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Impacts of Recent European Environmental Directives on Electronics Manufacturing Industries

For HK Society of Quality

Friday 17 December 2004

Edmond Chan / Stanedy Yue

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Waste of Electrical and Electronics Equipment (WEEE) + Restriction of Hazardous Substances (RoHS)

Stanedy Yue
Environmental Program Manager
Quality
BG Home Entertainment Networks

Latest two European Union (EU) Directives on Chemical Requirements

- Waste Electrical & Electronic Equipment (WEEE) Directive. (2002/96/EC)
- Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) Directive. (2002/95/EC)

http://europa.eu.int/comm/environment/waste/weee_index.htm

European Union Directives

- Bound to be adopted by the Member States
- NO direct effect within the Member States
- Supersede national laws

WEEE Directive

Objectives

- Reducing the amount of Waste of Electrical or Electronics Equipments (WEEE) produced.
- Increasing the re-use, recycling and recovery of WEEE.
- Minimising the remaining waste for disposal.
- Improving the cradle-to-grave environmental performance of electrical and electronic equipment.

WEEE Directive

Scope - General

- Operates at a maximum voltage of 1,000 V a.c. or 1,500 V d.c.
- 10 categories
- Excluded military Products

WEEE Directive

10 Categories

- Large household appliances;
- Small household appliances;
- IT & telecommunications equipment;
- Consumer equipment;
- Lighting equipment (Except filament light bulbs & household luminaires);

WEEE Directive

10 Categories

- Electrical and electronic tools (Except large stationary industrial tools);
- Toys, leisure and sports equipment;
- Medical devices (Except where implanted or contaminated);
- Monitoring and control instruments;
- Automatic dispensers;

WEEE Directive

Financing

- Producers (+Importers) shall pay for the collection, treatment, recovery/recycling.
- Provide a financial guarantee for the management of their WEEE.
- Pay for the treatment of “historical waste” through a collective scheme.

WEEE Directive

Implementation Timetable (1)

By 13 August 2004

- EE member States shall implement the WEEE Directive in their national laws.

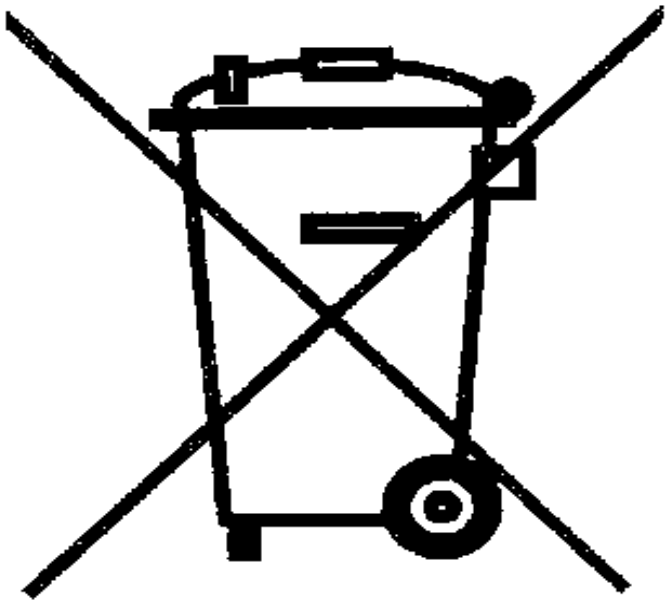
By 13 August 2005

- Systems shall be set up for the separate collection of all WEEE from private households
- "Producers" shall provide guaranteed finance for the management of their own WEEE, either individually or by joining a collective scheme;
- Products shall be marked with
  - **The crossed wheeled bin symbol**
  - **A mark clearly indicating that they were placed on the market after 13 August 2005. (New EU standards will be developed for this purpose)**

WEEE Directive

Marking / Labelling requirement

Crossed-out wheeled bin symbol:



Affixed to all applicable equipments on body.

- Where the product's size and function prevent this, it shall be placed on:
  - Packaging;
  - Instructions for use;
  - Warranty.

WEEE Directive

Implementation Timetable (2)

By 31 December 2006, "Producers", or third parties acting on their behalf, shall

- establish systems for the recovery or recycling of WEEE
- meet targets for the rates of recovery and recycling (based on the average weight per appliance for each category)

RoHS Directive

Objectives

- Reduction of the environmental and health risks posed by hazardous materials electrical and electronic equipment, even when separately collected and treated under the WEEE Directive.
- Complementary to & running in parallel with the WEEE Directive.

RoHS Directive

Scope 1

- Similar to the WEEE Directive, except:
  - Applies from 1 July 2006
  - Apply to categories 1,2,3,4,5,6,7 and 10.
  - Only covers new products placed on the market
  - Includes filament light bulbs and luminaires for household use
  - Medical devices or monitoring & control equipment are not covered

RoHS Directive

Scope 2

- Does not apply to:
  - Spare parts for the repair of products placed on the market before 1 July 2006;
  - Re-used products that were placed on the market before 1 July 2006

RoHS Directive

Requirements - Outline

- **From 1st July 2006, new electrical and electronic equipment placed on the market shall not contain**
- **Heavy metals:**
  - **Lead;**
  - **Mercury;**
  - **Cadmium;**
  - **Chromium (VI).**
- **Flame retardants:**
  - **Polybrominated biphenyls (PBB's)**
  - **Polybrominated diphenyl ethers(PBDE's).**

RoHS Directive

Requirements - Outline

- Maximum limits for these banned substances, tolerating levels not intentionally introduced, are proposed as follows :-
  - **Heavy metals:**
    - **Lead; (< 1000 ppm or 0.1% by wt.)**
    - **Mercury; (< 1000 ppm or 0.1% by wt.)**
    - **Cadmium; (< 100 ppm or 0.01% by wt.)**
    - **Chromium (VI). (< 1000 ppm or 0.1% by wt.)**
  - **Flame retardants:**
    - **Polybrominated biphenyls (PBB's) (< 1000 ppm or 0.1% by wt.)**
    - **Polybrominated diphenyl ethers(PBDE's). (< 1000 ppm or 0.1% by wt.)**

RoHS Directive

Exemptions - Lead

Glass in: - Cathode ray tubes;
- Electronic components;
- Fluorescent tubes.
Alloying elements in: - Steel (maximum 0.35% lead);
- Aluminium (maximum 0.4% lead);
- Copper (maximum 4% lead).
Solders: - servers, storage & storage arrays (until 2010);
- network infrastructure & telecom management.
Electronic ceramic parts.
(e.g. piezoelectronic devices)

RoHS Directive

Exemptions - Mercury

- **Compact fluorescent lamps (maximum 5 mg per lamp);**
- **Straight fluorescent lamps for general purposes:**
  - **Halophosphate (maximum 10 mg per lamp);**
  - **Triphosphate with normal life (maximum 5 mg per lamp);**
  - **Triphosphate with long life (maximum 8 mg);**
- **Straight fluorescent lamps for special purposes;**
- **Other lamps not specifically mentioned.**

RoHS Directive

Exemptions - Cadmium

- **Cadmium plating, except for applications banned under the Cadmium Directive 91/338/EEC. (E.g. production equipment or machinery and the associated products in certain industries**

RoHS Directive

Exemptions – Chromium (VI)

- **Anti-corrosion agent for the carbon steel system cooling system in absorption refrigerators.**

Implication to business

- Cost to do business increased.
- May have different costing system in different EU countries.
- Philips prefers visible fee.
- To be taken care by region, similar to the disposal fee of packaging.

- How to handle historical waste not yet agreed.

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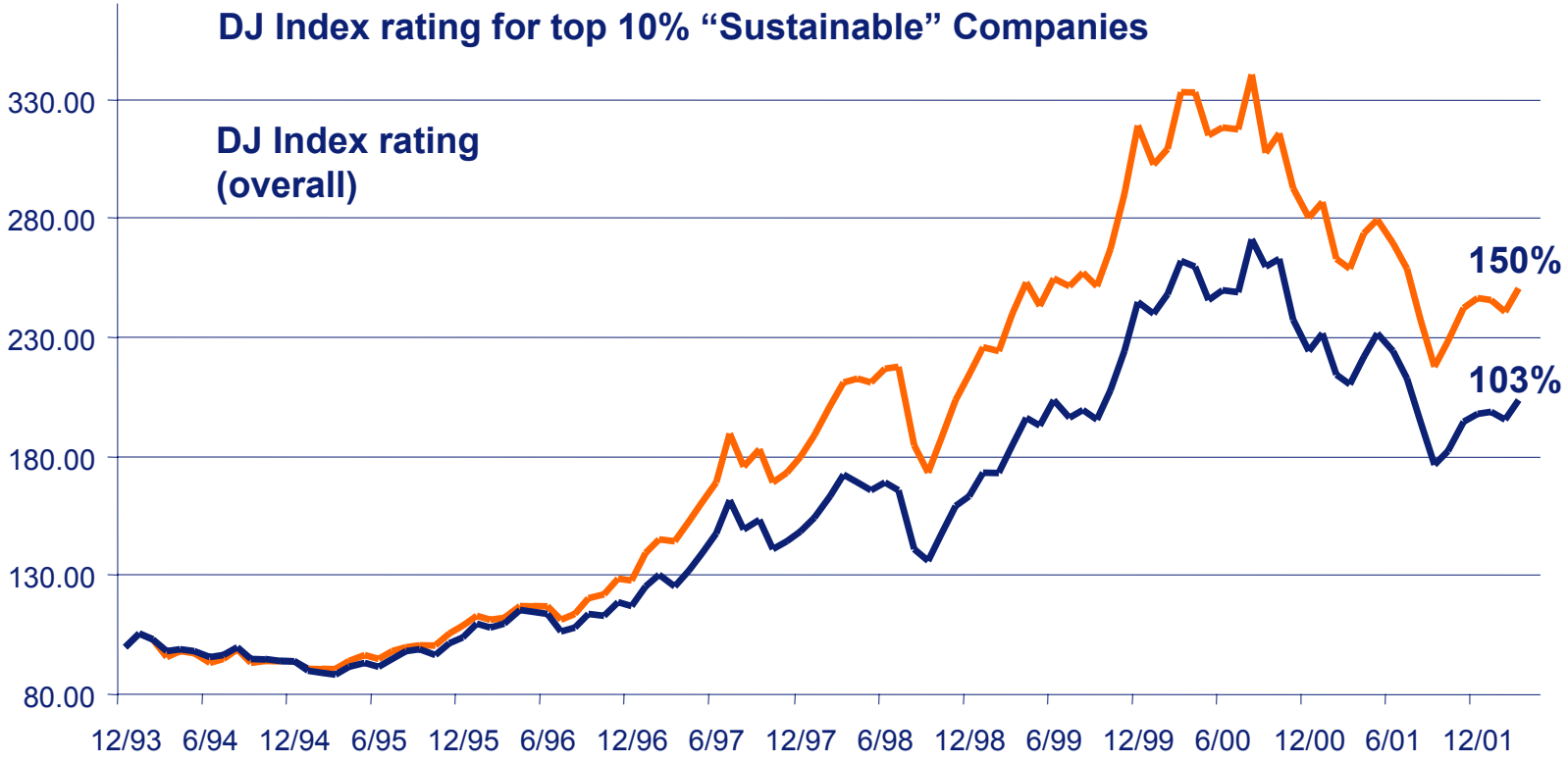
Philips Consumer Electronic Environmental Program

Dow Jones Sustainability World Indexes

(December 1993 - March 2002, Euro, Price Index)



"Sustainable" companies are seen as more financially sound.

