Technical Challenges for Pb-Free Components

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Massachusetts Toxics Use Reduction Institute
2nd Workshop on Lead-Free Electronics
June 29, 2000

Technical Challenges for Pb-Free Components

Objectives:

- Review key issues that confront Pb-free components.
- Show the **structure and technology of a successful Pb-free leadframe finish** for components.
- Show some solderability results of this finish with a Pb-free solder.

Technical Challenges for Pb-Free Components

1. By definition, the component must be Pb-free.
   The terminations or leads are obvious;
   die attach solders and Pb bearing ceramics less so.

2. This talk will be confined to plastic packages - Pb-free terminations.

3. To be accepted, the termination finish must compatible with the Pb-free board assembly system.
   - materials: solders, solder pastes, board finishes
   - processing: reflow temperatures
   - reliability

Technical Challenges for Pb-Free Components

As a rule of thumb, Pb is distributed in electronics:

solder - 75%
board - 20% (HASL)
components - 5%

Technical Challenges for Pb-Free Components

In Japan, the Pb-free approach mirrors this Pb distribution:

Phase I - Pb-free solder

(this is when you start to see boxes with “green leaves”)

Phase II - Pb-free board finishes

Phase III - Pb-free components

This makes sense as the board assembler has:

absolute control over the paste/solder

absolute control over the board finish

NO reasonable control over the component finish

Technical Challenges for Pb-Free Components

A big issue for component suppliers is which solder alloy?

SnCu	SnAgCu
SnAg	SnAgCuSb
SnBi	Other

How fast will the conversion/fanout take place?

And by extension, what reflow temperature will be used?

250-260°C? --- Yikes!

Technical Challenges for Pb-Free Components

Higher reflow temperatures mean:

- Popcorn effect/package delamination
- Moisture rating downgrading - by 2 or 3 levels
- Wire bond integrity (?)

There will be a cost to fix these issues…

Will the customer accept the added cost?

Technical Challenges for Pb-Free Components

How to fix the popcorn/moisture level issue?

Downgrade moisture ratings - not acceptable to customer

Dry pack - $$$ - not acceptable to customer

Improve mold compound adhesion to leadframe

- change leadframe finish ??
- change mold compound $$
- change molding process ??

These issues are under investigation by component suppliers.

Technical Challenges for Pb-Free Components

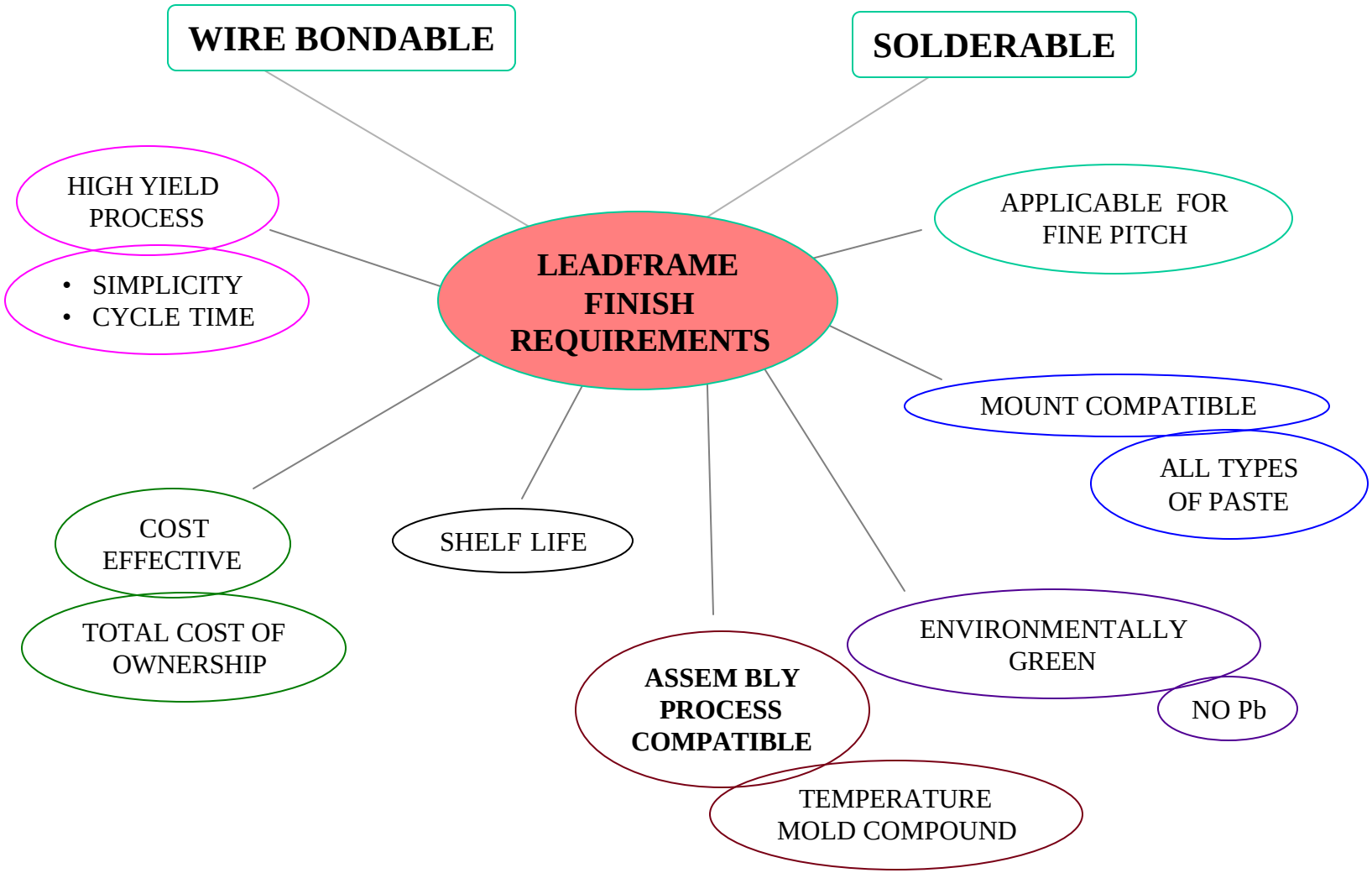
What are the options for Pb-free components?

