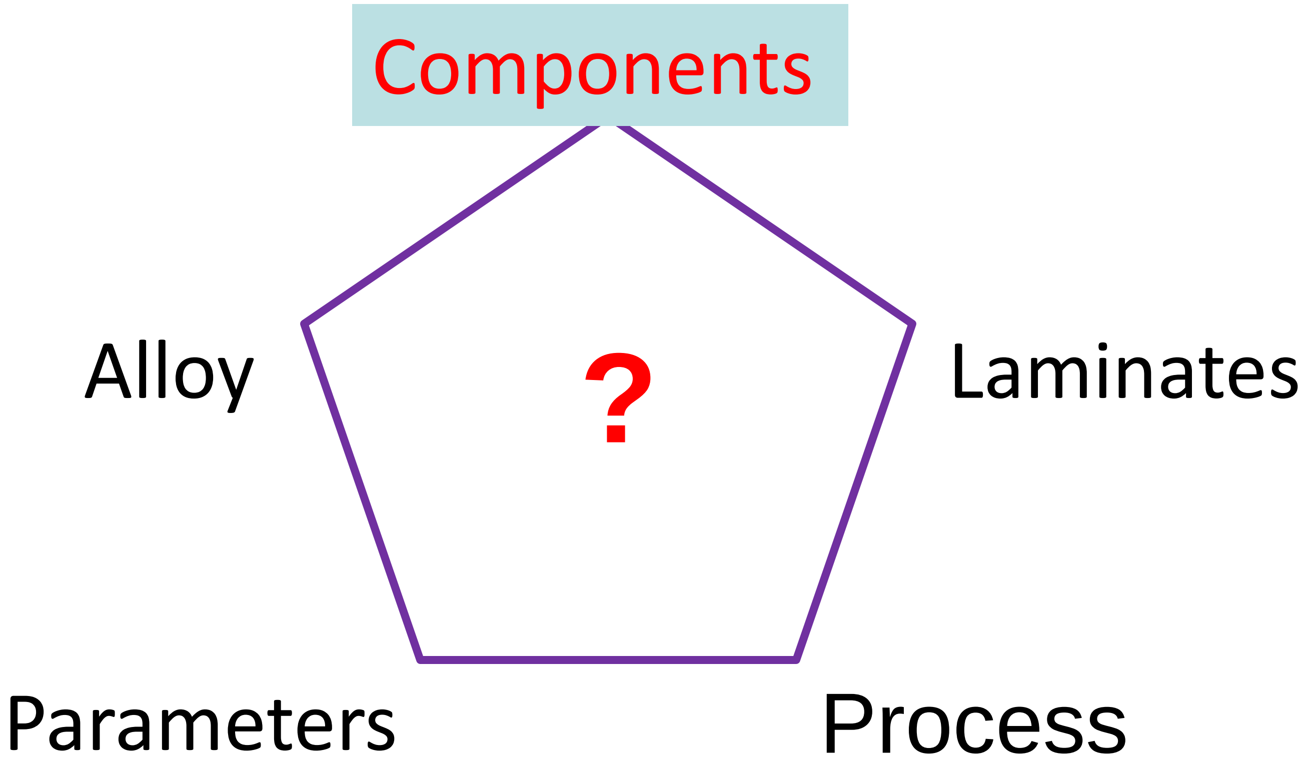
Low Temperature SMT Process Implementation

Drivers for Low Temperature Soldering

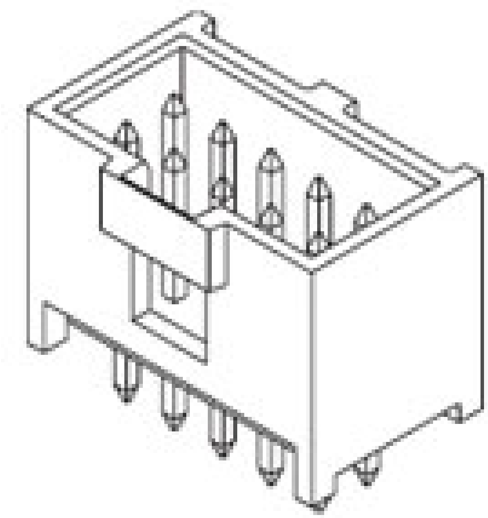
I. Lower Cost Components
II. Lower Cost Laminates
III. Lower Energy Consumption
IV. Eliminate Wave Soldering
V. Reduced Thermal Stress During Assembly Process

