



Texas Instruments Lead-Free Solutions

Speaker:

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Agenda:

- **TI Lead-Free Status**
- **Issues in the lead-free environment**



Texas Instruments Lead-Free Status

5-Jul-01

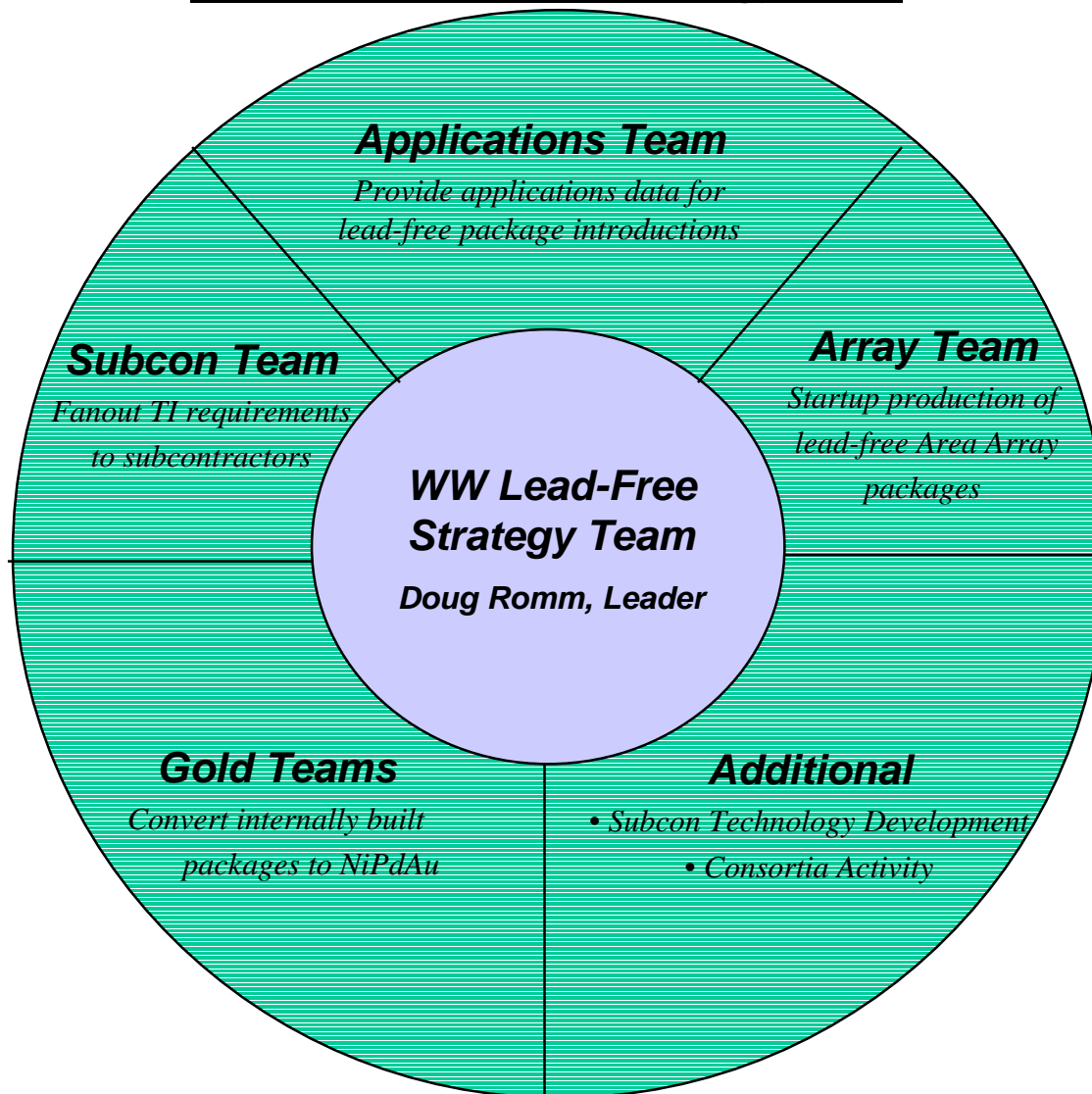
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THE WORLD LEADER IN DSP AND ANALOG

 TEXAS INSTRUMENTS



TI Internal Lead-Free Strategy Team



5-Jul-01

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Selection Criteria for a Lead-Free Component Finish

Soldering performance equivalent to SnPb component finish
Compatible with SnPb as well as lead-free processes (solders)
Mainstream (Industry standard finish)
Proven performance
260C capable
Proven shelf life
No cost impact for end user



