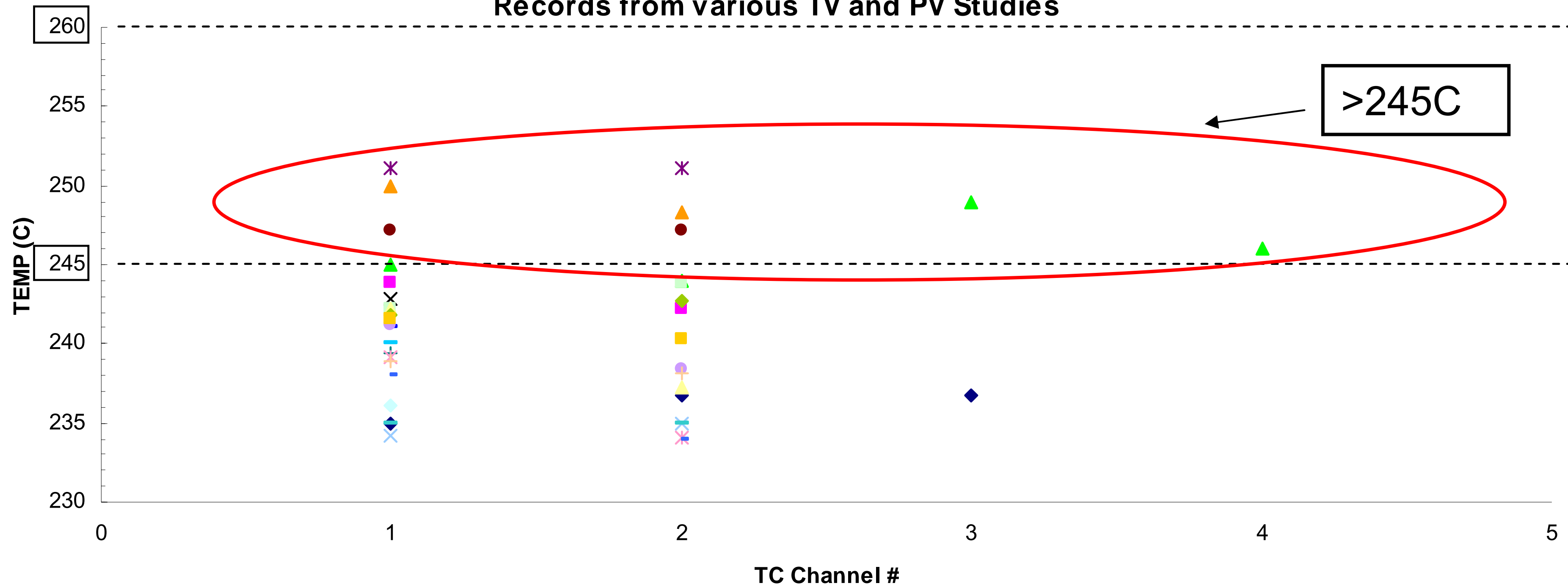
PCB Laminate Pb-free Assembly Requirements



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PCB Laminate Pb-free Assembly Requirements

- **Assembly processing effects**
  - Maximum PCB temperature required is a function of complexity
    - Pin density and thermal mass (components / connectors)
    - SMT complexity
    - PTH complexity
    - PCB construction: thickness, power planes, etc
  - Preconditioning must assure primary attach and rework
  - Assembly team continuing to monitor PCB temperatures
    - Ensure qualification limits are met
    - Increased data base across broad set of assemblies
    - Develop predictive tool for PCB reflow temperature required

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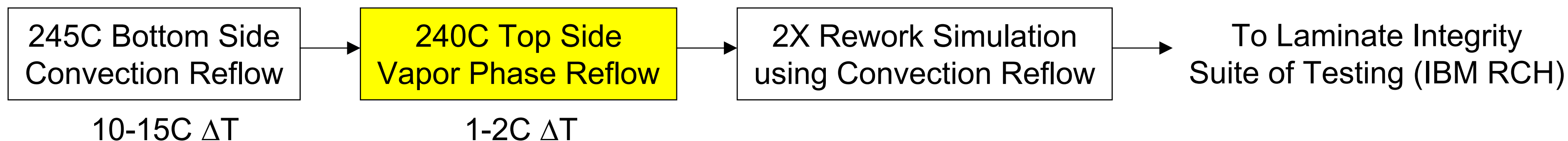
PCB Qualification – Vapor Phase

- **Vapor phase compatibility**
  - Certain pHE and z PCBAs currently require VP to meet all assembly requirements
    - Assume any PCBA in VP for SnPb will require VP for Pb-free
    - Pb-free reflow temperatures may increase VP assemblies
    - Improved convection ovens under evaluation to reduce impact
    - Planning underway to define transition point to VP for Pb-free
    - Thick PCBs: 180 – 200 mil
  - Preconditioning draft proposal under review by assembly team



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PCB Qualification – New Investigations

- **Additional Tests that Address PCB / Solder Joint Integration**
  - Effects of PCB upon solder joint – new solderability issues
  - PTH solder hole fill challenges – new surface finishes
  - Effects of Cu – SAC intermetallic formation
  - Effects of stiffer solder joint upon PCB – pad cratering

- **Effects of PCB Upon Solder Joint – New Solderability Issues**
  - Developing wetting balance test to replace solder dip test
  - Qualification method required for cards with reflow >245C
  - Method under development referencing J-STD-003B, Test F

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PCB Qualification – New Investigations

- **Pb-free PTH solder hole fill challenges – new surface finishes**
  - Wetting and spreading properties of Pb-free solder result in greater difficulty with wave solder hole fill
    - Card thickness > 100 mils increases challenge
    - Options for improvement over OSP surface finish?
  - Alternative surface finishes under consideration / evaluation
    - Immersion silver
      - Positive results for assembly processing and thermal cycle reliability
      - Corrosion concern in harsh environments (sulfur) too great to pursue
        - Immersion silver not preferred by IBM
        - Only allowed with specific approval (OEM content)
    - HASL (SnCuNi)
      - Positive results for assembly processing and thermal cycle reliability
      - Concerns under investigation for both vertical and horizontal processes
        - Thermal exposure during processing
        - Solder deposit consistency and surface flatness
        - Harsh environment performance

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PCB Qualification – New Investigations

- **Effects of Cu – SAC intermetallic formation**
  - Collaborating with IBM Bromont – chip carrier expertise
  - Assess propensity for formation of intermetallic voiding
    - Multiple PCB suppliers and plating chemistries
    - New test coupon (Isabel) and test method
      - SAC assembly, JEDEC preconditioning and high temperature soak
      - Compare 150C (2000 hr) and 175C (1000 hr) temperature soak
      - Ball pull, ball shear, microstructure
- **Effects of Stiffer Solder Joint Upon PCB – Pad Cratering**
  - Developing strategy by participating in several industry forums: Unovis, other direct collaborations
  - IPC 9708 in draft as a method document

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Summary

- **Server exemption expiration anticipated in 2014**
- **Pb-free compatibility readiness required**
  - System x and Storage – now
  - p and z series: 2011 Power On's and 2012 GA's
    - 260C compatibility needed
    - Significant challenges must be addressed
- **PCB reflow requirements and method vary by complexity**
- **Pb-free soldering brings additional challenges: solderability, surface finish, SAC intermetallic formation, pad cratering**
- **Collaboration with suppliers and industry required for success**

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Q & A

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