Low Temperature Conversion



Lower Cost Component Example

- Molex Shrouded Header (105ºC)
  - Catalogue Price $.84
- Molex Shrouded Hea
  - Catalogue Price $1.2
- 46% Savings



Source: Online component catalogs (like RS, DigiKey, Farnell)

Low Temperature Molding Compound Cost

MAJOR EMC PRODUCT ASP

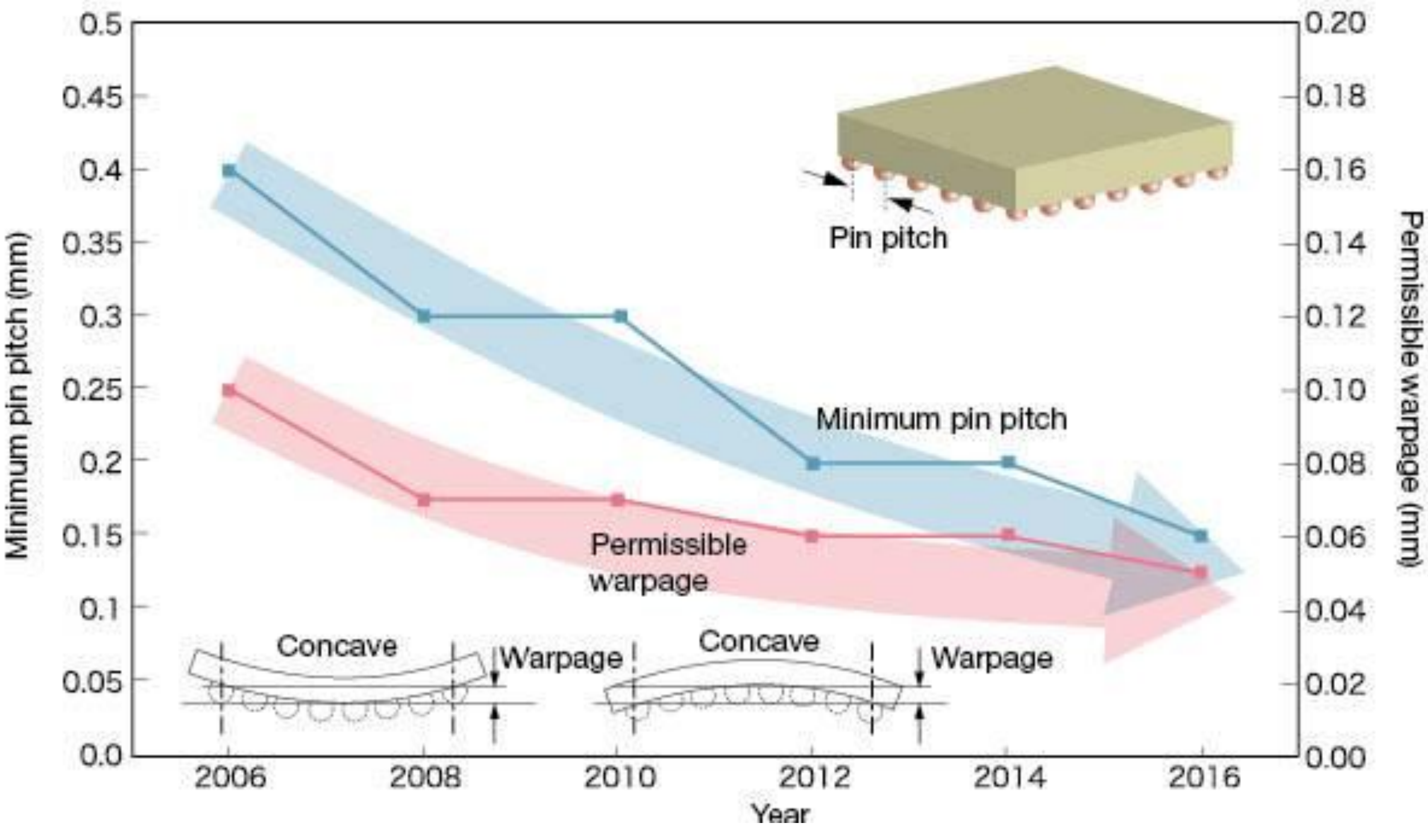
Package Categories	Discretes	Integrated Circuits			
		Through Hole	Standard SMT Packages	Thin SMT Packages	Array and QFN Packages
Base Epoxy Resins	• ECN/ OCN • Hybrid • DCPD, Biphenyl, Multi-Aromatic	• ECN/OCN	• ECN/OCN, DCPD • Hybrid • Biphenyl, Multi-Aromatic	• Biphenyl, Multi-Aromatic	• Biphenyl, Multi-Aromatic
Price Range: ASP ($/kg):	$3 – $12/kg $4.6/kg	$4 – $6/kg $5.5/kg	$5 – $15/kg $9.5/kg	$10 – $18/kg $14.7/kg	$12 – $20/kg $16.6/kg