Either pre-plated leadframes or post mold plated components.

Pre-plated leadframes: plating is done by leadframe supplier

Post-mold plated components: plating is done at assembly/test house after plastic encapsulation of the device.

Leadframe Finish Attributes



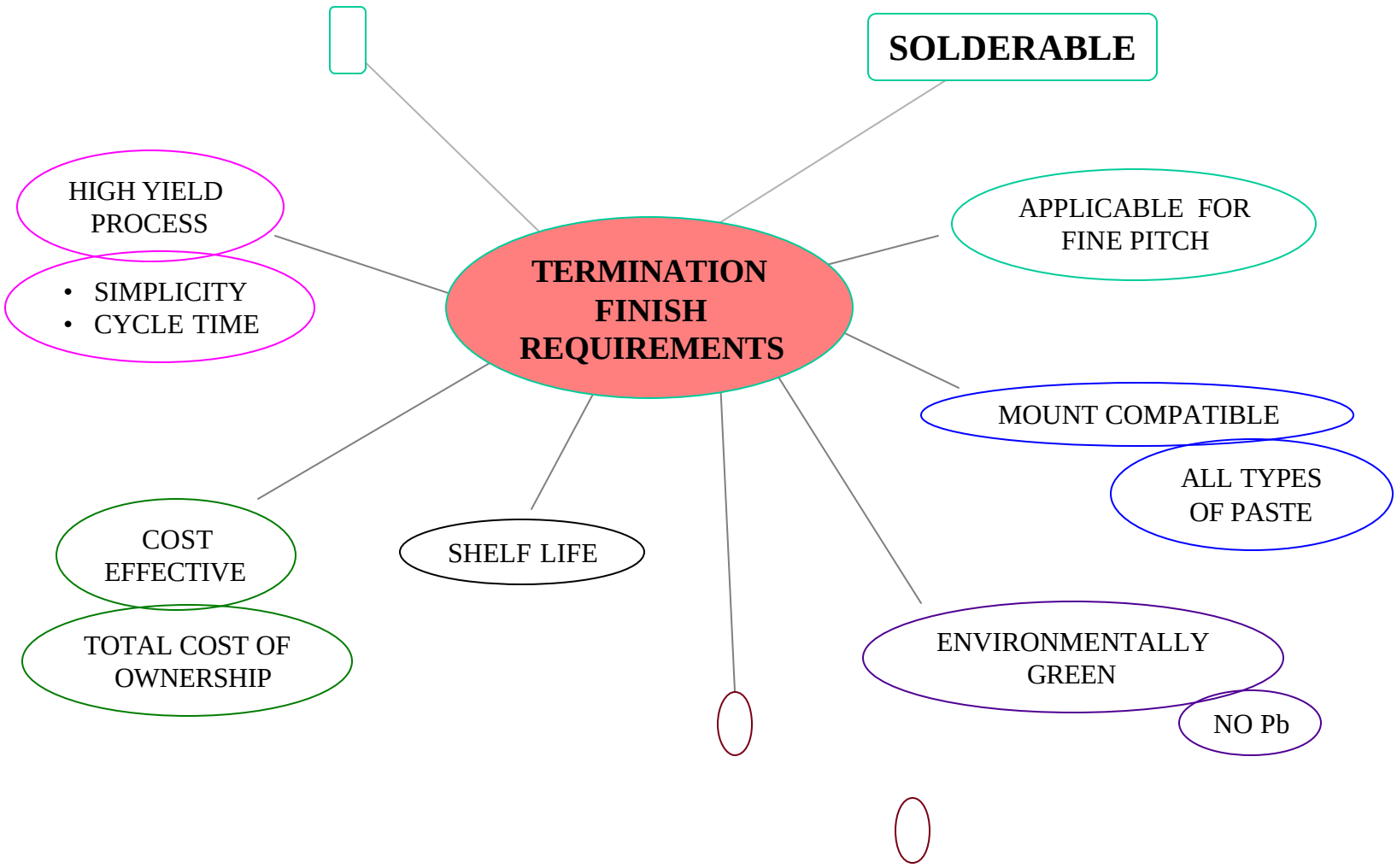
Technical Challenges for Pb-Free Components

For pre-plated leadframes there are two commercially available variations:

NiPd - nickel/palladium
NiPdAu - nickel/palladium with a gold flash

A third option is pre-plated solder applied to the external leads. This has not been widely accepted - solder must withstand assembly/test and there are selective plating requirements. Solder must be Pb-free.