PCE policy on Environment

- Determined by CEO Frans van Houten in PCE Environmental Steering Team 10 Feb 2004:

> "PCE should be leading in environment"

- Global perspective

Areas to take the Lead in for PCE

	Target
• Energy → Supports Flagships, Awards, EUP	10% better Than best competitor
• Lead free	01-01-2005
• Bromine (TBBA) free in PWBs	01-01-2006
• All suppliers Green by end of 2004	100% signed Sustainability & BSD
• Packaging reduction up till World Class	

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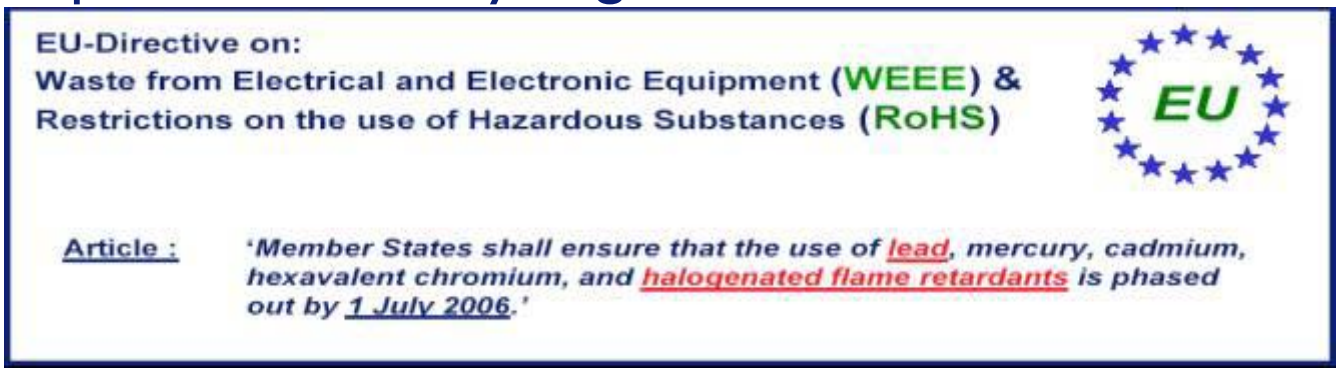
Lead free

Why Lead Free ??

- European Community Legislation

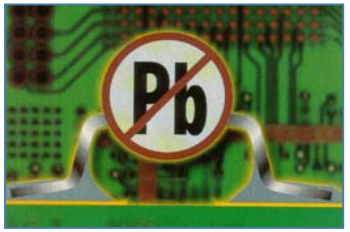


- Similar legislation published by Ministry of Information on Industry (MII) of PRC 中國信息產業部生產污染防治管理辦法 will be effective on Jan 01, 2005
- Health concerns for human body
  - Large doses of Pb (25mg/dl) in blood will result in heavy metal poisoning
- Environmental concerns
  - Source of Pb – waste and end of life
  - Disposal in landfill (groundwater contamination)

PCE Lead Free Policy

(Instruction : Frans van Houten, CEO PCE)

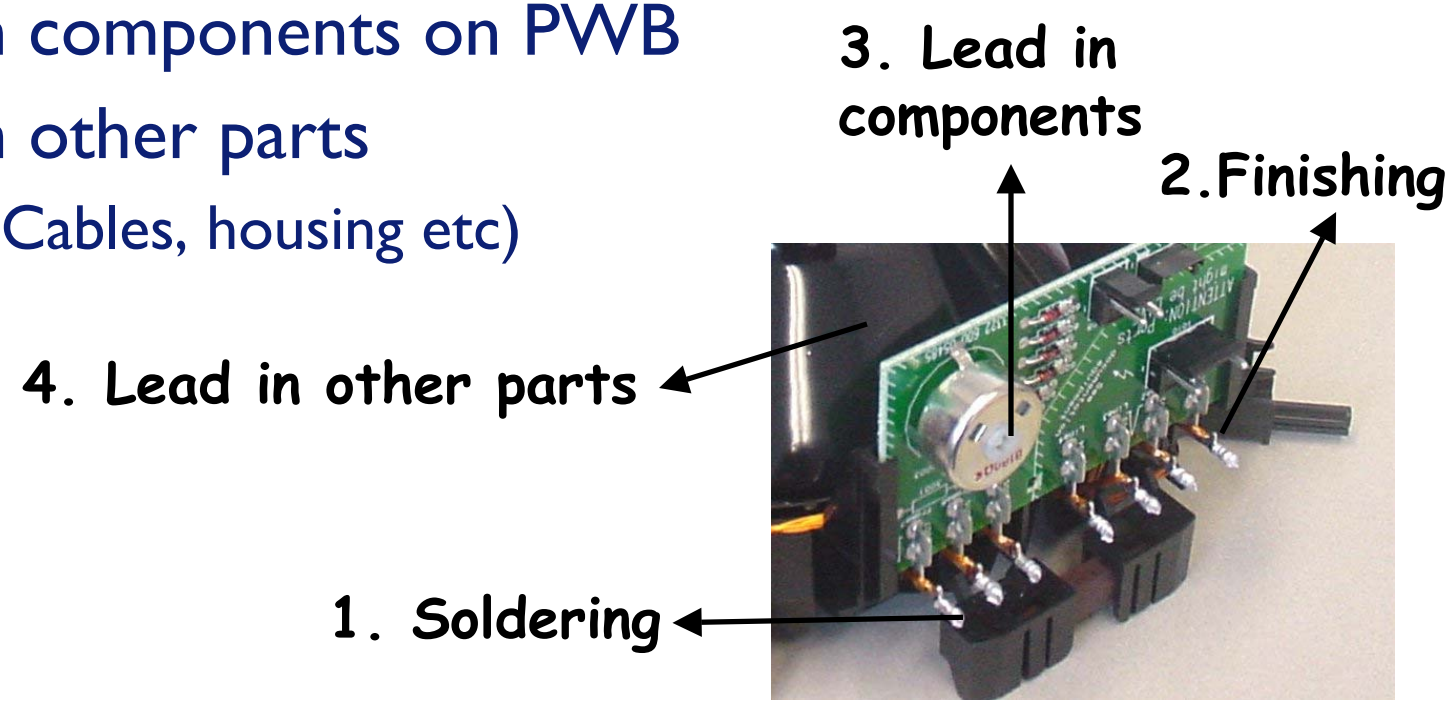
- Aim 1-Jan -2005 all PCE products will be complete lead free.
- Not only lead-free soldering, but including lead-free components (finishes, cables, internal lead, etc.).



Where can lead be found?

1. Lead in soldering
2. Lead in component plating/ finishes
3. Lead in components on PWB
4. Lead in other parts

   (incl. Cables, housing etc)



What is the level of detail required?

Industry Position

Most likely EU definition

TAC proposal on ad level measureme

Material level

Component level

Part/ assy level

Product level

1000 ppm measured on

What are the threshold values on lead?

1. Lead in soldering
   Max. Concentration of Lead < 1000 ppm
2. Lead in component plating/ finishes
   Max. Concentration of Lead < 1000 ppm
3. Lead in components on PWB
   Max. Concentration of Lead < 1000 ppm
4. Lead in other parts (incl. Cables, housing etc)
   Max. Concentration of Lead < 1000 ppm

RoHS req.

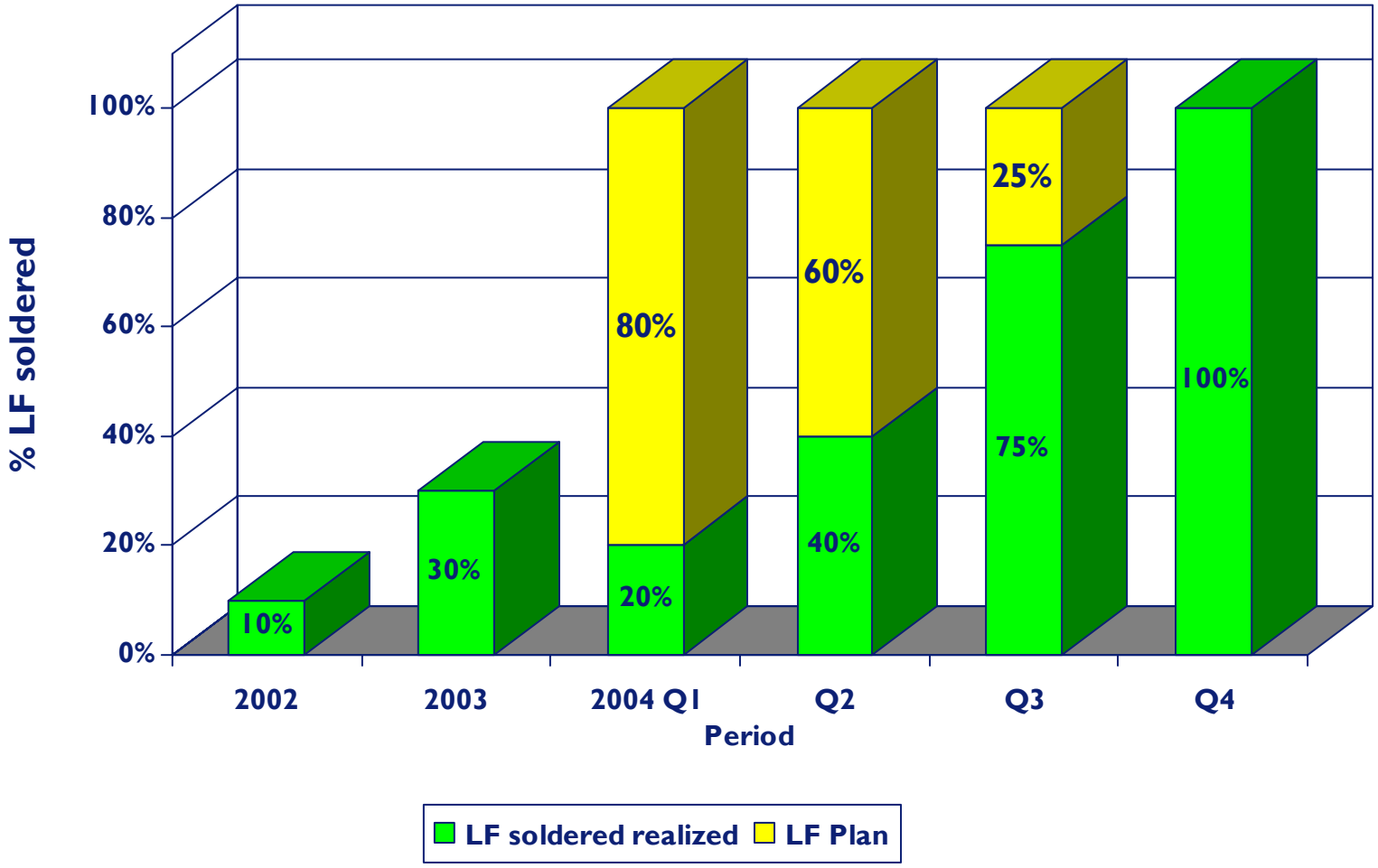
Remark: ONLY for Outer sleeves of cables
Max. Concentration of Lead < 300 ppm
(outer sleeves of Cables) Proposition 65