Epoxy **C**resole **N**ovolac

Ortho-**C**resole **N**ovolac

Di**c**yclo**p**enta**d**iene

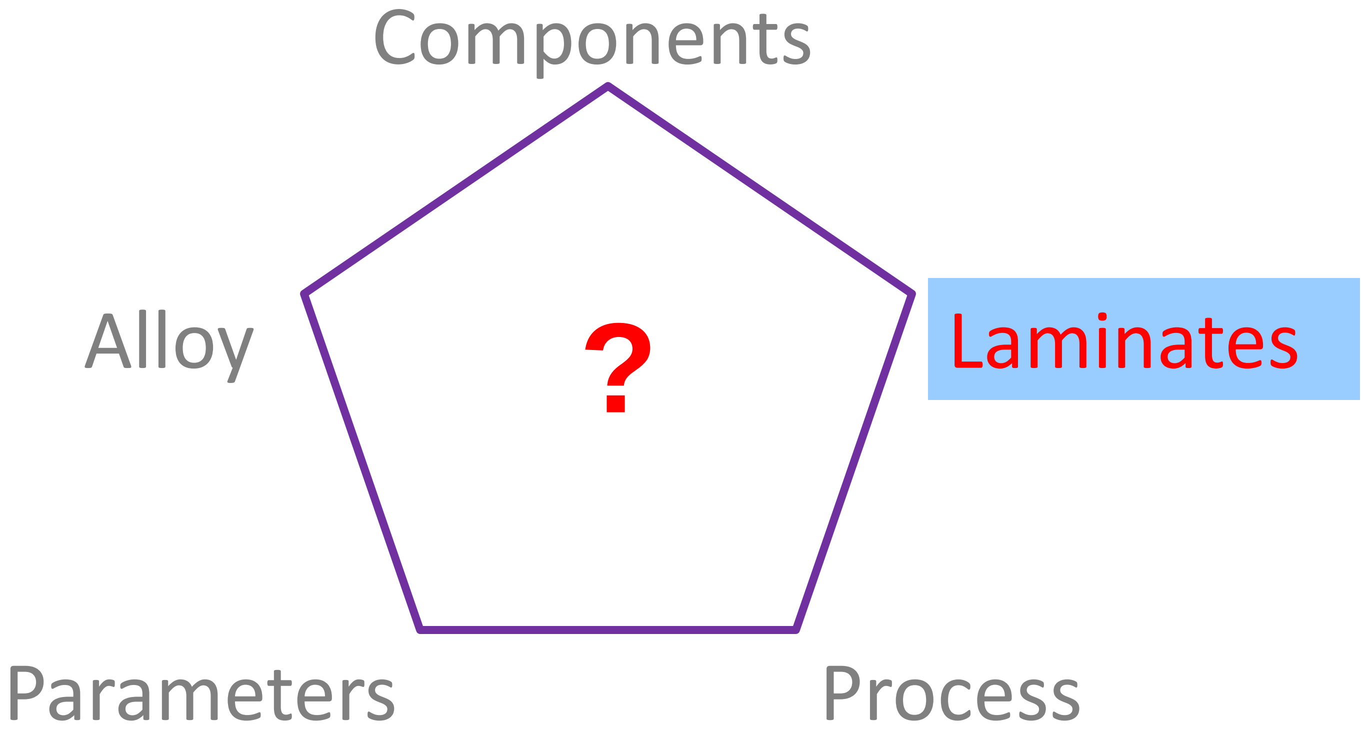
Component Warpage Concerns



Only 0.05mm Permissible warpage in 0.15mm pitch FBGA – JEITA roadmap

FBGA – Fine Pitch Ball Grid Array

Low Temperature Conversion



PCB ….. Cheap ⇨ Cheaper

Remote Control Manufacturer case study – potentially save >$108,000 / year through the use of low temperature processing .

