How is the commercial world responding to RoHS?

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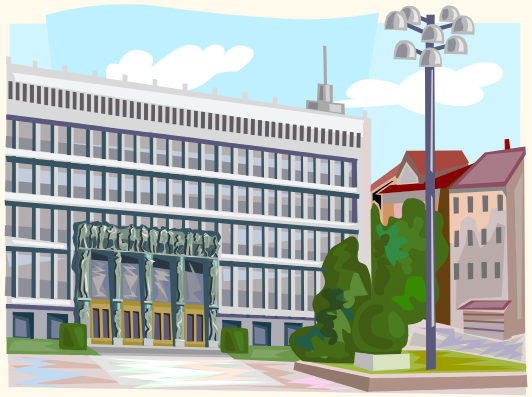
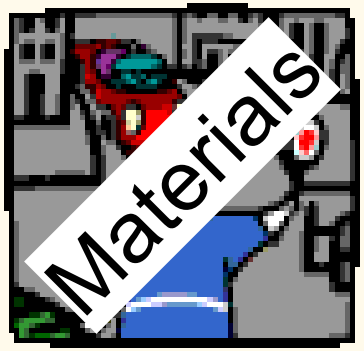
What is RoHS?

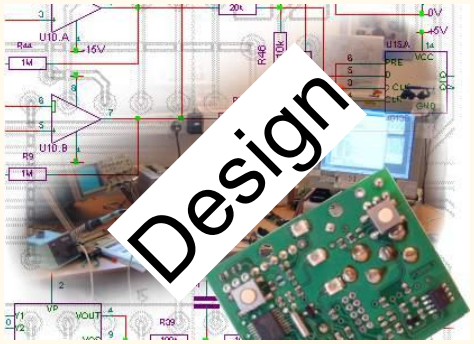
Restriction **O**n the use of certain **H**azardous **S**ubstances in Electrical and Electronic equipment (July 1, 2006)



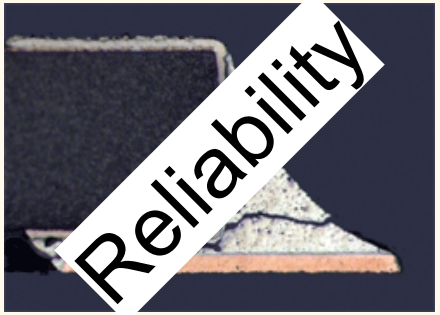
- Created by the European Union
- What is restricted?
  - Lead, mercury, cadmium, Cr^{6+}, polybrominated biphenyls (PBB), polybrominated diphenylethers (PBDE)
- Who is covered?
  - Household appliances, IT & telecom, Consumer equipment, Lighting, Tools, Toys and leisure equipment, Automatic dispensers
- Copycats spreading around the world
  - China (2007), Korea (2008), California (2010), South America (?)
- The result?
  - SnPb parts hard to find and getting expensive (40-50% increase)

Concerns of the Commercial Marketplace



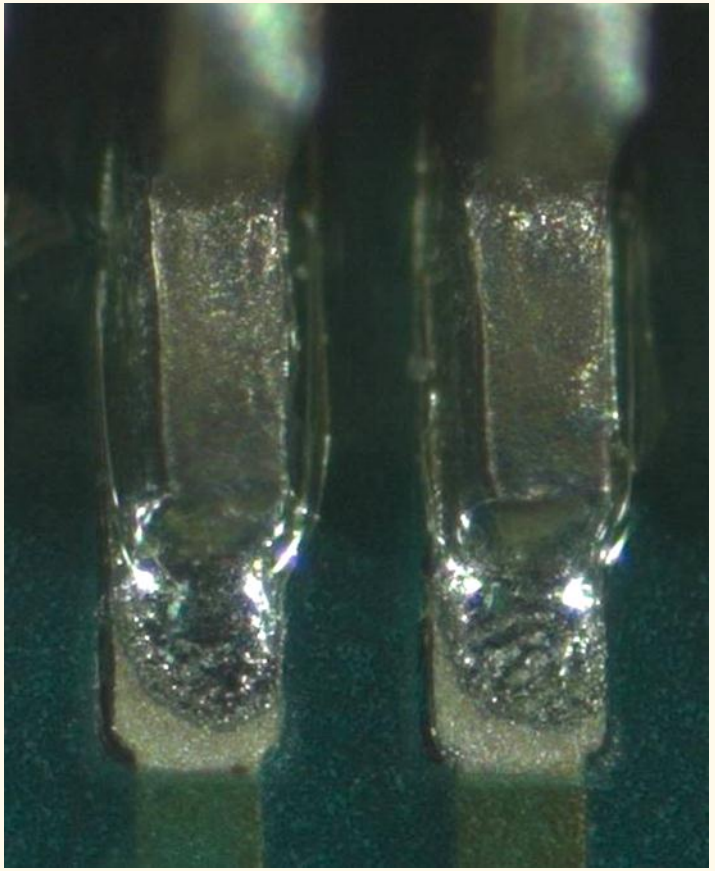


Everything they've always worried about?