Prop. 65

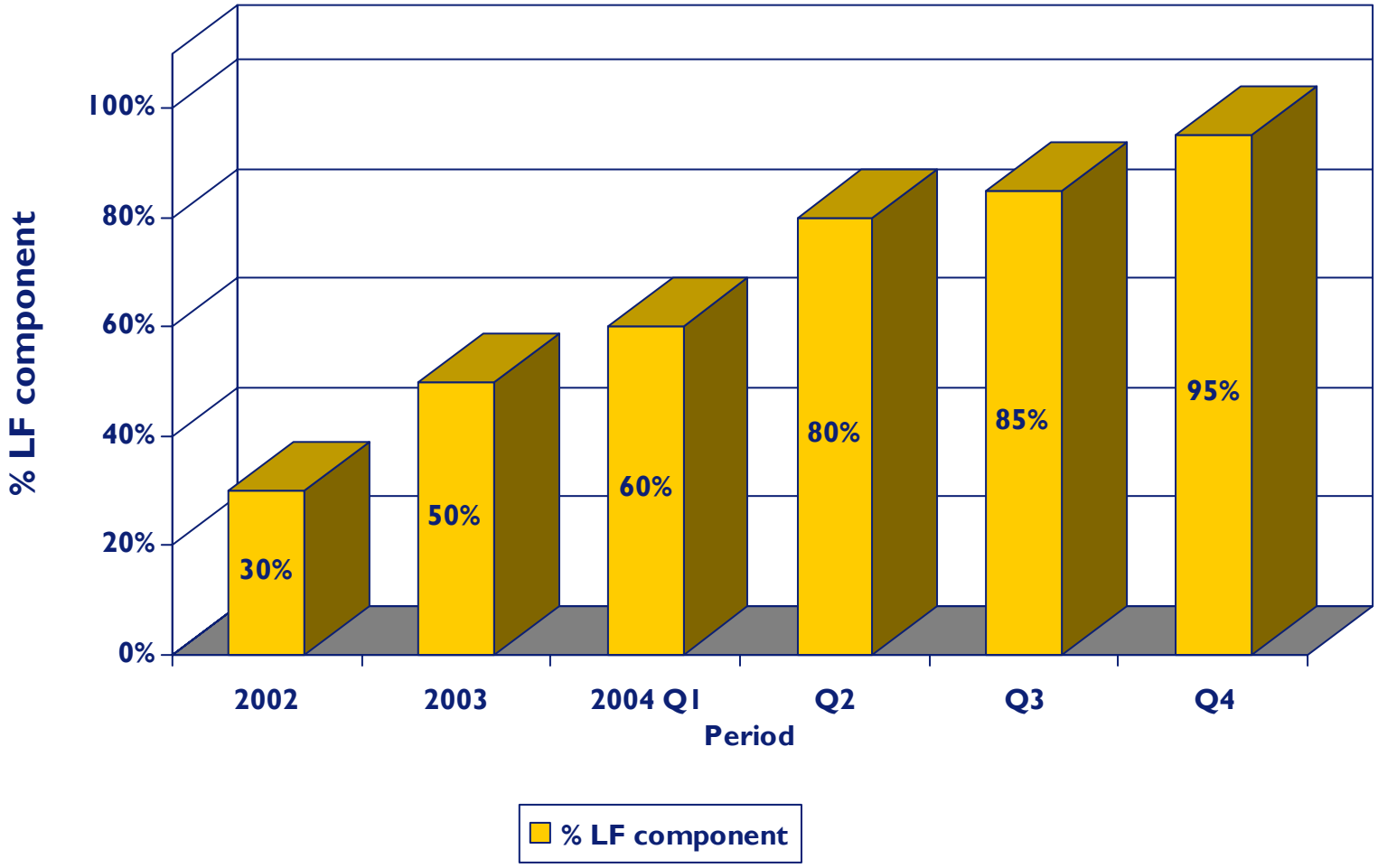
Other regions follow EU approach

- EU Legislation 2002/95/EC
  - RoHS (Restriction of Hazardous Substances), 1 July 2006
- China " exact copy" of EU RoHS text 1 July 2006
- California issues "SB20" legislation, 1 Jan. 2007,
  PBDE exempt, but reporting obligation.

Lead free status (% LF soldered)



Lead free status (% component)



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Technical Highlights

Edmond Chan
Engineering Manager
Philips South China Industry
BG Home Entertainment Networks

Lead Contamination Level Evolution for Wave Soldering

Assumption of the Simulation

- Maximum allowed Pb content as per EU directive (01-07-2006): **1000 ppm**
- Nominal Pb level in SAC solder bar: 300 ppm
- Class 2 panel with 2100 joints (axial, radial, SMC, etc)
- Average SnPb coating thickness is 4 um
- Pb content in component lead coating: 40% (SnPb40)
- Number of FR2 boards (250 x 328 mm) per hour: 133
- Shift: 8 hours & 3 shifts per day
- Solder bath content: 96 liter SAC305
- Consumption virgin SAC alloy: 2.27 kg/hr
- Drag out of solder due to board soldering: 2.28 kg/hr
- Drag in of solder from terminal coatings: 0.028 kg/hr

Simulation 25% Pb-I = 6

Speakers removed information for proprietary reasons.

After 31 shifts the Pb level of 1000 ppm is reached.

Simulation 15% Pb-I = 6

Speakers removed information for proprietary reasons.

After 89 shifts the Pb level of 1000 ppm is reached.

Simulation 10% Pb-I = 6

Speakers removed information for proprietary reasons.

The Pb contamination level remains at 800 ppm and the threshold of 1000 ppm is not reached.

LSDB Lead-Free Indicator Explanation

Pb-I	Compliant to LFS Process	Compliant to LF Plating	Indicated date compliant to :
2	X	X	X
3	X	X	LFS √
6	√	X	LF plating √
9	√	√	
X	Component is not relevant for our LFS process		
P	Applicable based on our positive experience with our lead-free soldering process		

Selection of LF Solder Alloy & Flux

Criteria for choice of LF solder

- adequate wetting characteristics
- abundant supply
- melting point as low as possible
- good fatigue resistance
- good joint strength

Alloy Candidates

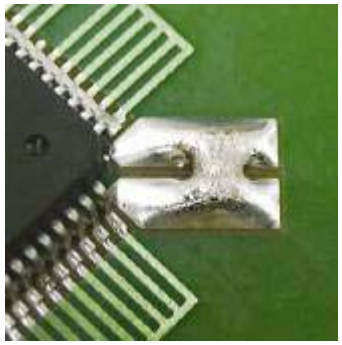
Lead-free solder alloys					
Melting point	Alloy	Reflow	Wave	Selective	Remarks
227 °C	SnCu	-	++	+	Low cost
221 °C	SnAg	++	+	+	Copper contamination in wave
217 °C	SnAgCu	+++	+++	+++	Most recommended
200-216 °C	SnAgBi	+++	+	+	Superior strength, fillet lifting
199 °C	SnZn	+	-	-	Corrosion
138 °C	SnBi	++	-	-	Low temperature

Why Cu/ Ag are used in LFS

- Sb : harmful element
- Ge : low in reactivity table
- Bi : scarce element
- Au : too expensive
- In : too scarce
- Zn : form dross/ oxidation

Flux & Wavesolder Evaluation

- Alpha Metals EF3215 VOC free flux (with SAC405 solder)
  - No shorts on 50 QFPs wavesoldering
  - Less micro balling
  - No shorts on solder thieves
  - Thinner flux required
  - Good wetting on old class 2 boards



LF Wavesoldering Requirement

- Solder alloy SAC405
- EF3215 VOC free flux
- Extended preheating capacity 1.8m
- Nitrogen blanketing to reduce dross & oxidation