Termination Finish Attributes



Technical Challenges for Pb-Free Components

For post-mold plating, the options are more straightforward.

Assuming post-mold plating for SnPb is in place, then the issue is selecting the “right” Pb-free solder with which to replace the SnPb…unfortunately the only viable candidate now is SnCu.

On the horizon are SnAg and SnBi…but which paste and board finish will the customer use?

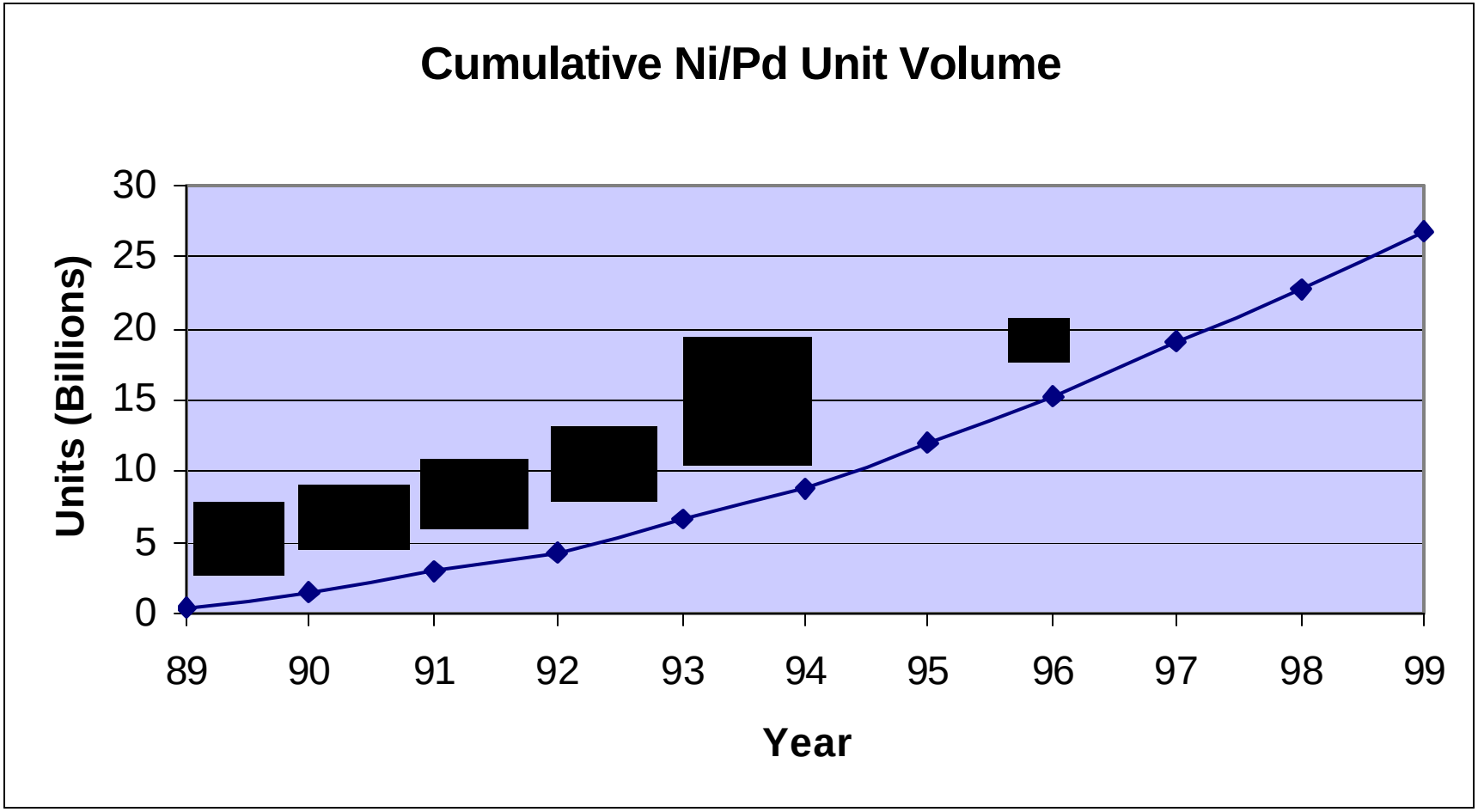
There are process control issues in plating these alloys.