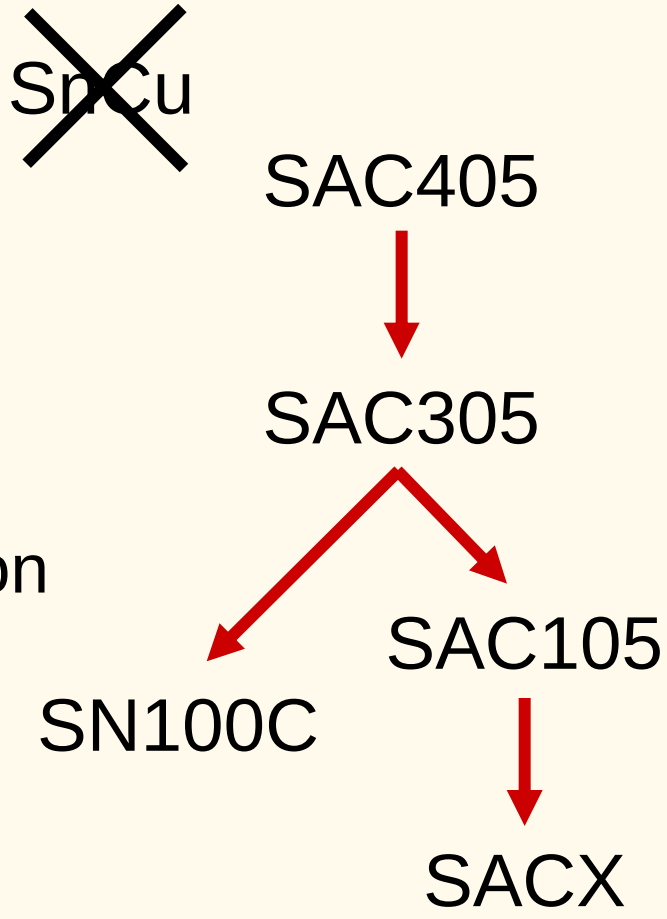
Design

- No major design changes
  - Some reduction in bond pad dimensions
  - Smaller ceramic capacitors for wave soldering



Good News!

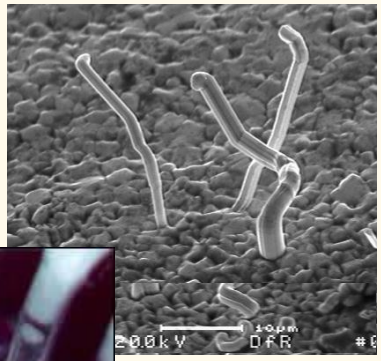
Suppliers (Parts)

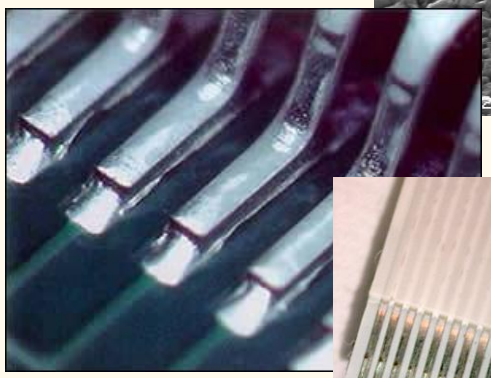


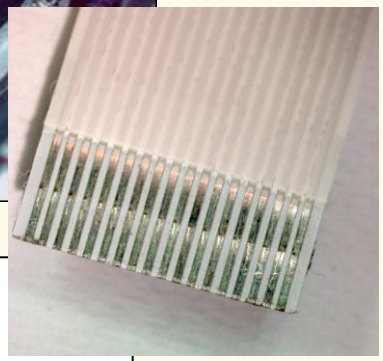
- Tracking of RoHS5 / RoHS6 compliance
  - Update of part control systems
  - Availability (Obsolescence)
- Market still unsteady; proliferation and evolution of material sets
  - Die Attach
  - Platings
  - Solder ball
- Robustness at elevated reflow temp
  - Pretty much addressed
- Tin whiskering

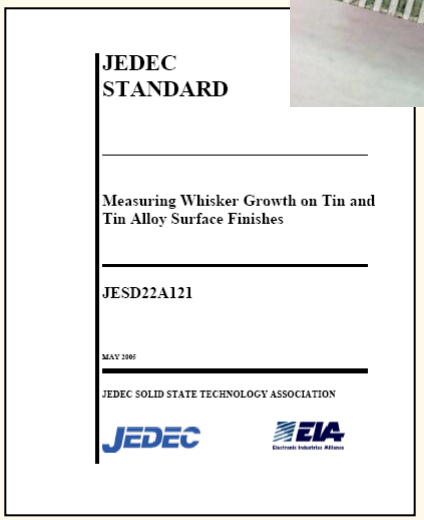
Supply Chain (Tin Whiskering)