SAC	= Tin (Sn), Silver (Ag) & Copper (Cu)
405	= Ag 4% & Cu 0.5%

LF Reflow Requirement

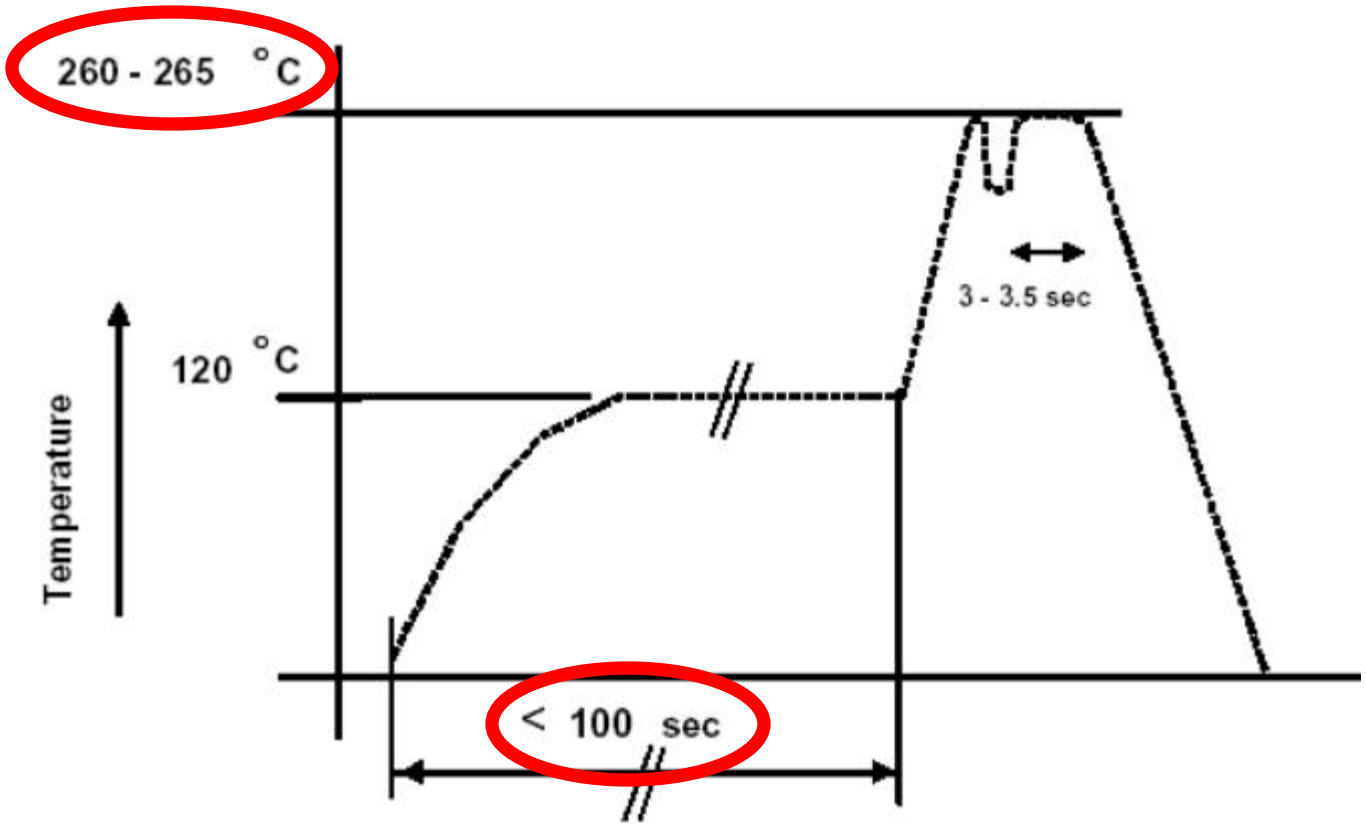
- Solder alloy SAC405 (SnAg3.8Cu0.7)
- Nitrogen atmosphere to maintain OSP solderability for double sided reflow

Summary wavesolder & reflow solder

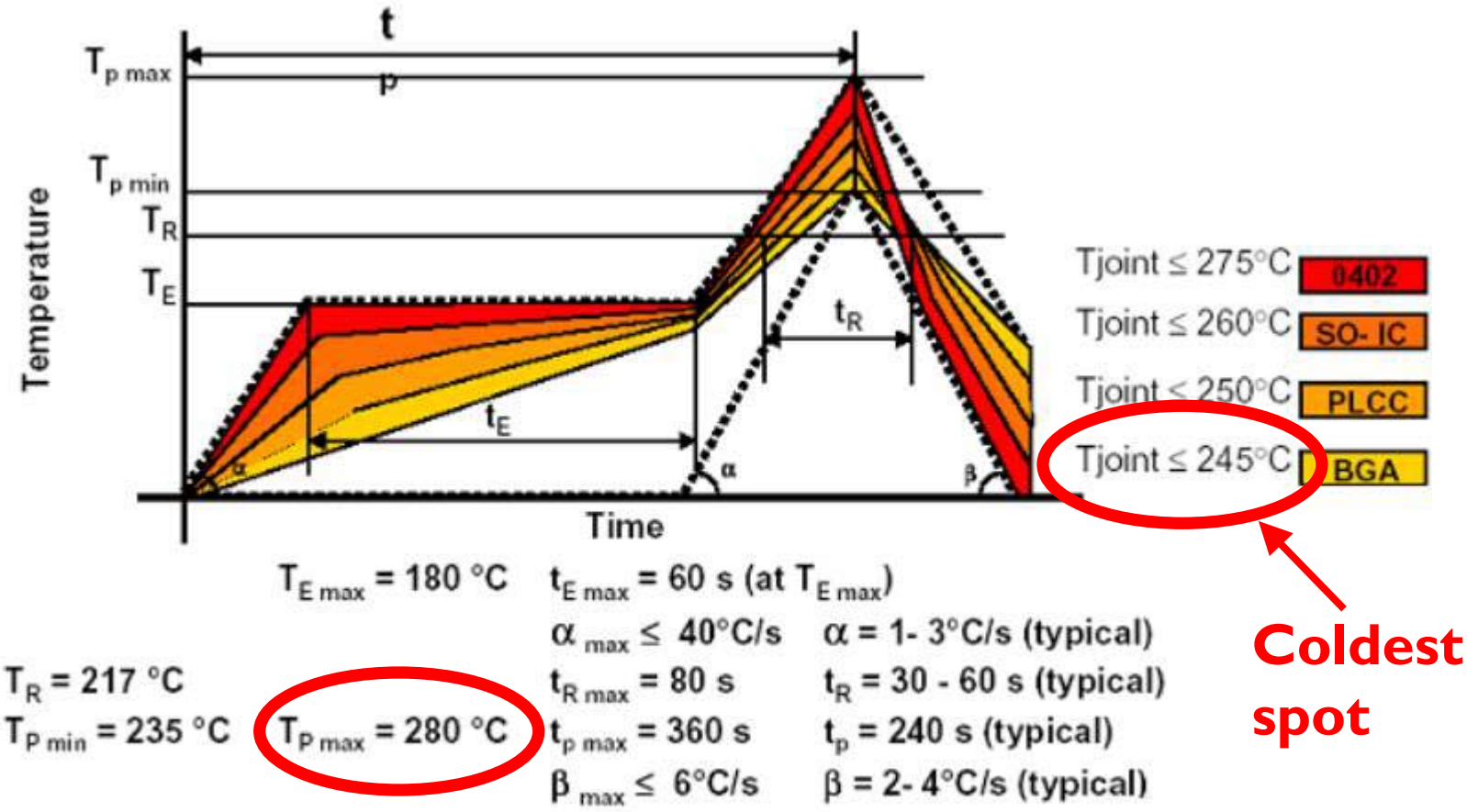
Solder paste	: SAC405 (e.g. Alpha Metals)
Solder bar	: SAC405 or SAC305
Alloy	: SnAg3.8Cu0.7
Flux	: EF3215 VOC free

Time – Temperature Profile

Profile – Wavesoldering



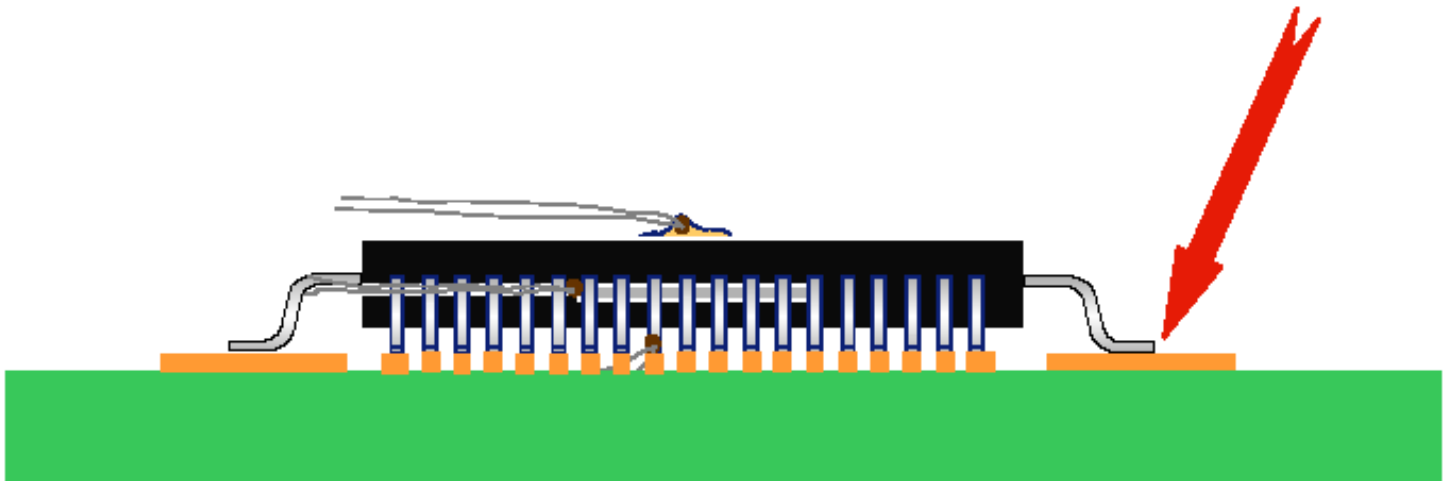
Profile – Reflow solder



Solder joint temperature

SAC alloy melts at 217 ºC
Sn finish melts at 232 ºC

→ Solder joint temperature should reach **235** ºC



Summary Temperature Profiles

Wave solder

90 sec preheat @120 degC

T_{max} @265 degC

Reflow solder

60 sec preheat @180 degC

T_{max} @280 degC (case by case)

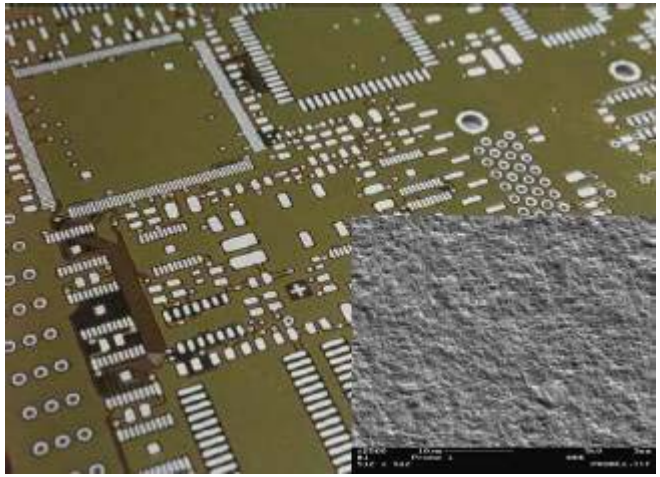
Manual solder

3-4 sec @380-420 degC

PCB Finishing

Immersion Tin or Gold

- Flat surface
- 0.8 – 1.2 micron thick
- Withstand multi reflow passes



OSP

- **O**rganic **S**olderable **P**rotective (OSP) coating
- Standard **Micro-Etch**