Technical Challenges for Pb-Free Components

Texas Instruments has been Pb-free for 10+ years

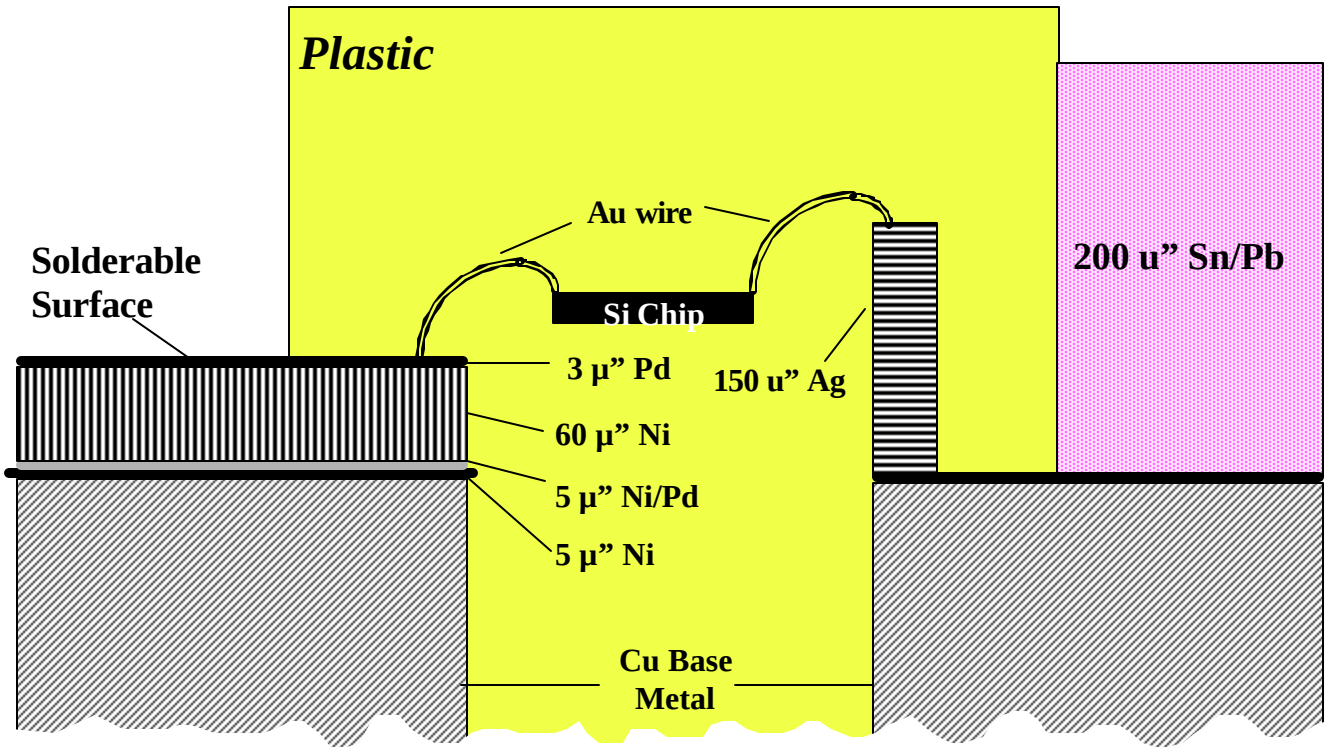
NiPd plated leadframe

>30 Billion in the field


Cumulative Ni/Pd Unit Volume
Units (Billions)
30
25
20
15
10
5
0
89
90
91
92
93
94
95
96
97
98
99
Year

Structures of NiPd and Ag Spot + Solder Finishes

NiPd Finish | **Ag Spot & Post Mold Sn/Pb**



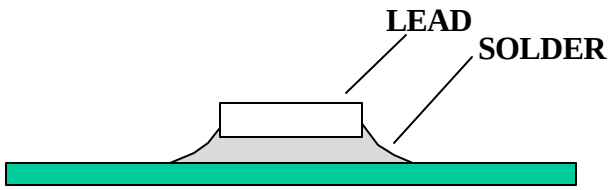
Technical Challenges for Pb-Free Components

Dissolution of Au, Cu, Pd and Ni in Molten Solder
(from Bader, Welding Research Supplement, 1969)

	RATE u/SEC (215C)	RATE u/SEC (250C)
Ni	<0.0005	0.005
Pd	0.00175	0.07
Cu	0.08	0.1325
Au	1.675	4.175