- Focus on critical components
  - < 1 mm pitch (0.3 mm spacing)
  - Metal can housing
  - Contact points (flex connector)
  - Welds (electrolytic capacitors)
- Follow industry specifications
  - Perform testing
  - Request test data
- Demand mitigation
  - Anneal for 1 hr at 150C
  - Use nickel underplate (>1.2 μm)
  - Plating thickness > 10 μm
- Request alternatives
  - Not aware of any commercial company considering solder dipping








JEDEC
STANDARD

Measuring Whisker Growth on Tin and Tin Alloy Surface Finishes

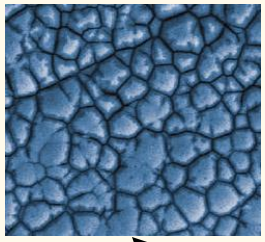
JESD22A121

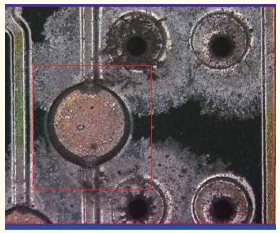
MAY 2006

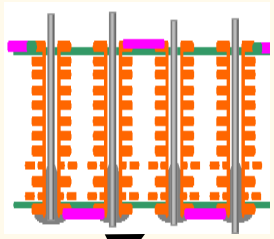
JEDEC SOLID STATE TECHNOLOGY ASSOCIATION

JEDEC EIA

Manufacturing (Printed Circuit Board)







- HASL – ENIG – ImAg – OSP – HASL (Pb-free)
  - Better wetting, good co-planarity, long storage life
- Damage during reflow

Board thickness	IR-240~250℃	IR-260℃
≤60mil	Tg140 Dicy All HF materials OK	Tg150 Dicy HF- middle and high Tg materials OK
60~73mil	Tg150 Dicy NP150, TU622-5 All HF materials OK	Tg170 Dicy HF –middle and high TG materials OK
73~93mil	Tg170 Dicy, NP150G-HF HF –middle and high TG materials OK	Tg150 Phenolic + Filler HF –middle and high TG materials OK
93~120mil	Tg150 Phenolic + Filler HF –middle and high TG materials OK	Phenolic Tg170 HF –middle and high TG materials OK
121~160mil	Phenolic Tg170 HF –high TG materials OK	Phenolic Tg170 + Filler HF –high TG materials OK
≧161mil	PhenolicTg170 + Filler HF material - TBD	TBD

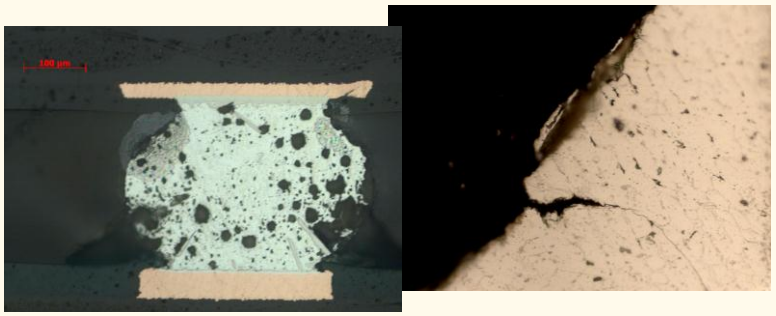
HASL – Hot air solder level
ENIG – Electroless nickel/immersion gold
ImAg – Immersion silver
OSP – Organic solderability preservative

Manufacturing (Printed Circuit Board Assembly)

- Narrower process window
  - Solvable (takes more time then you might think)

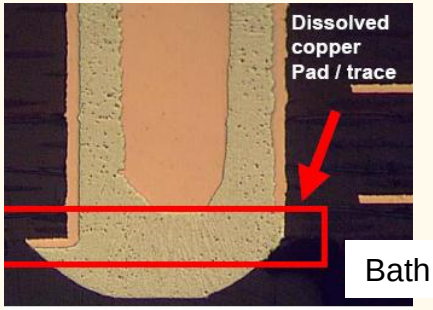
- Hole Fill
  - Higher pot temperatures, avoidance of OSP