Good wettability
VOC free flux compatible

Solderability Test for OSP

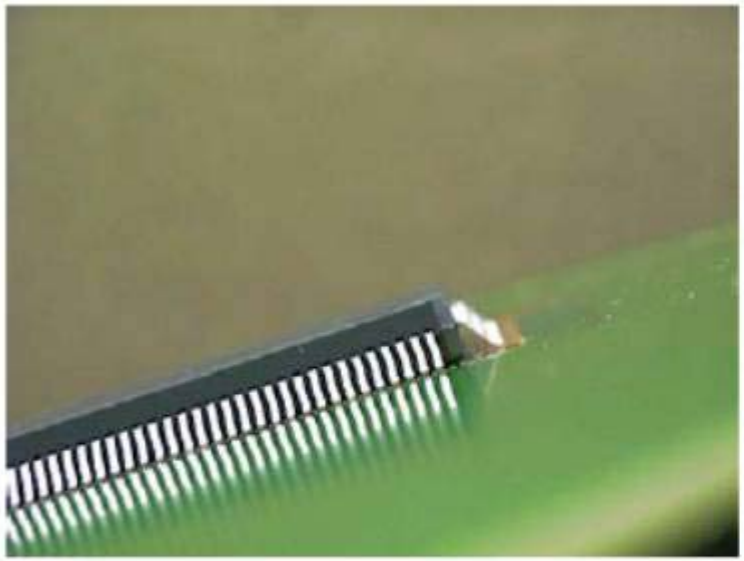
Speakers removed information for proprietary reasons.

Summarize LF finishing

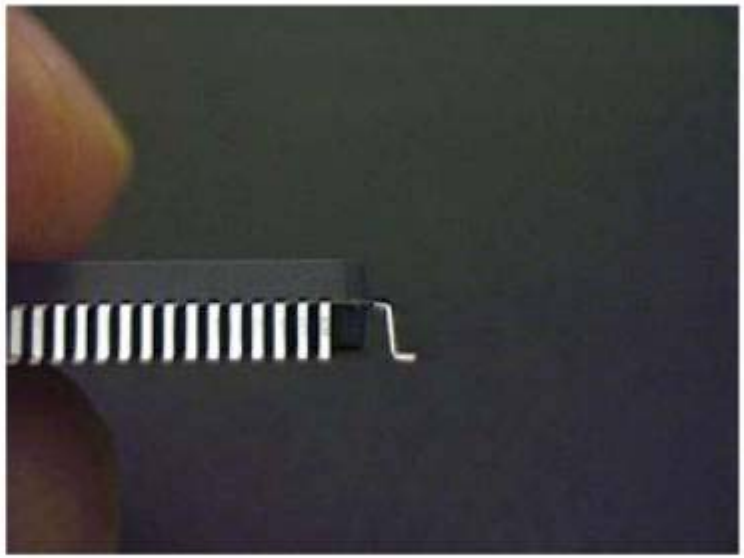
- Micro etch + OSP
- Immersion Sn
- Immersion Au

QFP128 Lead Free Wave Soldering Test

QFP128 lead angle 60 & 90 degree



Type 1: lead angle 60°

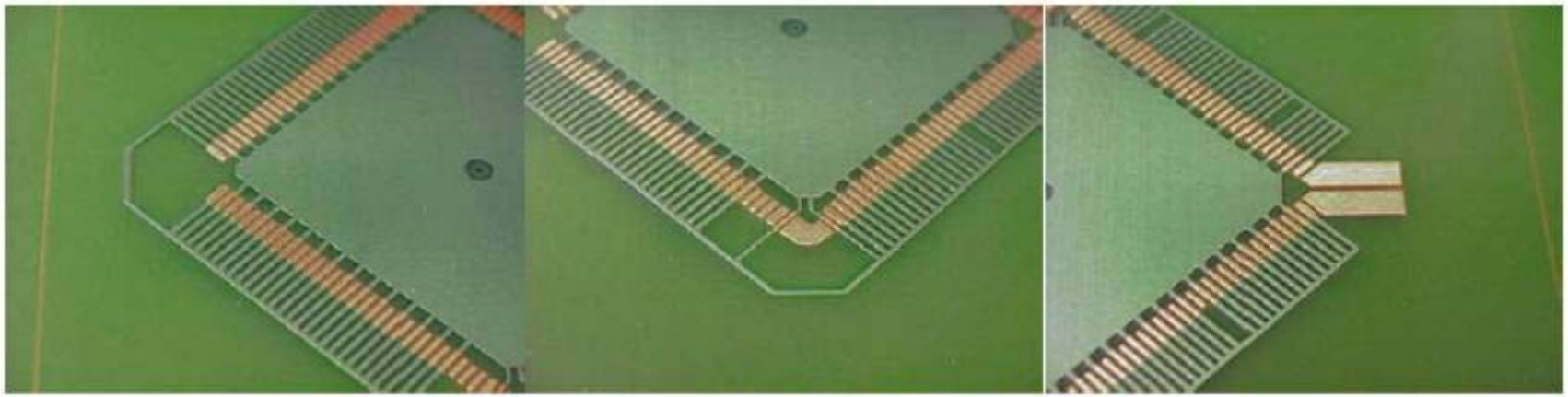


Type 2: lead angle 90°

Objectives:

Find out the **best lead angle** and **LFS footprint** for QFP128

Footprint of the Test Board

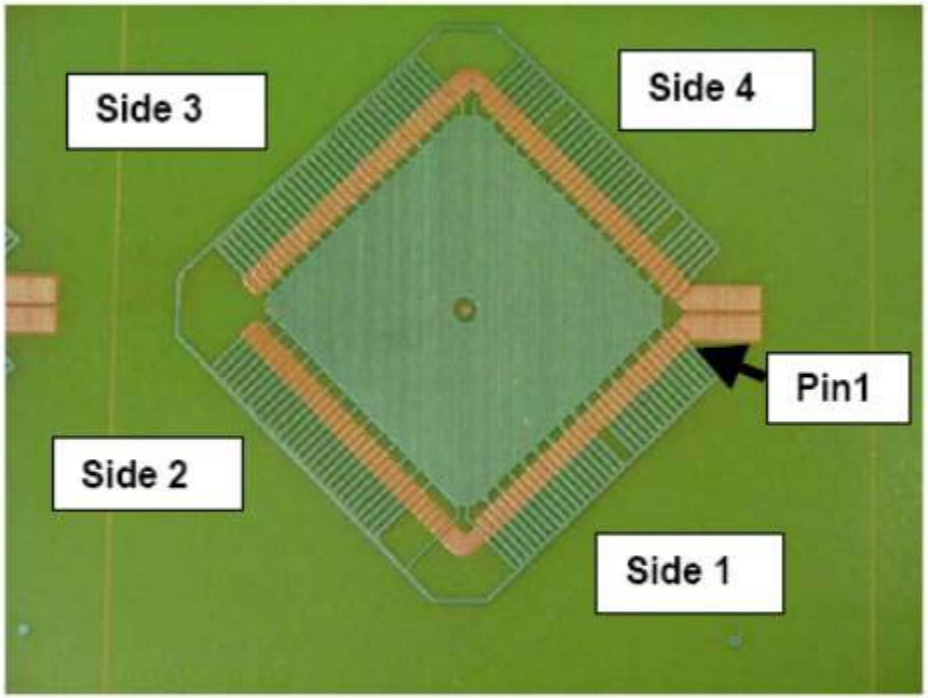


Leading edge of footprint | Side solder thief | End solder thief

Generic Layout and Dimension

Speakers removed information for proprietary reasons.

Assessment & Results



Observation:

More shorts at side 2 & 3

	ppm (short/ cpt)
60 deg	846
90 deg	4237

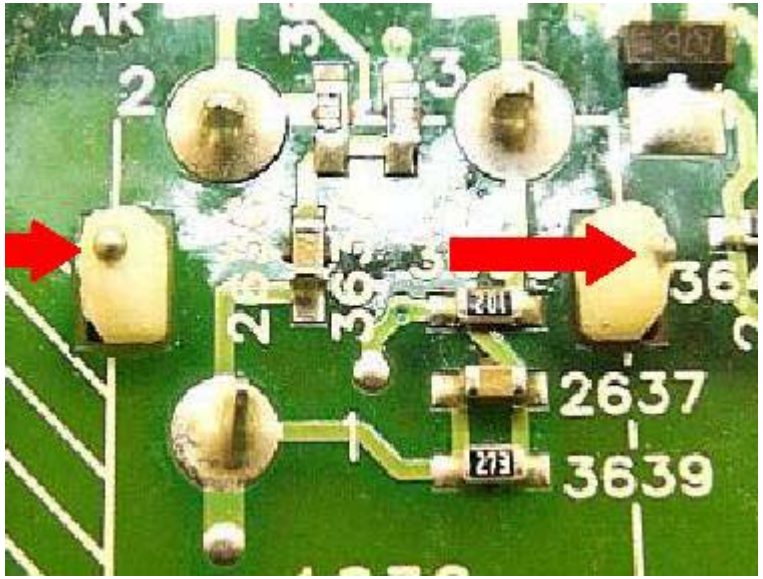
Findings & Conclusion

- The 60° lead angle is compliant with the mechanical requirements of D1809
- The 90° lead angle is far more sensitive for shorts
- Micro solder balling is omni-present on Lead Free wave soldered boards
- Larger solder balls occur due to the explosive boiling of not fully evaporated water of the flux after preheating
- The inspectability and repairability of the 60° lead angle QFP is better than of the 90°
- For Lead Free Soldering the distance between the 2 end solder thief parts need to be increased till 0.85 mm, to reduce the short risk