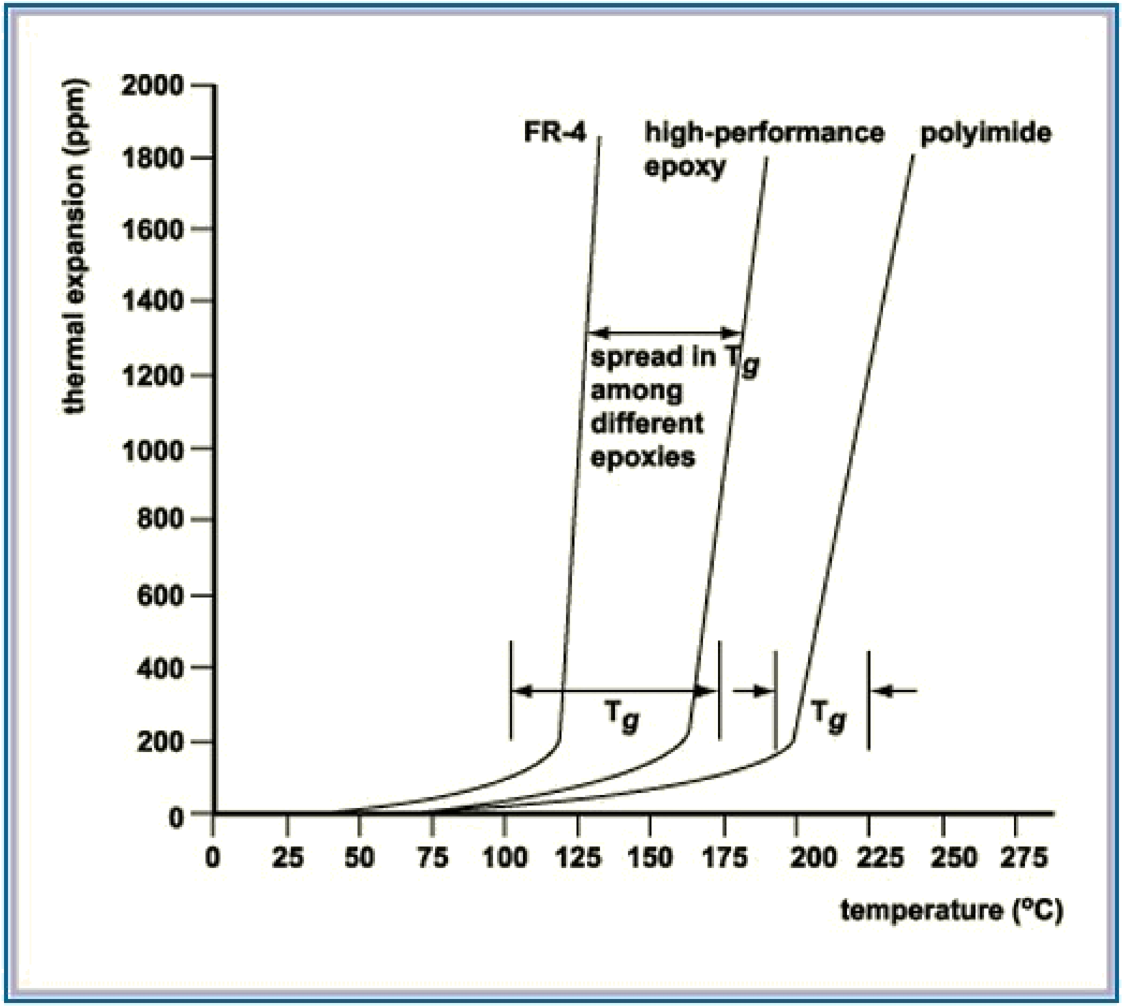
VIU

Since this was a feasibility study of PCB materials only, the potential savings are estimated below PCB cost difference was estimated at 10% between materials based on various PCB suppliers.

	FR-1	XPC	Potential Savings	Value Savings
PCB cost / panel	US$ 6.00	US$ 5.40	US$ 0.60 / panel	
Ave Production / week	20,000	20,000	US$ 2,000	US$ 2,000
Ave Production / annum	1,080,000	1,080,000	US$ 108,000	US$ 108,000 / annum

FR-4 to Phenolic Paper Laminate Conversion yields even greater savings if possible to implement

Higher T_g = Higher Cost Laminates



FR-1 vs XPC – Stiffness Under Heat

GRADE :- RL *FR1* ANSI /NEMA TYPE FR1

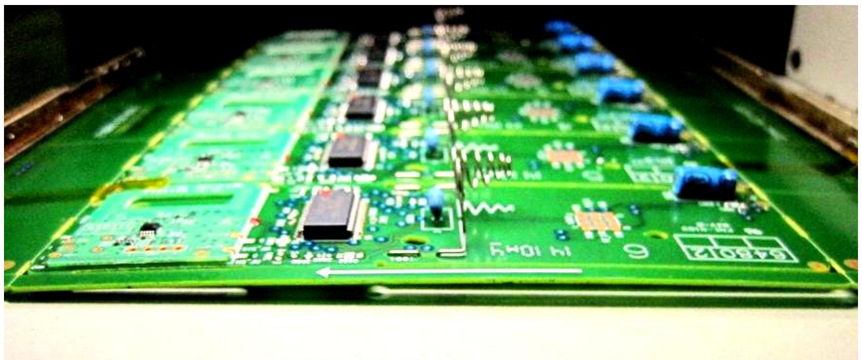
Bow and Twist (304mm x 304mm)	As is	mm/M	**10(with Cladding)**