- Shrinkage cracks / Hot tearing
  - Solvable



- Optical inspection
  - Pb-free now shiny

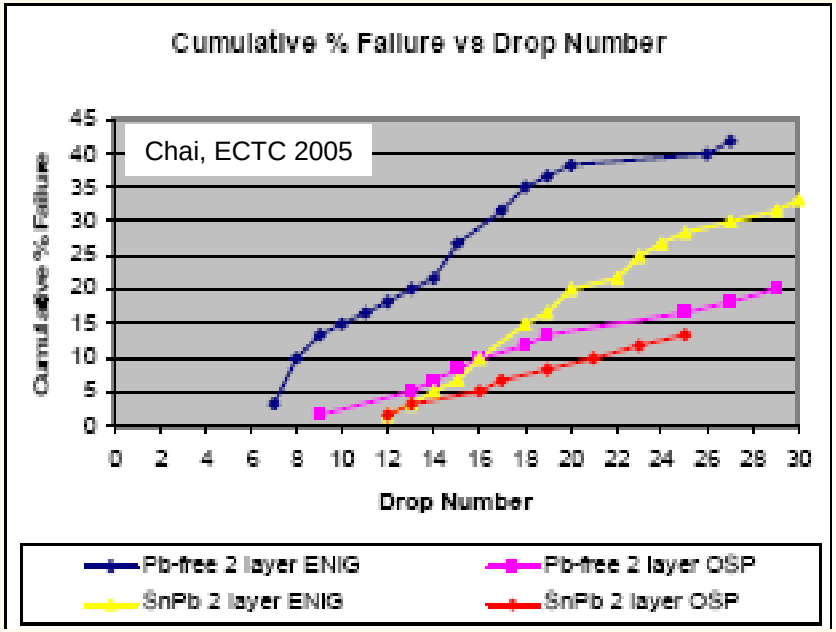
- Copper dissolution
  - Primarily a rework/repair issue
  - Isn't rework/repair always an issue?



Bath, iNEMI

Reliability

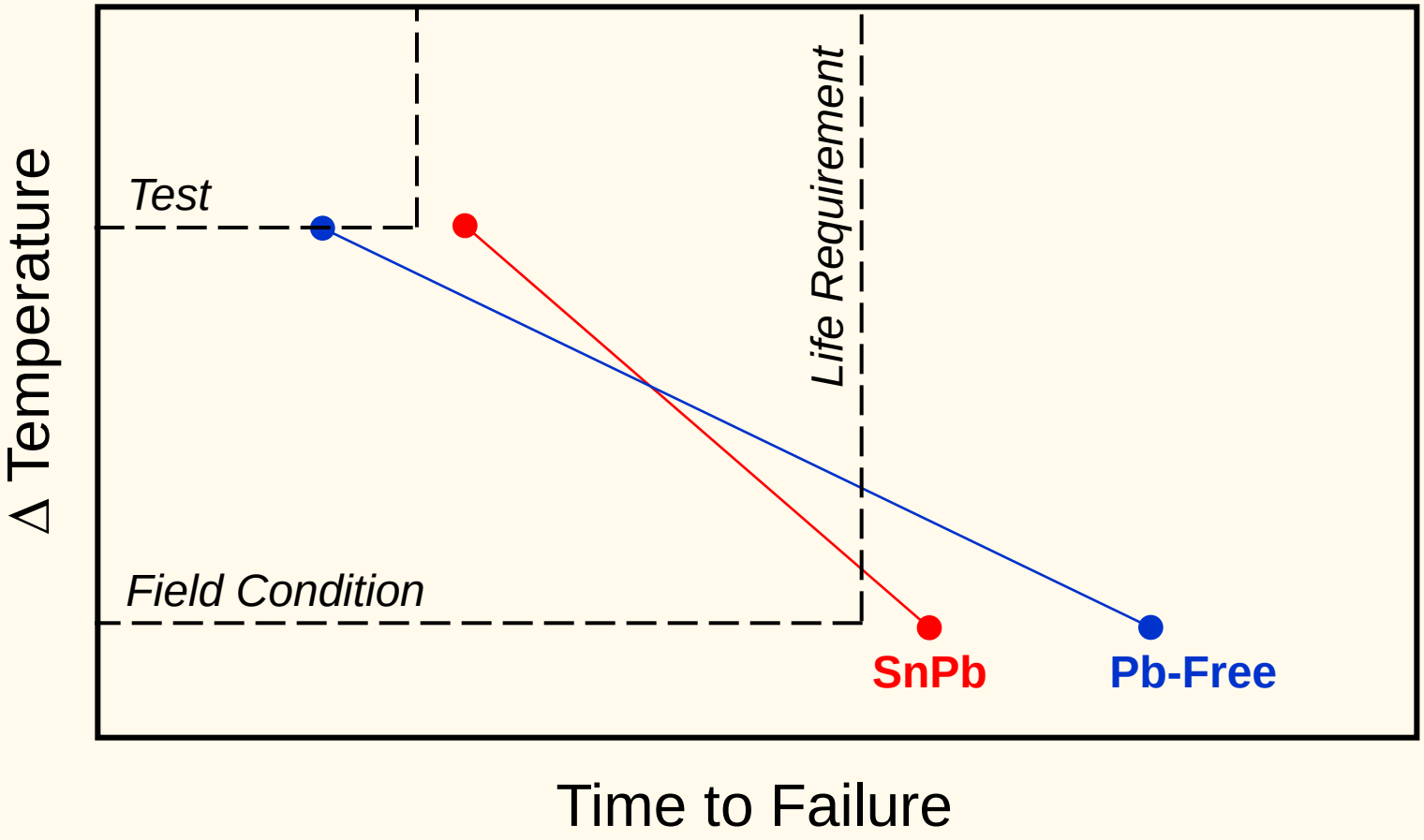
- Number one concern? Mechanical shock
  - High stress, high strain rate event
  - Drop, crash, direct-hit
- General findings
  - SAC less robust than SnPb
  - Plating materials are a greater driver
  - Still some uncertainty and contradiction