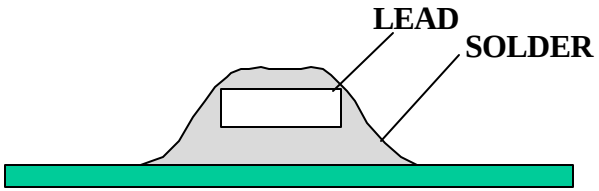
Schematic Solder Joint Comparison

PALLADIUM PLATED LEAD

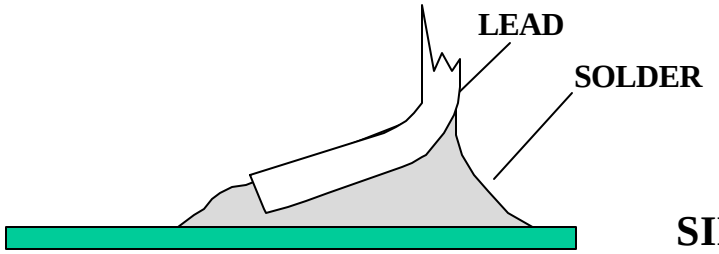


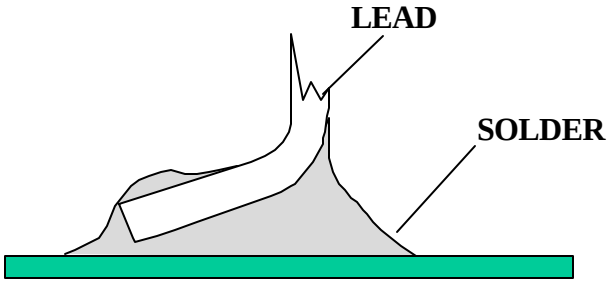
Solder does not flow over top of foot on Pd plated leads