XPC twists > double FR-1

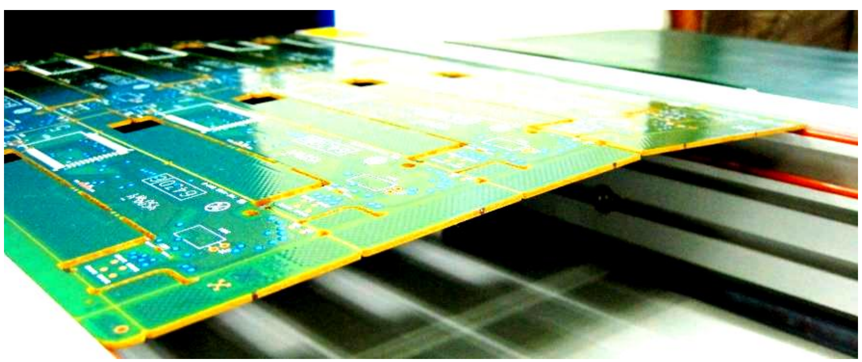
GRADE :- RL *XPC* ANSI /NEMA TYPE XPC

Bow and Twist (304mm x 304mm)	As is	mm/M	**25(with Cladding)**

Warpage Example



FR-1, 1.2mm Thick, 245° C Peak



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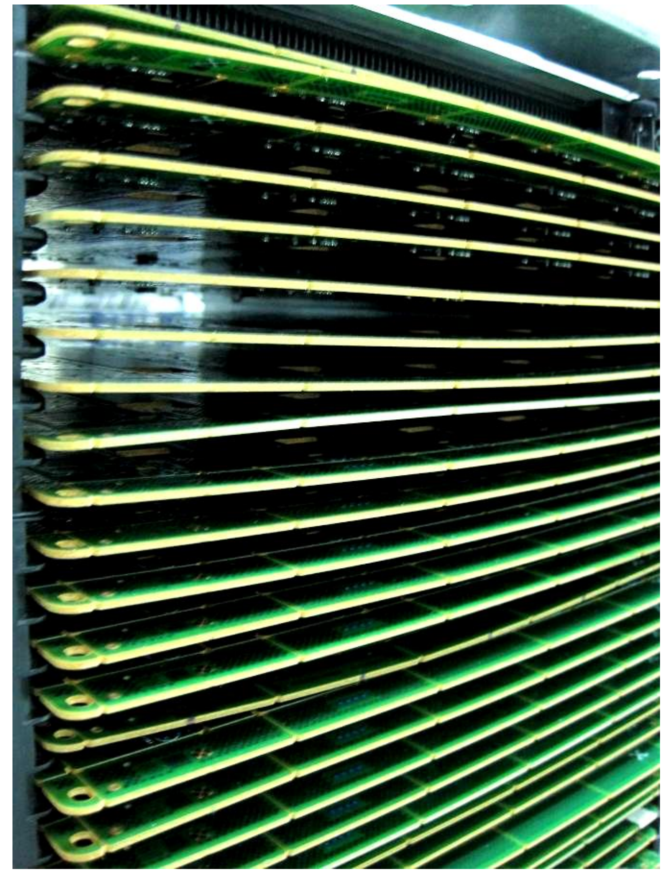
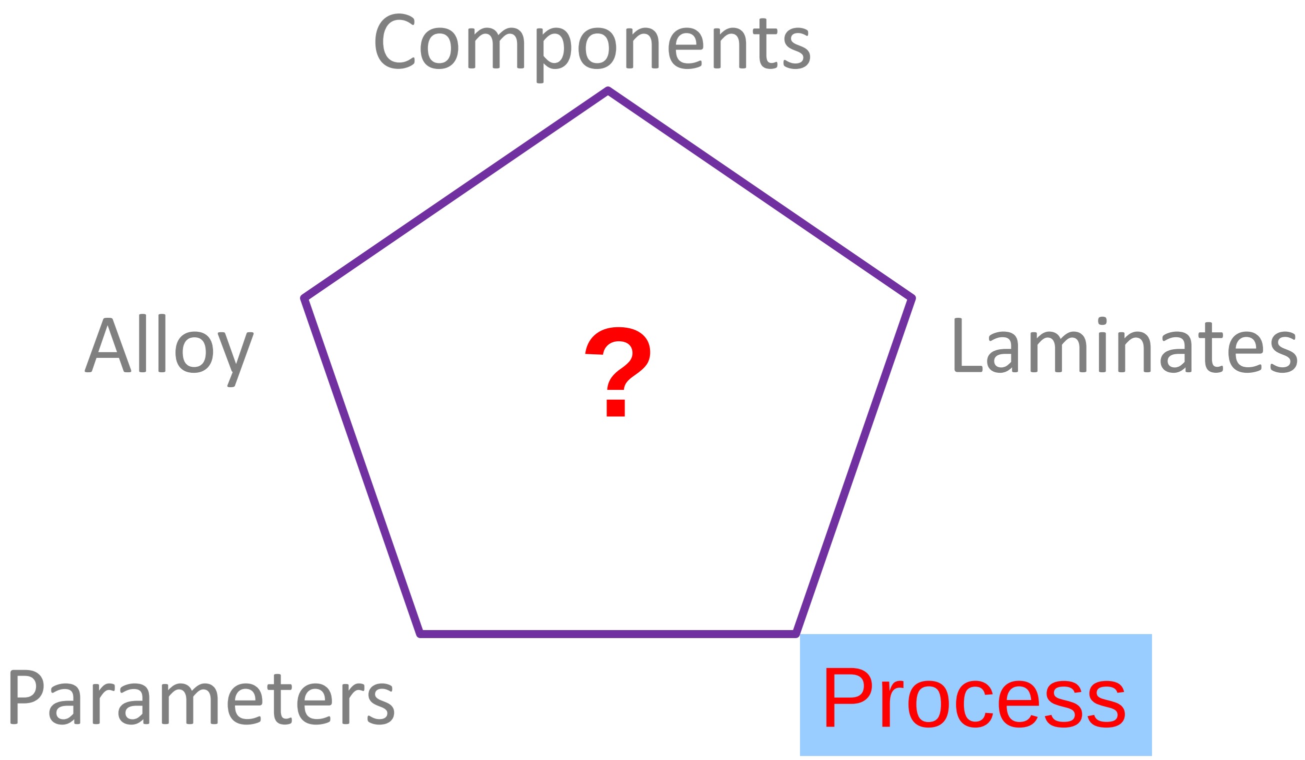