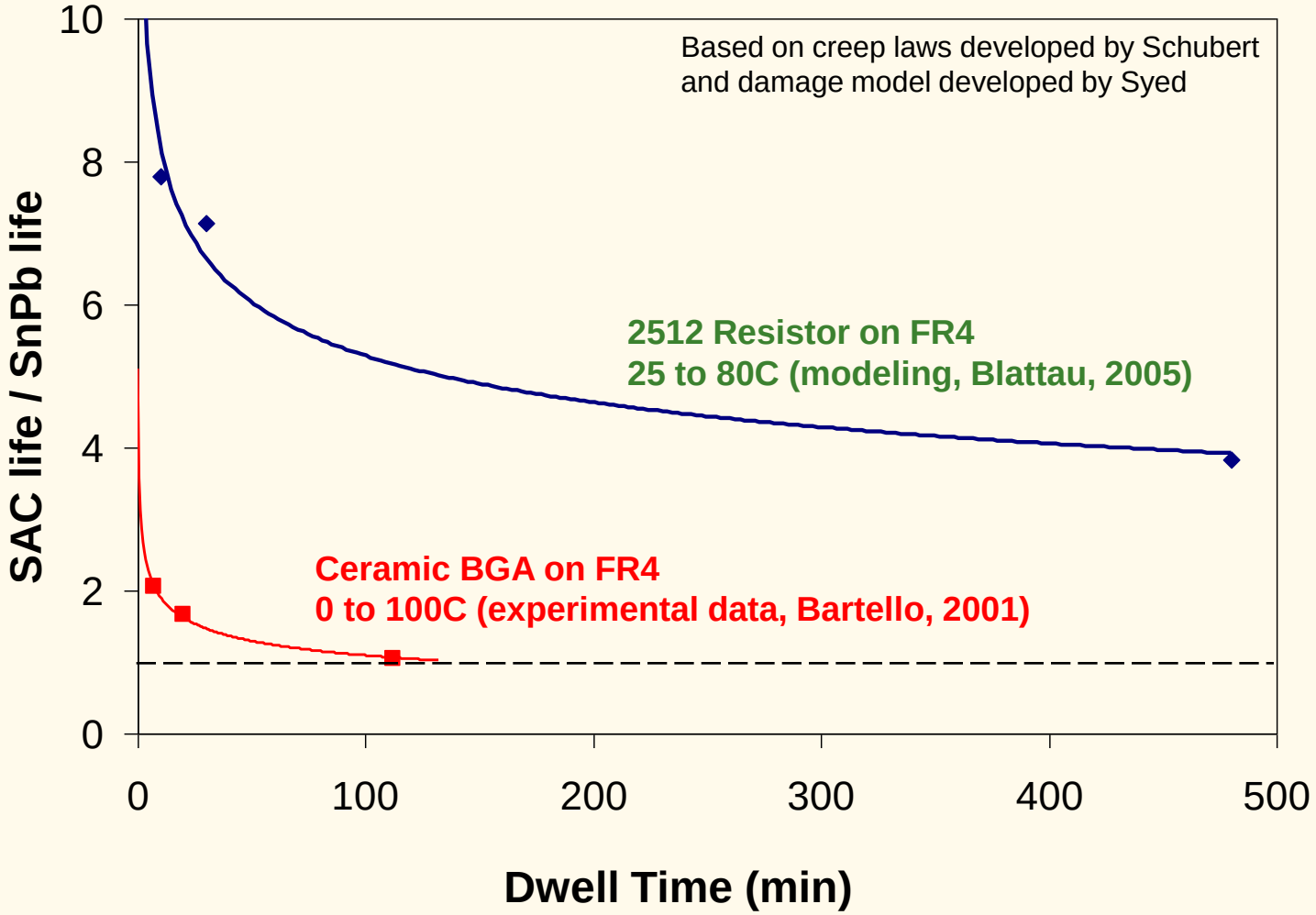
PQFP (28x28mm, 208 I/O)	Failures	
Pb-Free on ENIG	2/6	44/50, 45/50
Pb-Free on OSP	2/6	16/50, 29/50
SnPb on OSP	0/6	--

Chong, ECTC 2005

When is Failure not a Failure?