SOLDER COATED LEAD



END VIEW

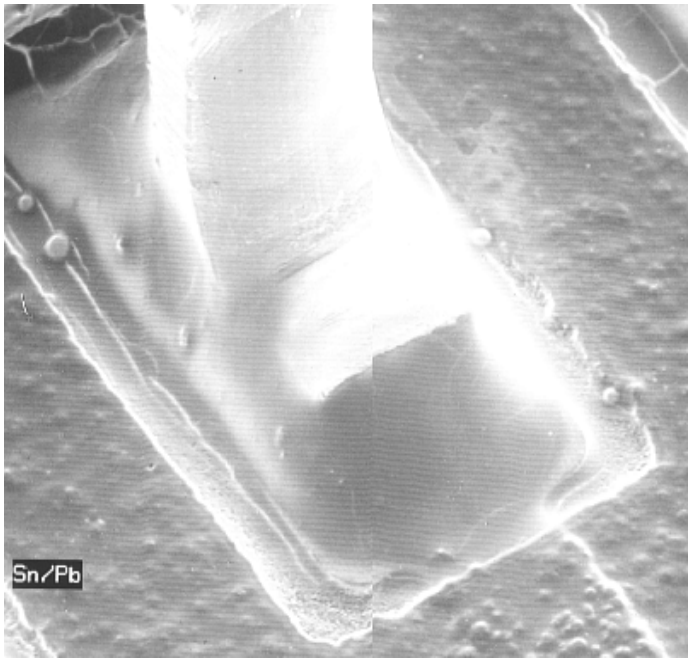




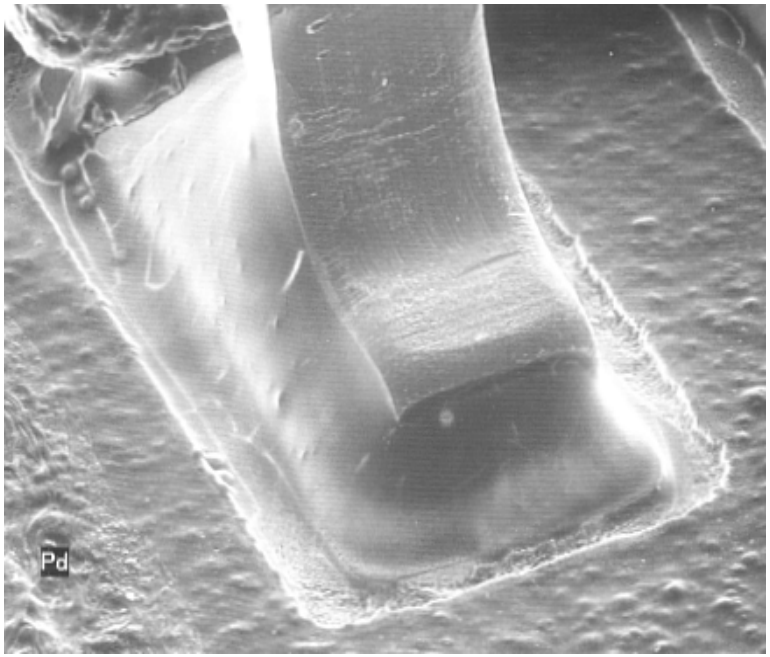
SIDE VIEW

PALLADIUM SOLDER JOINT STRENGTH (FATIGUE & SHEAR)
AS GOOD OR BETTER THAN SOLDER DIP STRENGTH

Micrographs Showing NiPd and SnPb Plated Leads After Reflow



Sn/Pb Plated Lead

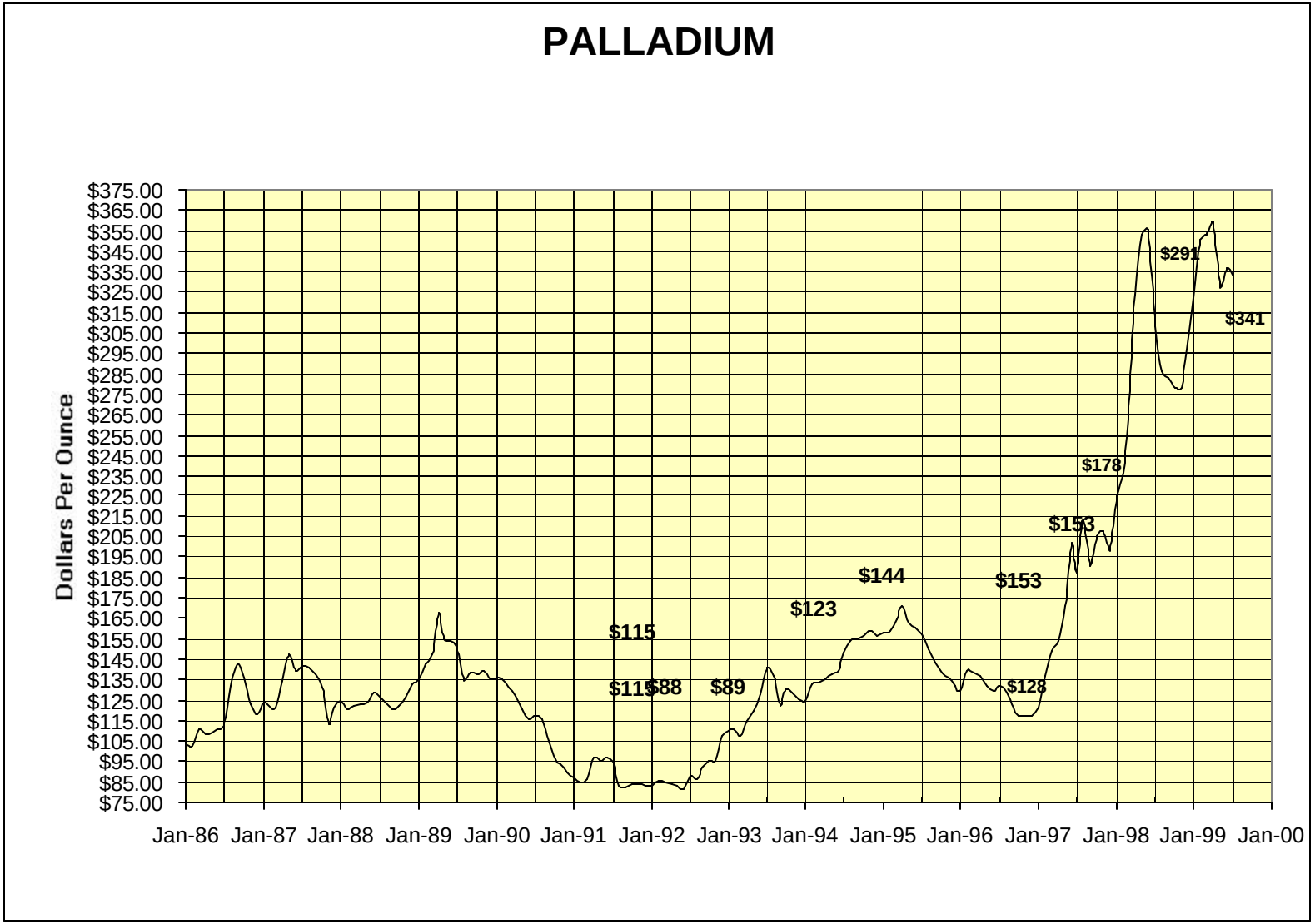


Ni/Pd Plated lead

Technical Challenges for Pb-Free Components

There is a BIG issue for NiPd plated leadframes.

Average Monthly London PM Fix for Palladium



Technical Challenges for Pb-Free Components

In 1998 TI undertook a study of NiPd performance with one commercially available Pb-free solder, Castin™ .