Texas Instruments Lead-Free Status

- **Leadframe Based Packages:**

- TI introduced Ni/Pd finish as a replacement for Sn/Pb plating on IC packages in 1989.
- ~90% of TI internally built packages now use Ni/Pd finish.
- Over 40 Billion TI Ni/Pd plated IC packages in the field.
- Ni/Pd and Ni/Pd/Au are lead-free finishes.
- Ni/Pd and NiPdAu finishes are compatible with Sn/Pb paste (220°C) and lead-free paste (240-260°C)
- TI has qualified Ni/Pd/Au finish for leadframe based packages.
- TI Lead-Free Process Solutions web page: <http://www.ti.com/sc/leadfree>

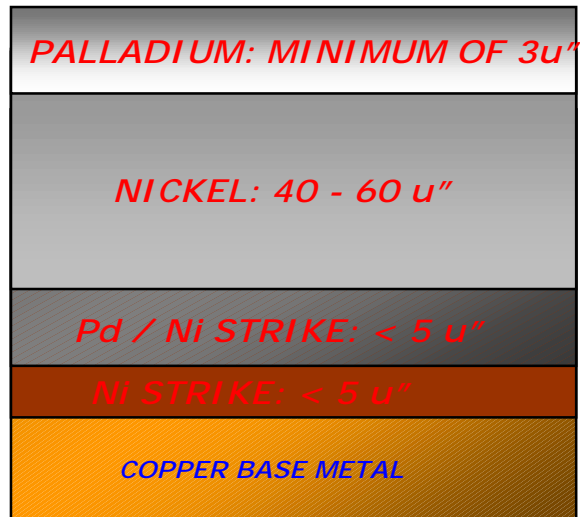
- **Area Array Packages:**

- Successfully qualified MicroStar BGA packages (0.8mm ball pitch) with lead-free ball in 2000.
- Working with major subcontractor to qualify PBGA packages with SnAgCu ball alloy.

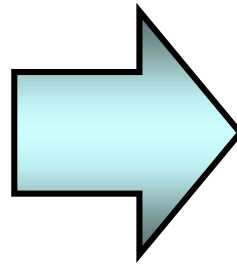
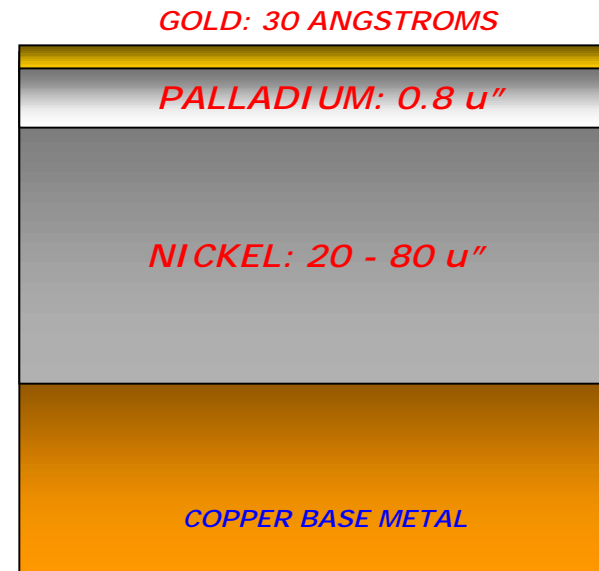


Leadframe-Based Solutions

TI NiPd finish: Past



TI NiPdAu finish: Present



- NiPdAu structure shown has been in use in Japan since early 1990s.
- TI conversion is driven by customer demand from Japanese market.
- Enhanced wetting performance with NiPdAu finish seen in solderability tests.



Leadframe-Based Solutions

- **Similarities between NiPd and NiPdAu finishes:**

- NiPd and NiPdAu finishes both lead-free.
- Long field history, good performance.
- Compatible with Sn/Pb paste (220°C) and lead-free paste (240-260°C). Does not require that end user be totally lead-free to use.

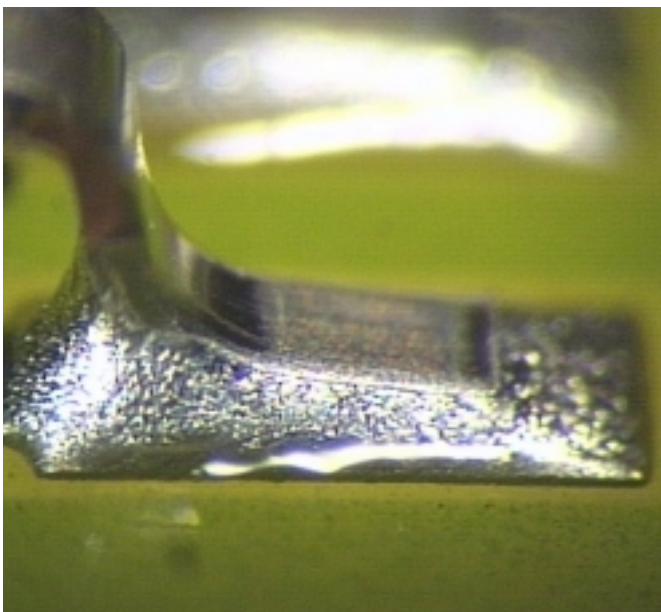
- **Benefits of NiPdAu structure:**

- Enhanced wetting balance performance.
- NiPdAu will provide better wetting with the wide spectrum of lead-free solder alloys.
- Industry standard Pd finish.