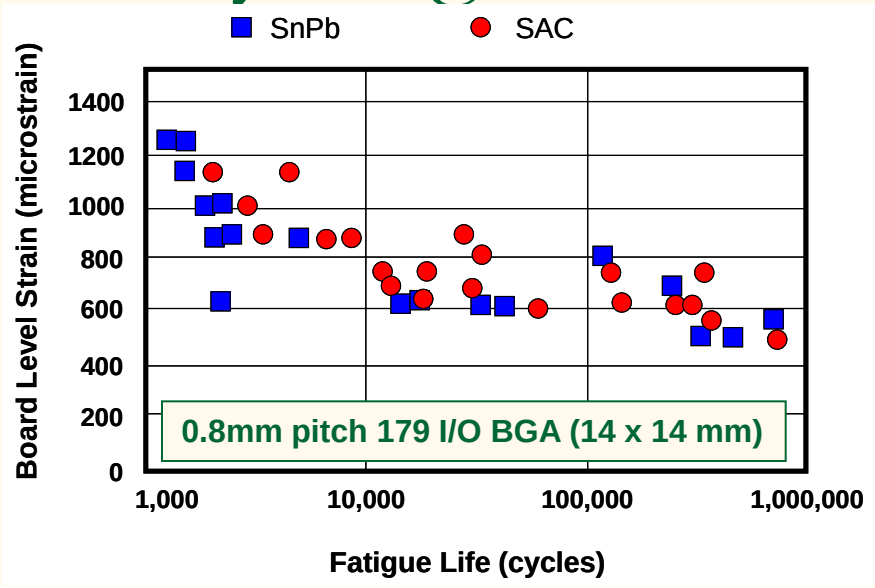
Long-Term Reliability of Pb-Free

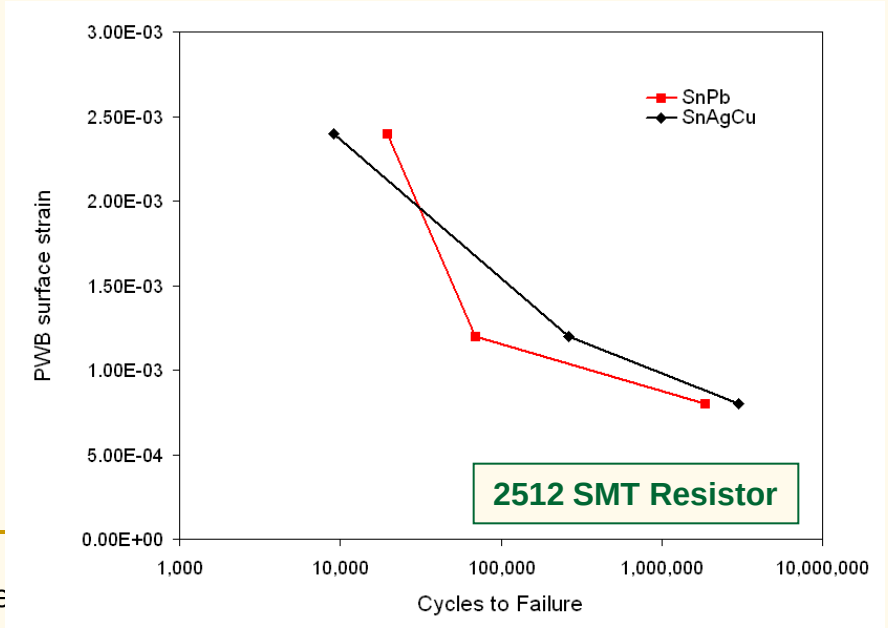


Visual concept courtesy of J.P. Clech

Vibration / Mechanical Cycling

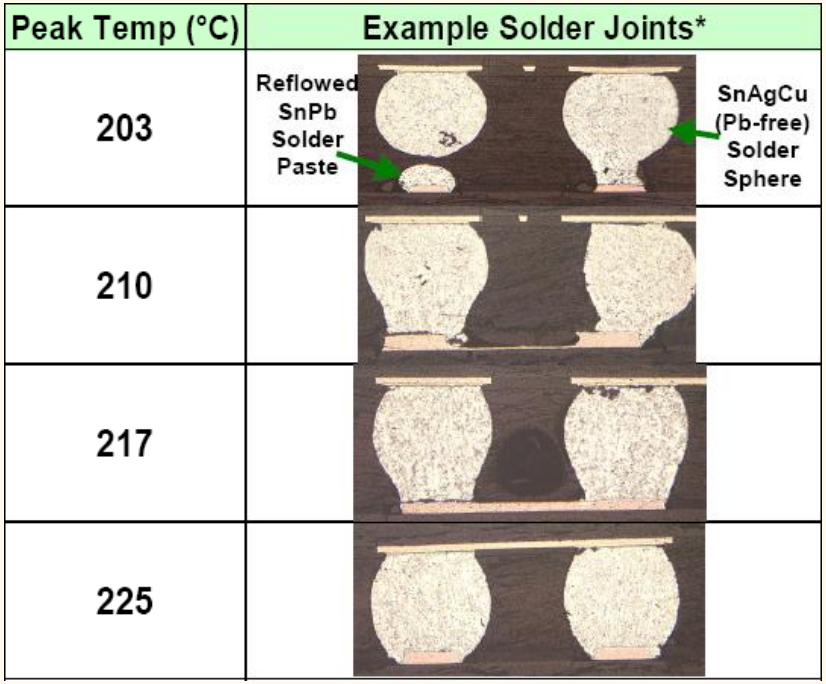
- Findings
  - High strain: SAC worse
  - Low strain: SAC better
- Missing datapoint
  - Leaded devices
  - Failure is in lead, not solder
  - Solder transfers stresses
- What does this mean?
  - Problems with vibration and SnPb → Problems with vibration and SAC
  - No problems now? No problems later