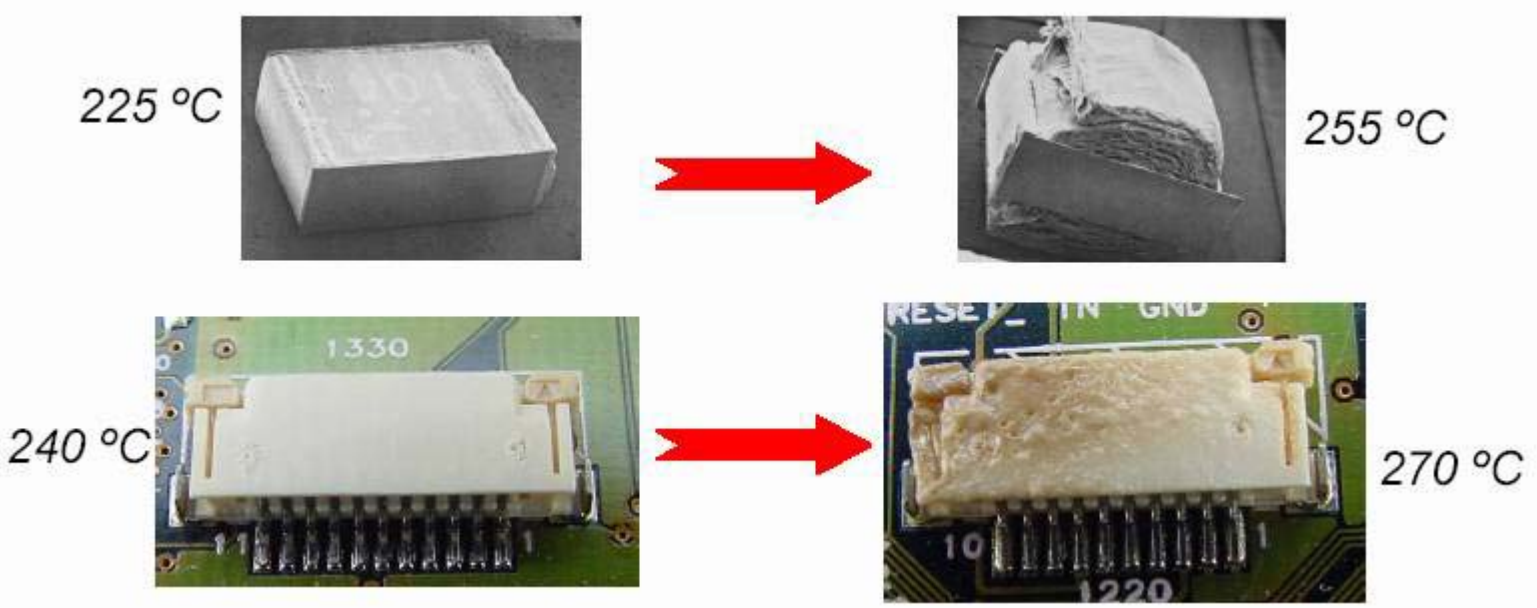
Lessons learnt from Pilot Project

E/M parts melt

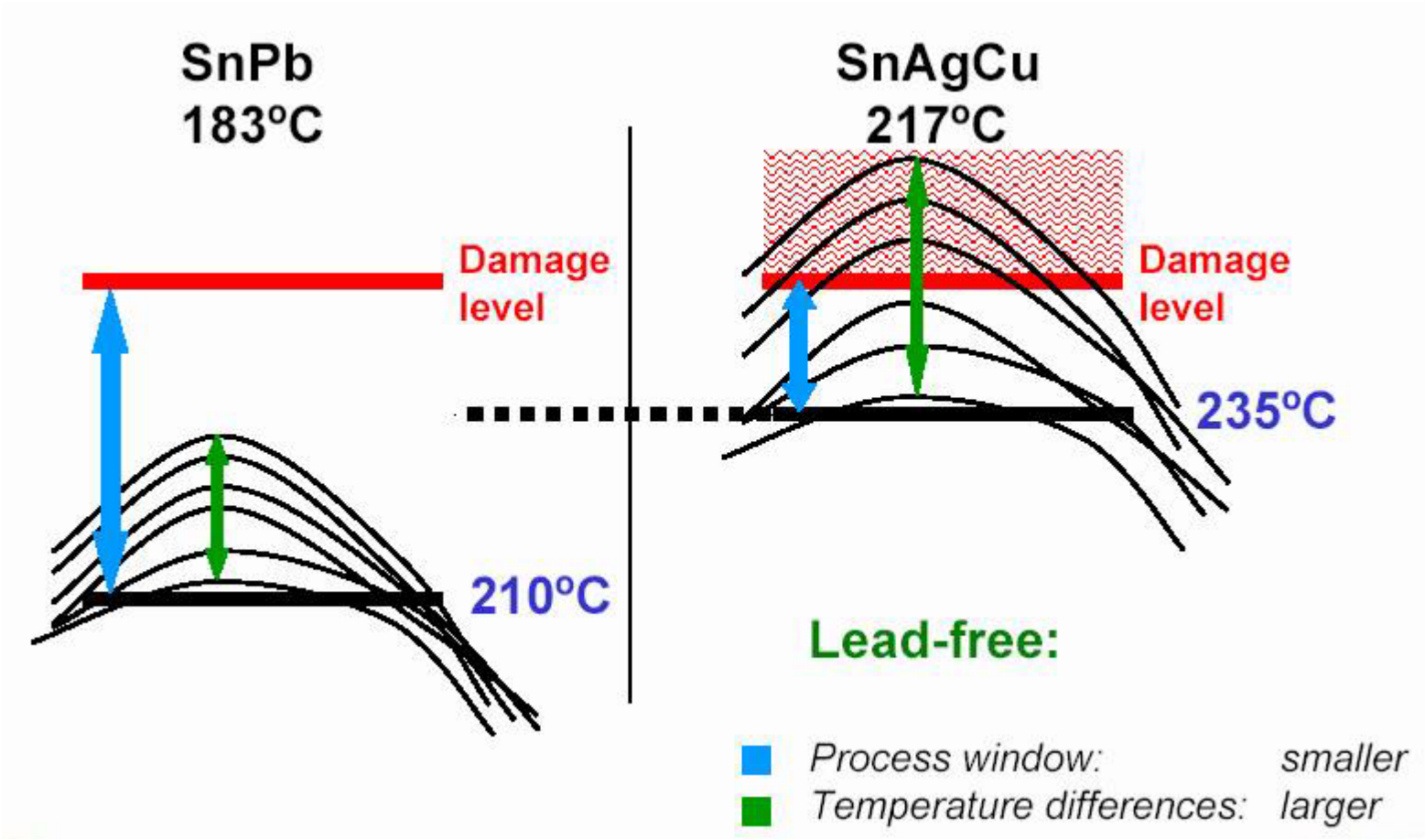
- Intensive preheat + 265 degC solder bath



Components damage

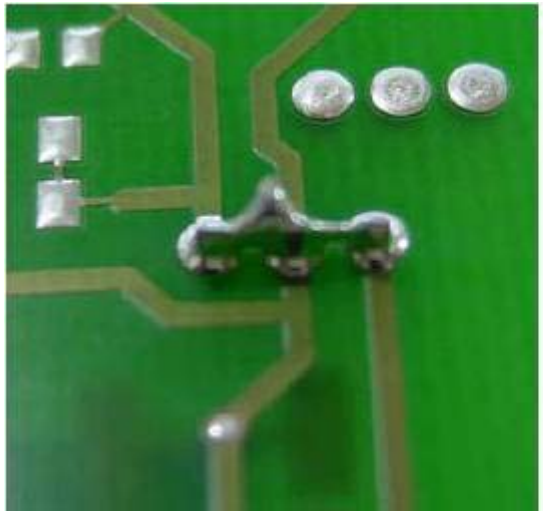


Process Window



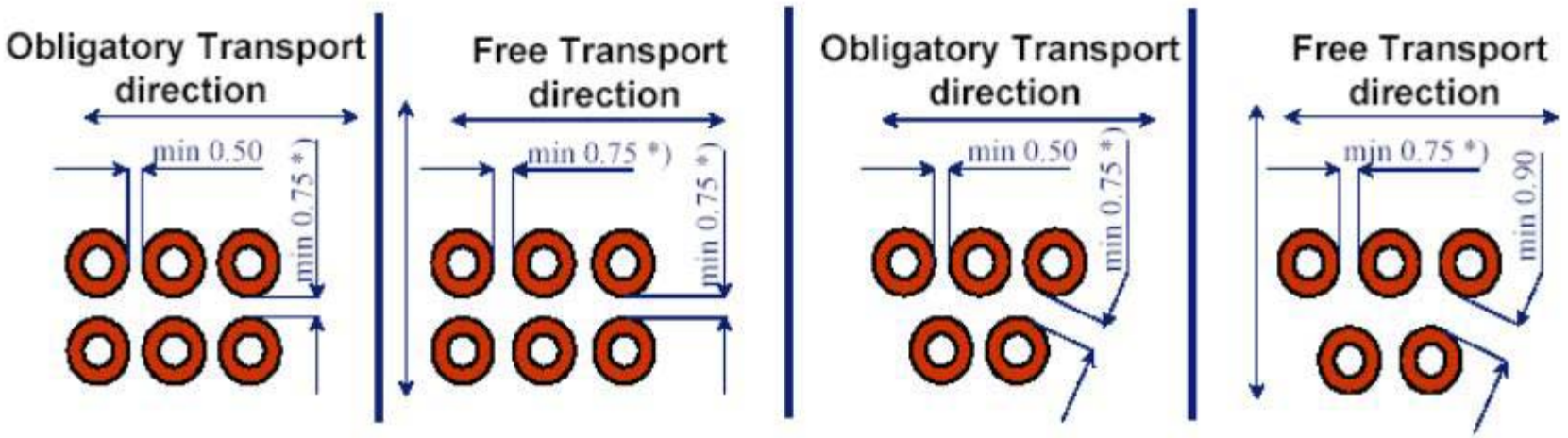
Design Rule Change

Risk of short-solder



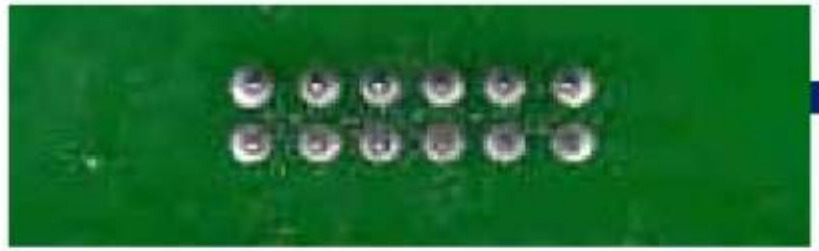
- Higher surface tension for SAC alloy
- Higher susceptibility for oxidation