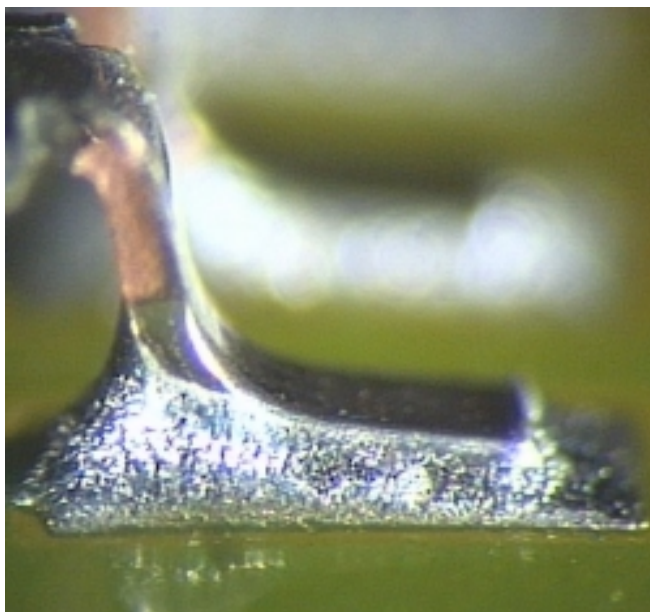
Leadframe-Based Solutions

Visual solder joint appearance, SnAgCu 235°C, NiAu board pad finish



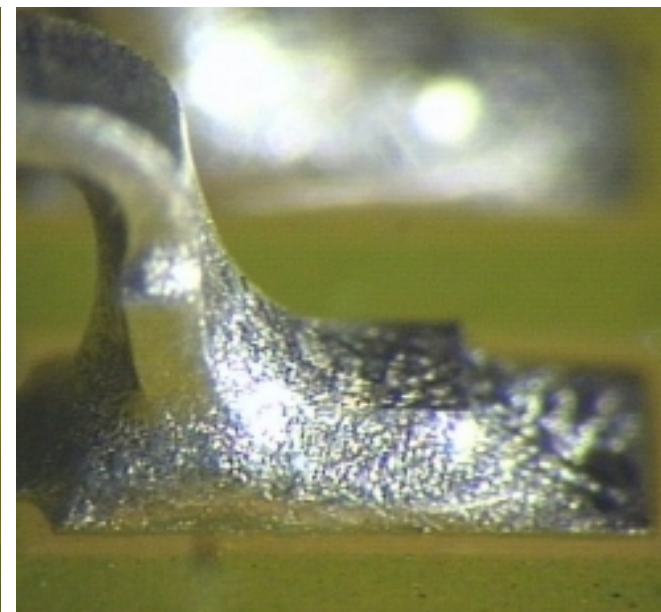
NiPdAu lead finish

good solder joint and side wetting visible on lead-free finishes.



NiPd

good solder joint and side wetting visible on lead-free finishes.



SnPb

Some solder wicking observed.



Area Array Solutions

- **MicroStar BGA™ Packages :**

- Qualified 128 MicroStar BGA with lead-free balls in September 2000.
- Currently qualifying 0.8mm pitch MicroStar BGA packages, completion 3Q2001.

- **Other Area Array Packages:**

- Partnering with major subcontractor to qualify 256 PBGA (27mm body size) with Sn/Ag/Cu balls.
- Qualification expected Q3 2001.
- Lead-Free Flip chip packages available in late 2001.