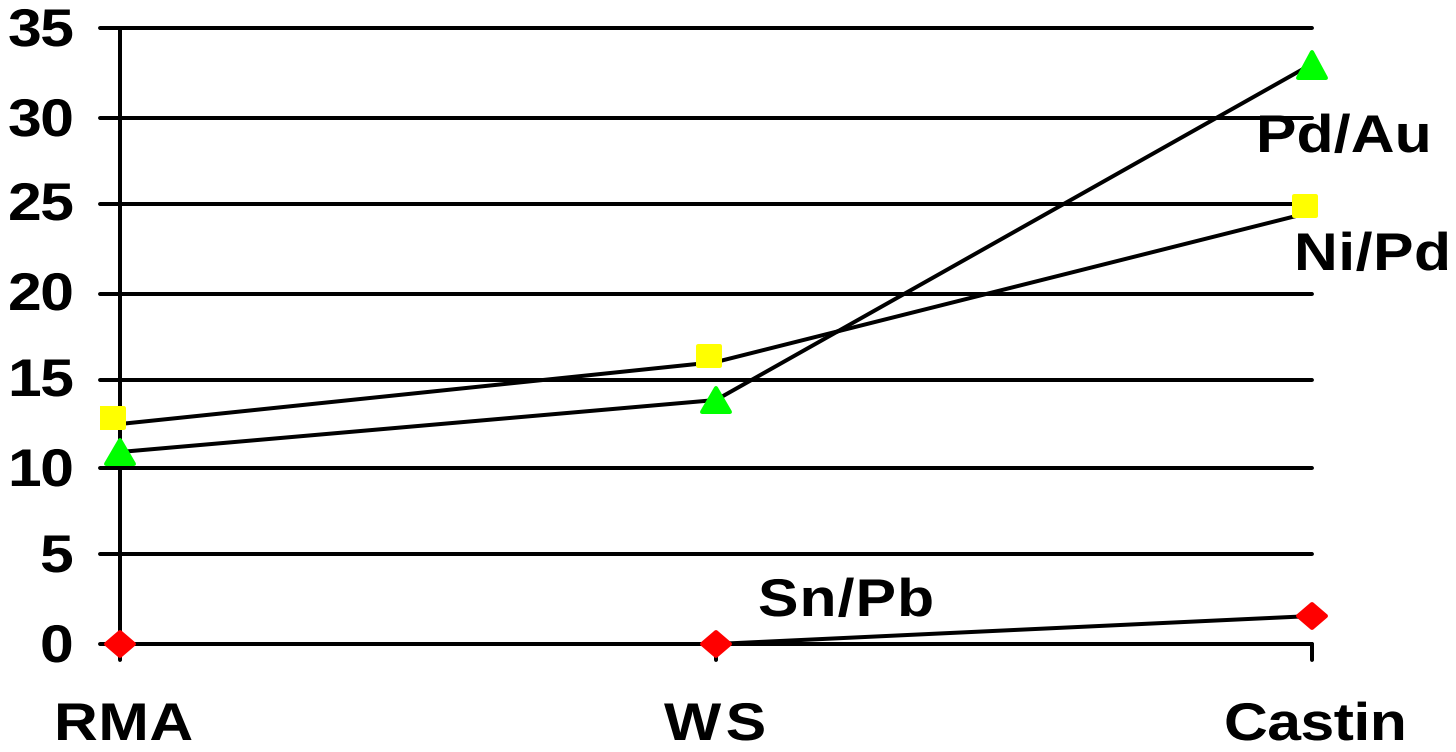
A brief overview of our results follow.

Pb-Free Solder Study

L9 Designed Experiment

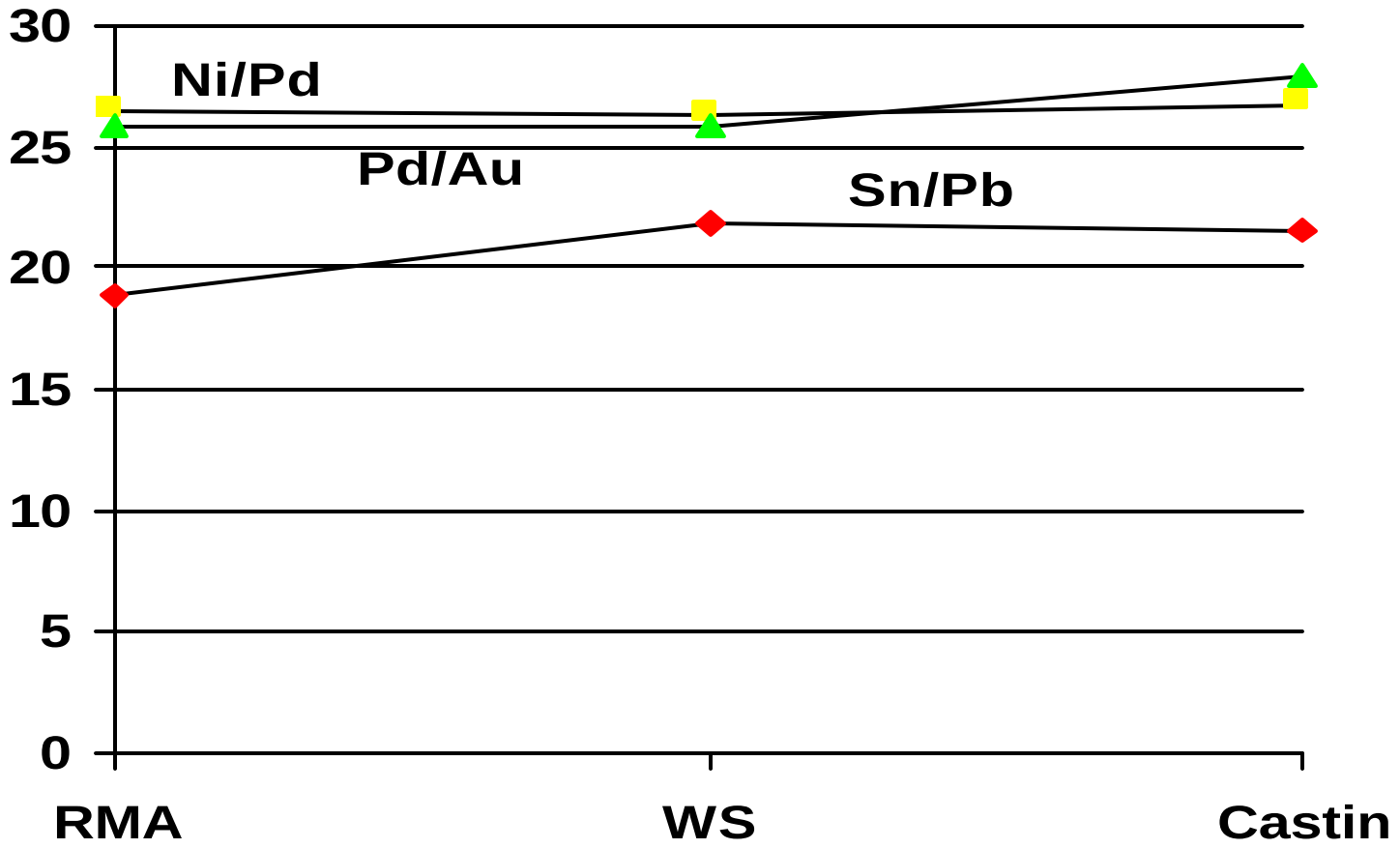
Run	Lead Finish	Solder Paste
1	Sn/Pb	Sn/Pb RMA
2	Sn/Pb	Sn/Pb WS
3	Sn/Pb	Castin Pb-Free
4	Ni/Pd	Sn/Pb RMA
5	Ni/Pd	Sn/Pb WS
6	Ni/Pd	Castin Pb-Free
7	Ni/Pd/Au	Sn/Pb RMA
8	Ni/Pd/Au	Sn/Pb WS
9	Ni/Pd/Au	Castin Pb-Free