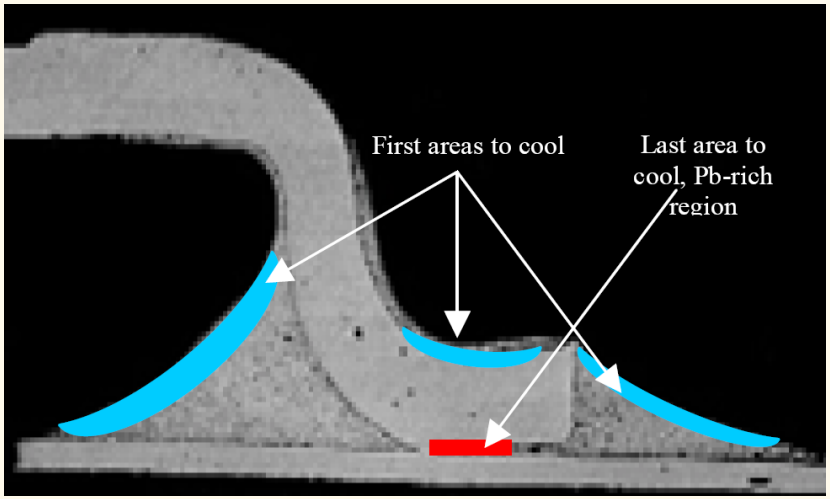




Material Issues 1

- How to combine SnPb and Pb-free?
- Case Study 1: Pb-Free BGA with SnPb solder
  - >225°C to 245°C peak
  - Vibe, Mechanical Shock performance lacking
- Case Study 2: SnPb Lead with Pb-free solder
  - Potential risk





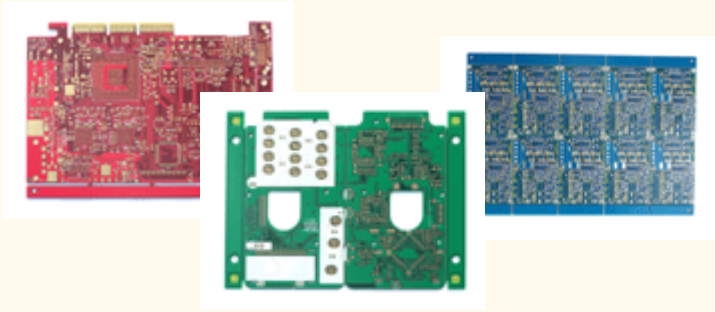
Material Issues 2

- How to segregate SnPb from Pb-free?

Incoming materials (parts, boards)

Analysis (surprisingly few)

Assembly (different lines, material segregation, change in solder pots)



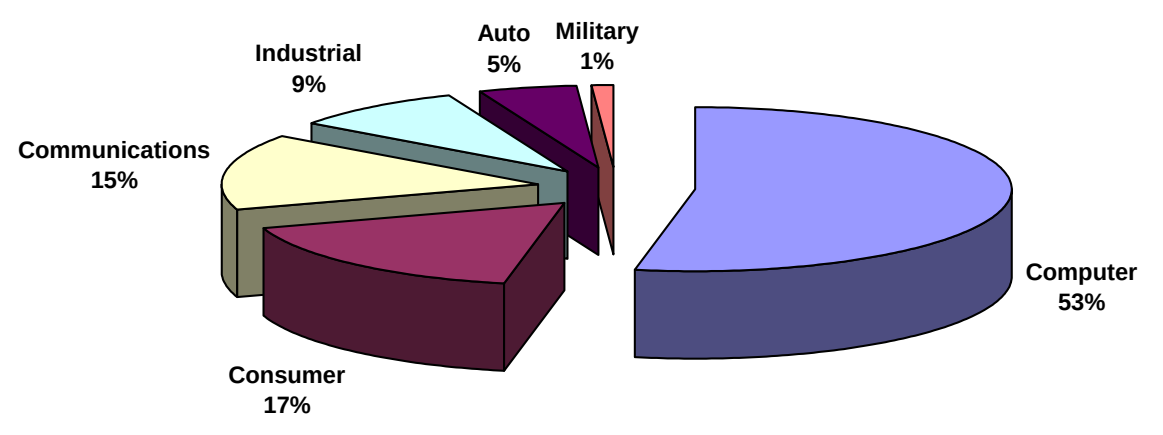
Product markings (part number, label, symbol, solder mask, silkscreen)