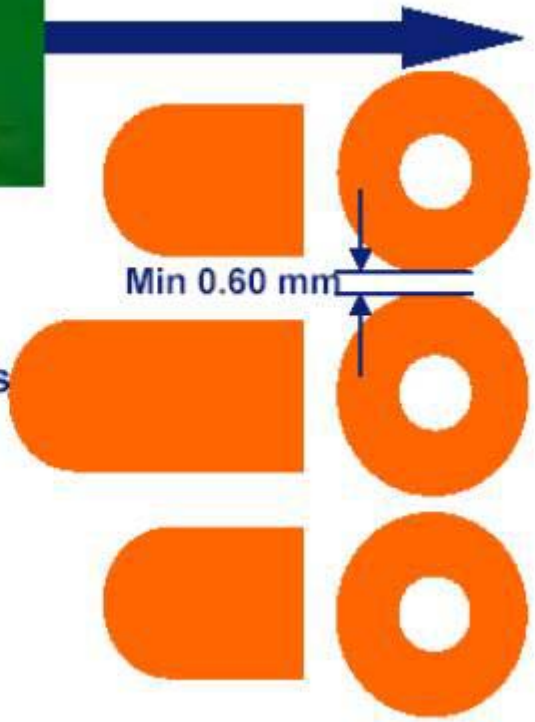
Round Pad Dimension



If spacing requirement is not met, oval shapes can be chosen

Solder Thieves





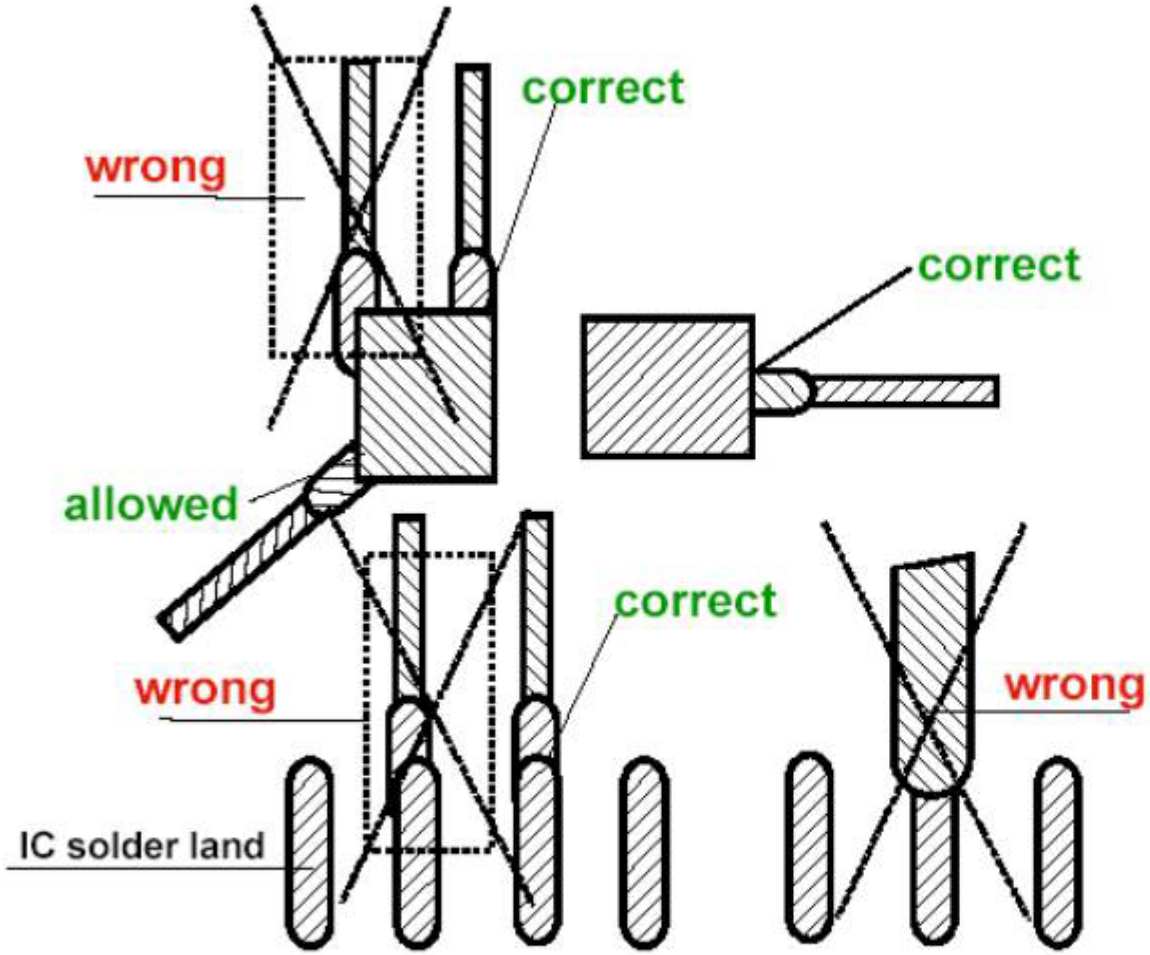
Perpendicular component placement

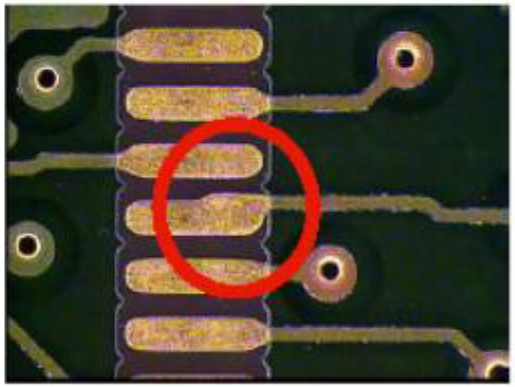
- add extra solder thieves down streams

(W = 1 mm, L = 1.5 – 3 – 4.5 – 6 mm)

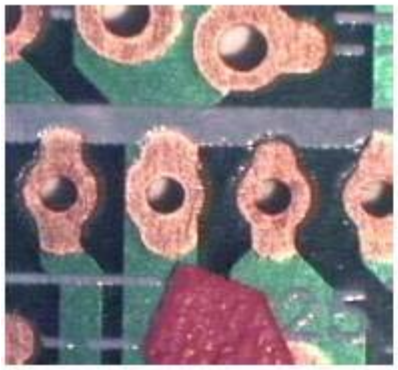
(distance to solder land = 0.3 mm)

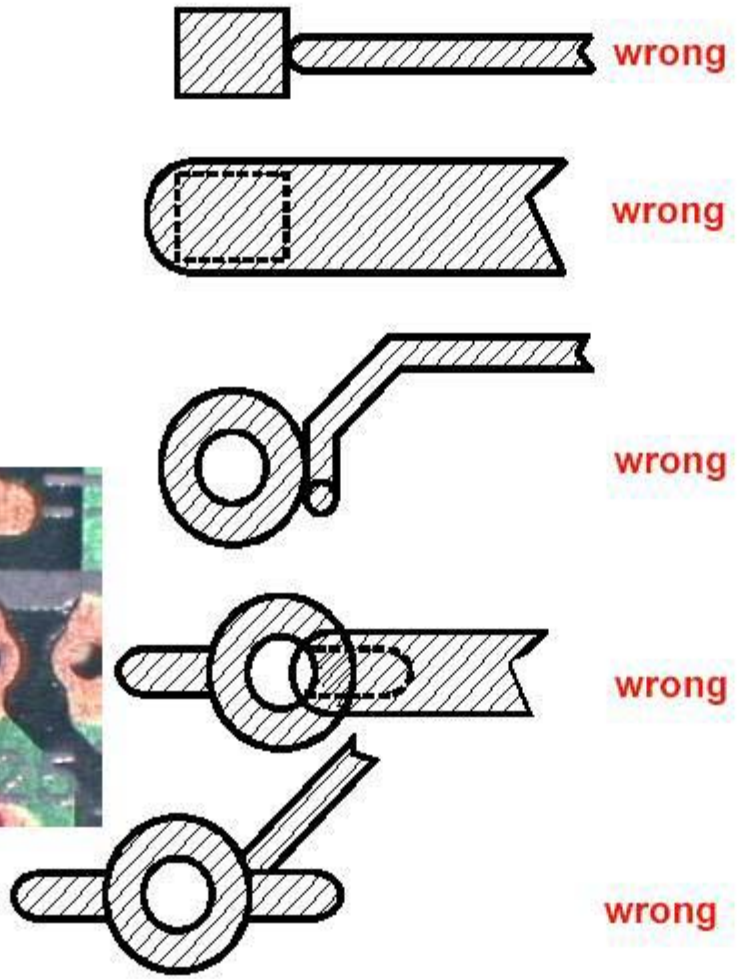
Track – Solderland Connection

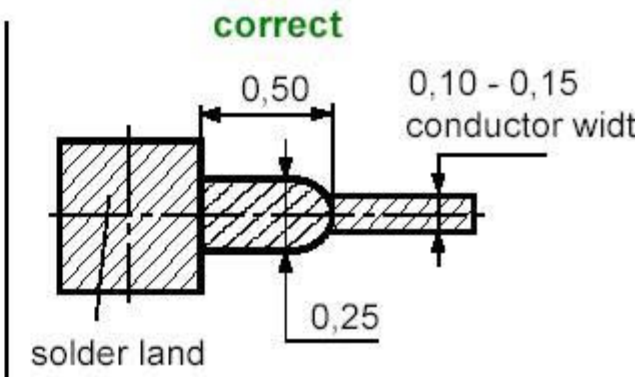


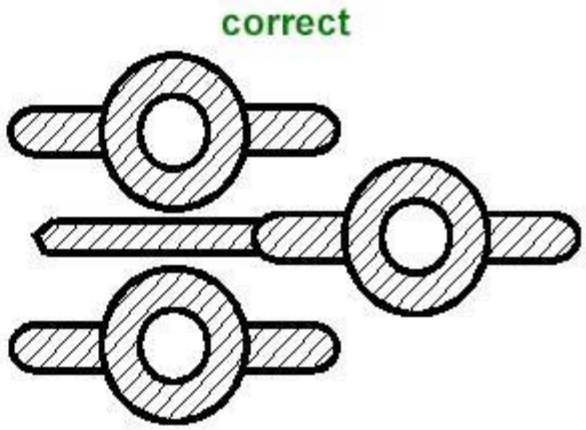


Track – Solderland Connection









Summarize Design Rule Change

- Enlarge solder thief 0.5 to 0.85mm
- Solder space multi-pin connector 0.6 to 0.75mm
- No track – solderland connection that will reduce solder space