Pb-Free Solder Study



Contact Angle Measurements

Pb-Free Solder Study



Lead Pull Results

Pb-Free Solder Study

Failure Modes for Lead Pull

Lead Finish	Solder Paste	Mode 1	Mode 2
1 - Sn/Pb	1 - Sn/Pb RMA	3	39
1 - Sn/Pb	2 - Sn/Pb WS	2	40
1 - Sn/Pb	3 - Castin Pb-Free	0	42
2 - Ni/Pd	1 - Sn/Pb RMA	30	12
2 - Ni/Pd	2 - Sn/Pb WS	40	2
2 - Ni/Pd	3 - Castin Pb-Free	39	3
3 - Ni/Pd/Au	1 - Sn/Pb RMA	39	3
3 - Ni/Pd/Au	2 - Sn/Pb WS	39	3
3 - Ni/Pd/Au	3 - Castin Pb-Free	41	1

Pb-Free Solder Study

Temp Cycle Results (Sample Size/# Fails)

Gr\Cycles	0	100	150	250	500	1000	2000	3000
1	10/0	10/0	10/0	10/0	10/0	10/0	10/0	10/0
2	10/0	10/0	10/0	10/0	10/0	10/0	10/0	10/0
3	10/0	10/0	10/0	10/0	10/0	10/0	10/0	10/0
4	10/0	10/0	10/0	10/0	10/0	10/0	10/0	10/0
5	10/0	10/0	10/0	10/0	10/0	10/0	10/0	10/0
6	10/0	10/0	10/0	10/0	10/0	10/0	10/0	10/0
7	10/0	10/0	10/0	10/0	10/0	10/0	10/0	10/0
8	10/0	10/0	10/0	10/0	10/0	10/0	10/0	10/0
9	10/0	10/0	10/0	10/0	10/0	10/0	10/0	10/0

-65 deg C - 155 deg C

Conclusion Pb-Free Solder Study

Contact Angle:

Ni/Pd and Ni/Pd/Au > Sn/Pb for all types of solder pastes

Differences in contact angle = a cosmetic issue

No correlation to any difference in reliability or mechanical strength of the joint.

Lead Pull:

Sn/Pb < Ni/Pd and Ni/Pd/Au for all types of solder pastes
Ni/Pd and Ni/Pd/Au equivalent

Sn/Pb components failed within the solder

In most cases, Ni/Pd and Ni/Pd/Au, solder was pulled completely from the pad.

Conclusion Pb-Free Solder Study

Temperature Cycle: All lead finish components with each solder paste showed no failures out to 3000 cycles.

Cross-sections: showed no cracks in the solder joints out to 250 temperature cycles.

Wetting balance: Showed that Sn/Pb took longer to pass the T_0 line than the Ni/Pd or the Ni/Pd/Au. Gold flash on the Ni/Pd/Au components improved wetting performance as measured by T_0.

Technical Challenges for Pb-Free Components

Conclusions

- Pb-free termination finishes are available, one has been in use 10+ years - NiPd.
- Major source of Pb in electronic assemblies is solder (~75%).
- Pb-free solder type must be selected - SnCu, SnAgCu?
- Major concern ($$$) for component suppliers is reflow temperature (250°C+) and effect on device integrity.
- Second major contributor to Pb in electronic assemblies is board finish (~20%).
- Board assemblers have excellent ability to control solder and board finish, less control over component finish.