Recommendations for Program Managers

- No. 1: Be educated, be aware
  - Most commercial suppliers and OEMS, even if exempt from RoHS, are going Pb-free (General Motors / Ford, Maytag / Whirlpool, even Wal-Mart)
    - Diminishing availability and skill set with SnPb
  - Plethora of good research and experience with Pb-free (find it!)
    - Google.com and Scholar.google.com
  - Whether to ban or accept Pb-free product should be based on the capability of the supplier, reliability expectations, use environment, and maintenance requirements
    - Each program's experiences and concerns will be different

Recommendations (cont.)

- Do not underestimate purchasing power



Semiconductor International Association

Recommendations (cont.)

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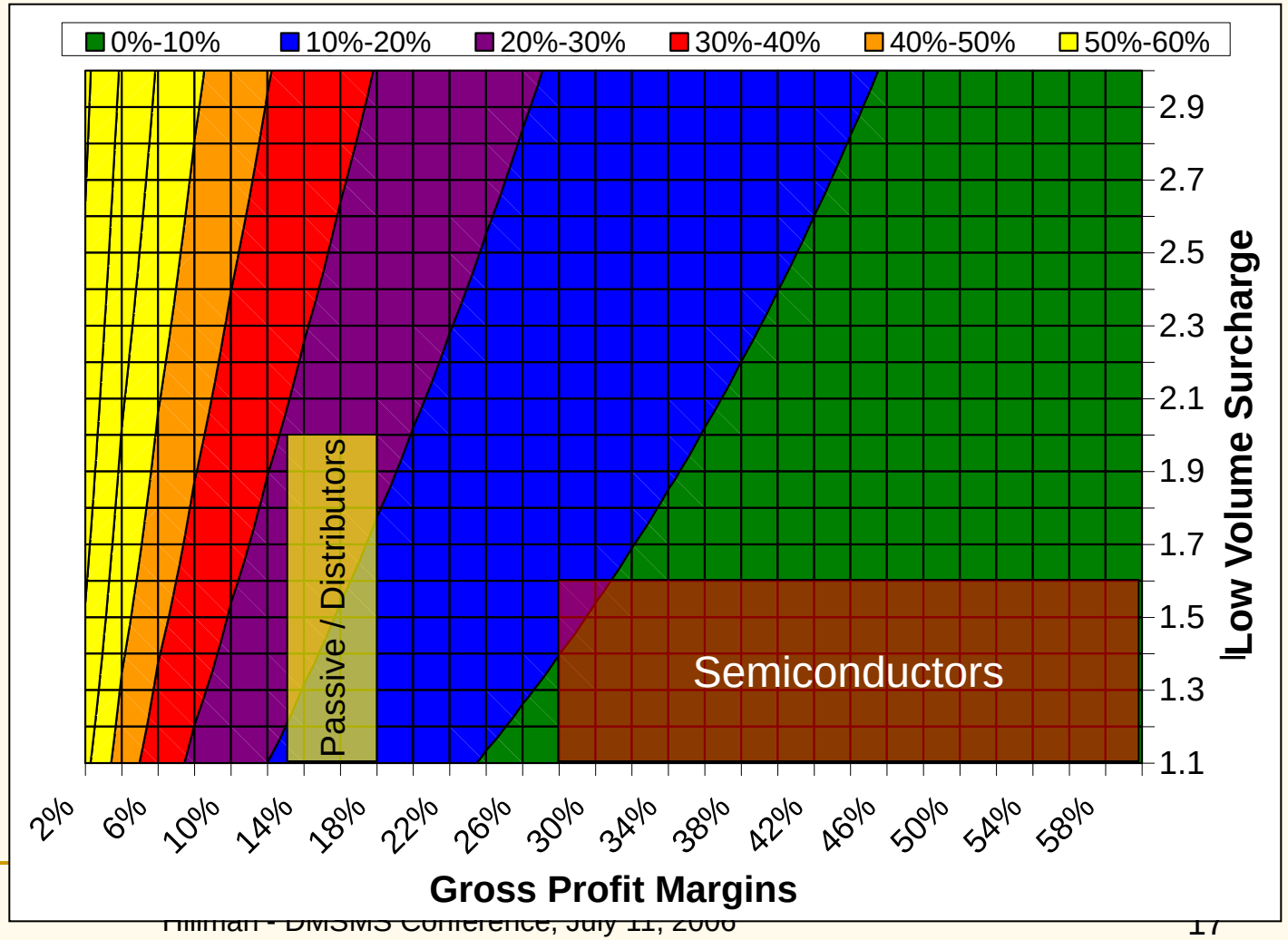

Assumes 3% market share