Lead-Free Package Matrix

Application	Package Type	3D	Available Finish			Lead-Free Finish Available
			NiPdAu	NiPd	SnPb	
Surface Mount	SOIC/SOP		Now	Now		Now
	SSOP/TSSOP		2Q01	Now		Now
	QFP/TQFP		2Q01	Now	Now	Now
	SOT				Now	TBD
	PLCC				Now	TBD



Lead-Free Package Matrix

Application	Package Type	3D	Available Finish			Lead-Free Finish Available
			NiPdAu	NiPd	SnPb	
Surface Mount Power Packages	PowerPAD		2Q01	Now		Now
	PowerFLEX TO-220/TO-92				Now	TBD
Through-Hole	PDIP		1Q01	Now		Now
Area Array	BGA				Now	3Q01
	MicroStar BGA™				Now	Now
	MicroStar Junior™ BGA				Now	3Q01
	Flip Chip				Now	4Q01

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Issues in the Lead-Free Environment

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Issues with Industry Lead-Free Conversion

- High temperature moisture performance degradation:





Lead-Free Solder Alloy	Liquidous Temperature (C)
Sn / 37 Pb	183
Sn / 4 Ag / 0.5 Cu	217
Sn / 2 Ag / 0.8 Cu / 0.5 Sb	216 - 222
Sn / 0.7 Cu	227
Sn / 2 Ag	221 - 226
Sn / 3.5 Ag	221
Sn / 7.5 Bi / 2 Ag	207 - 212
Sn / 3.5 Ag / 3 Bi	206 - 213

- Peak reflow temperature is typically set 30-40C above liquidous temperature.
- Issue: Majority of IC packages are rated for moisture sensitivity performance at 235C (or less), not 260C. Increase in peak reflow temperature of ~30C could have an adverse impact on package integrity.



Issues with Industry Lead-Free Conversion




- **Impact of 260C:** 'Leading-Edge' Packages, current material sets

Application	Package Type	3D	Moisture Rating		
			235 C	260 C	Impact
Surface Mount	TSSOP / TVSOP		Level 1	Level 1	None
	TQFP / LQFP		Level 1 (Reduced metal leadframe)	Level 1	None
Area Array	MicroStar BGA™		Level 2/3	Level 2/3	None
	MicroStar Junior™ BGA		Level 2/3 (220C)	TBD	TBD



Issues with Industry Lead-Free Conversion

- **Impact of 260C:** 'Mature' Packages, current material sets

Application	Package Type	3D	Moisture Rating		
			235 C	260 C	Impact
Surface Mount	SOIC / SOP		Level 1	Level 3-4	2-3 Levels
	TQFP / LQFP		Level 2-3 (Conventional Pad)	Level 3-6	1-3 Levels
Area Array	BGA		Level 3	Level 4-5	1-2 Levels



Issues with Industry Lead-Free Conversion

- **Impact of 260C:** Possibility of a lower peak temperature
- It has been demonstrated that SnAgCu can be reflowed in the range of 235C peak temperature (Skidmore, Romm/Abbott/Lange)
- NEMI is discussing lead-free profiles with peak temperature of 240-245C:
 - MSL typically degrades by one level for every 5 to 10C increase in peak reflow temp
 - Targeting 240 to 245C would be beneficial.
 - Maintaining a minimal delta T across the circuit board will support lower peak temperatures.
 - Newer convection cure ovens will perform better for larger circuit boards with high thermal mass components.
- IPC / JEDEC Task Group
 - Members have indicated that 230-235C can form good solder joints with Sn/Ag/Cu solders.
 - For smaller packages, 240-245C is adequate.
 - Some Japanese companies also appear to be moving toward 245C peak.



Issues with Industry Lead-Free Conversion

- *Component finish options:*

Finish	Positive	Negative
NiPd	<ul style="list-style-type: none">• Compatible with SnPb as well as industry preferred lead-free solders• No whiskering concerns	
NiPdAu	<ul style="list-style-type: none">• Compatible with SnPb as well as industry preferred lead-free solders• No whiskering concerns• Industry 'standard' Pd finish	
Pure Sn	<ul style="list-style-type: none">• If proven, would be drop-in replacement for post-mold plating of IC packages.	<ul style="list-style-type: none">• History of whisker issues, possible shelf life issues
SnBi	<ul style="list-style-type: none">• Addresses pure Sn whisker issue	<ul style="list-style-type: none">• Compatible with lead-free processes only
SnCu	<ul style="list-style-type: none">• Addresses pure Sn whisker issue	<ul style="list-style-type: none">• Not proven; low temperature issue



Selection Criteria for a Lead-Free Component Finish

Criteria	Component Finish				
	NiPd	NiPdAu	Sn	SnBi	SnCu
Soldering performance equivalent to SnPb component finish	Yes	Yes	Yes	?	?
Compatible with SnPb as well as lead-free processes (solders)	Yes	Yes	Yes	No	No
Mainstream (Industry standard finish)	No	Yes	No	No	No
Proven performance	Yes	Yes	Yes/No	No	No
260C capable	Yes	Yes	Yes	?	?
Proven shelf life	Yes	Yes	No?	?	?
No cost impact for component user	Yes	Yes	Yes	?	?

Judgements based on TI history and knowledge of industry