Visual Inspection on LFS Joints

QFP

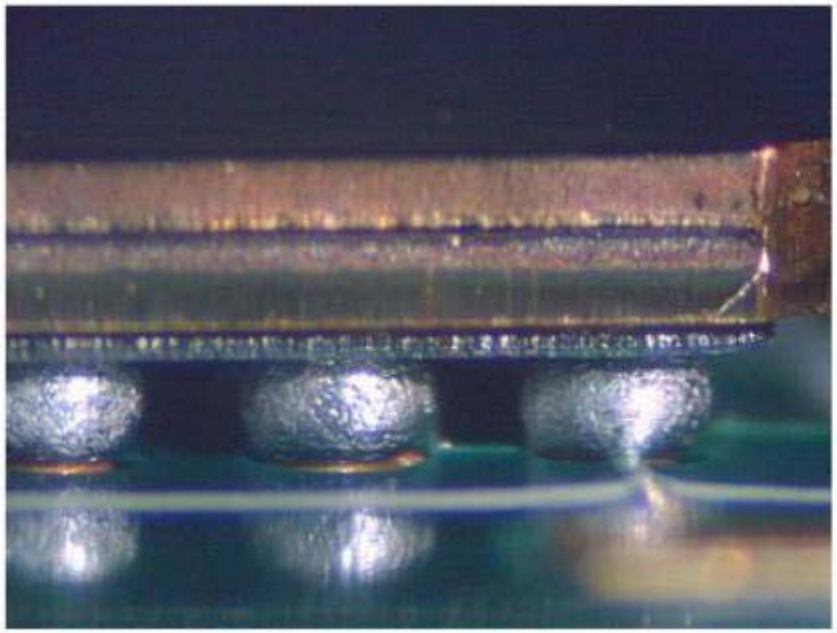
Non Lead-free

Smooth & shiny

Lead-free (SAC alloy)

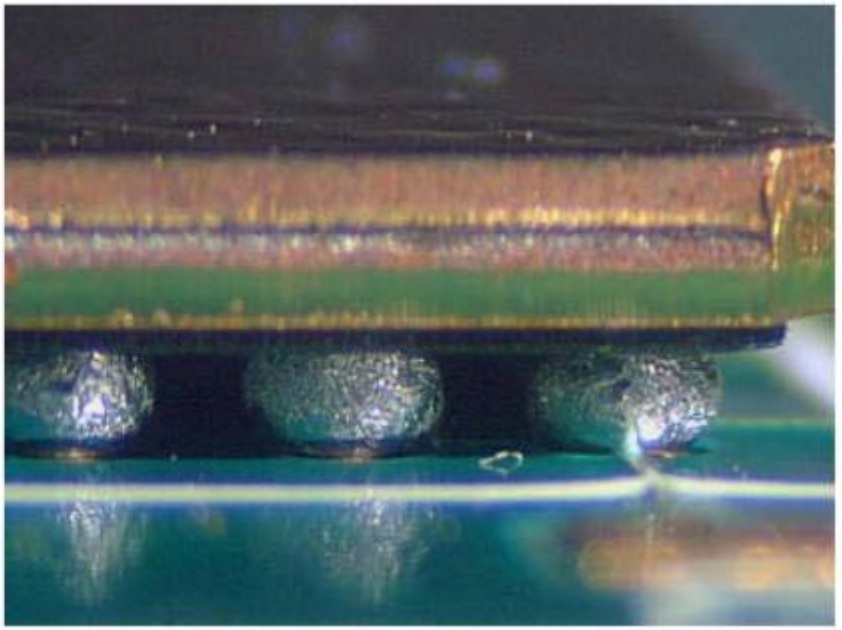
Semi-dull

BGA



Non Lead-free

Smooth & shiny

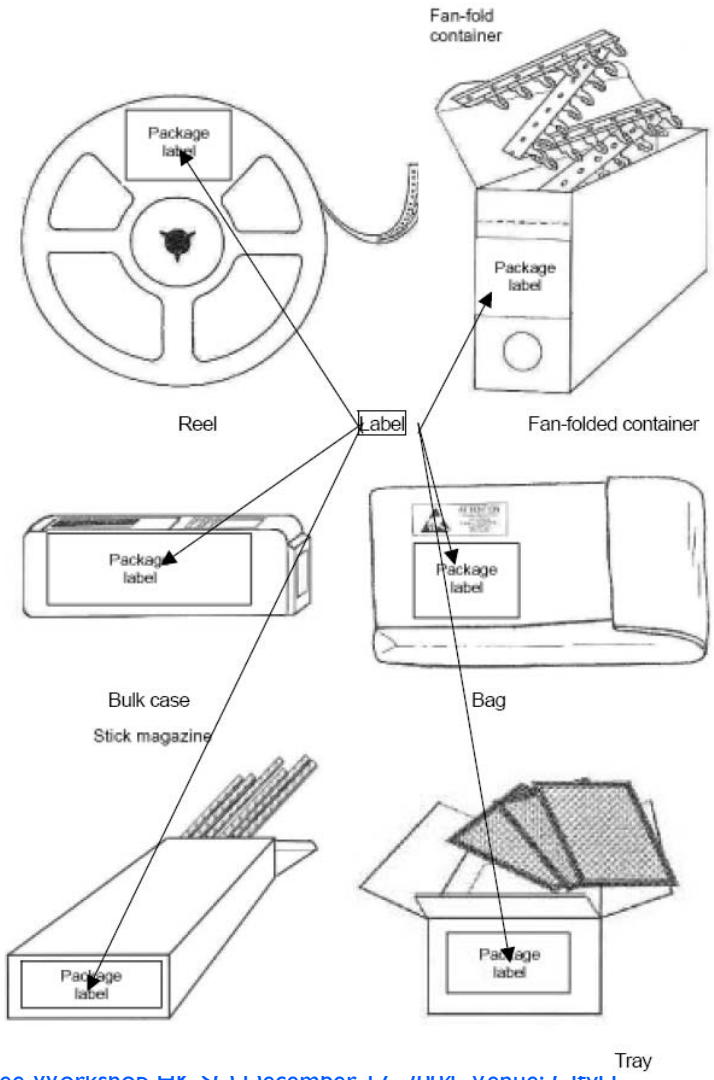


Lead-free (SAC alloy)

Grainy, Semi-dull

Markings

Minimum Units of Packaging



- bag, reel, bulk case, stick, magazine and tray

LF Marking on PCBA

- Same as JEDEC Categories Same as JEDEC Categories
- e1 – SnAgCu
- e2 – Other Sn alloys - No Bi or Zn
- e3 – Sn
- e4 – Pre-plated (i.e. Ag, Au, NiPd, NiPdAu)
- e5 – SnZn, SnZnx (no Bi)
- e6 – contains Bi
- e0, e7, e8, e9 symbols are unassigned
- Bare board – optional

Marking Hierarchy on PCBA

Example: HF e1 e2 XY

This board marking indicates **Halide-free** resin, board surface mount assembled with **SnAgCu** with wave assembly using **SnAg/ SnCu/ SnAgCuX** solder followed by Parylene conformal coating

8-Step Lead free Product Introduction Plan for Philips CE

8 steps

1. Define carrier project
   > Current/ new projects
2. Simulate LF process
   > Check process quality
3. Inventorized PB + components on LF
   > Accumulate LF know-how
4. Execute Design Stress Tests
   > Define product spec
5. Component replacement + design adaptation
   > Check impact on spec
6. LF process implementation in Jabil
   > Quality plan, yield study
7. LF process implementation in PA
8. "Green image" marketing & sales

The 8-step Roadmap

Speakers removed information for proprietary reasons.

2001 2005

Reliability Test Plan for OEM/ODM

Solder Joint Reliability Release

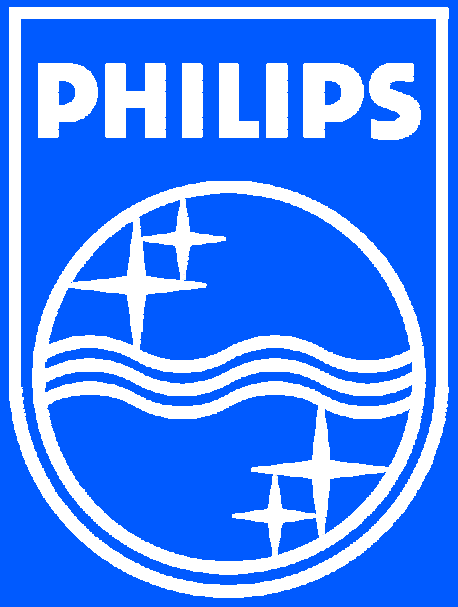
PARAMETERS	REQUIREMENTS	ASSESSMENT	
		YES *)	NO
Lead Free solder alloy composition	Tin (**Sn**) – Silver (**Ag**) – Copper (**Cu**)		Please provide alloy specification
Lead Free solder joints reliability (for other LF alloys than SAC305 or SAC405)	Accelerated Thermal Stress Test -20 degrees C / + 85 degrees C / min. 1 hr cycle with 20 min. at max and min temperature **) Number of cycles to be agreed upon per product (for TV products this is 3000 cycles)		Please provide solder joint reliability test data

If answer is **NO**

Application Release

Date	Test Name	Sample Size	Test Condition	Result	Remarks
June 7 - 8	Dry Heat, Exposure	2 sets	+70C, 2 x 24h	accept	After tested, then turn to burn-in test
June 7 - 8	Cold Exposure	2 sets	-25C, 2 x 24h	accept	After tested, then turn to burn-in test
08-Jun	Dry Heat, Function	2 sets	+55C, 4 h	accept	After tested, then turn to burn-in test
07-Jun	Cold Functional	2 sets	-10C, 4 h	accept	1 set after tested, then turn to burn-in test
June 6 - 2	Damp heat	2 sets	+40C, 93%RH		1 set OK, 1 set CD door can not be opened.
10-Jun	Cold Drop	1 sets	-10C, 16 h; 68cr	accept	
15-Jun	Transport	2 sets	Vibration + Drop	accept	

If answer is **YES**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