XPC, 1.2mm Thick, 240° C Peak

Low Temperature Conversion



Wave Solder Replacement

Single or Double Sided SMT + Wave Solder

Single or Double Sided SMT (PITH)

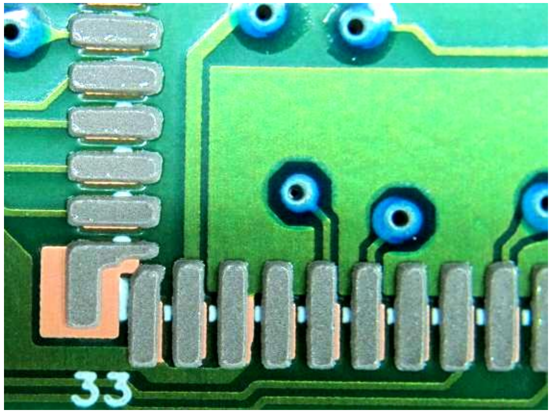
Best opportunity with only few Through-Hole components cases

Wave Soldering Elimination

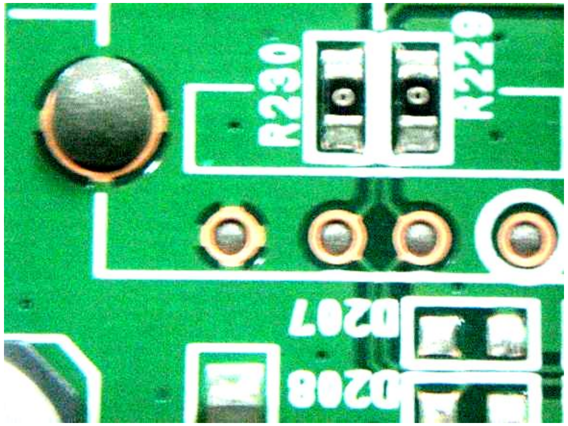
- Savings In:
  - **Factory Footprint** – Wave, Touch Up, Inspection
  - **Equipment** – W/S, Soldering Stations
  - **Working Capital** – 800kg alloy @ $40/kg
  - **Manpower** – Operator, Tech, Engr, Touch Up
  - **Maintenance** – Labor, Spares, Tools, Supplies, Pallets, Dross Management
  - **Processes** – One less thermal excursion
  - **Materials** – Flux and Bar Solder

Eliminating Wave with PITH

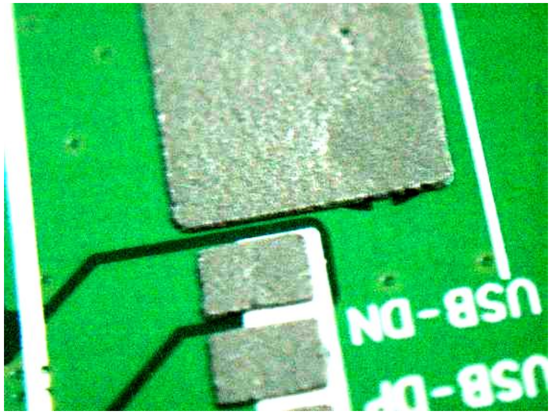
Conventional



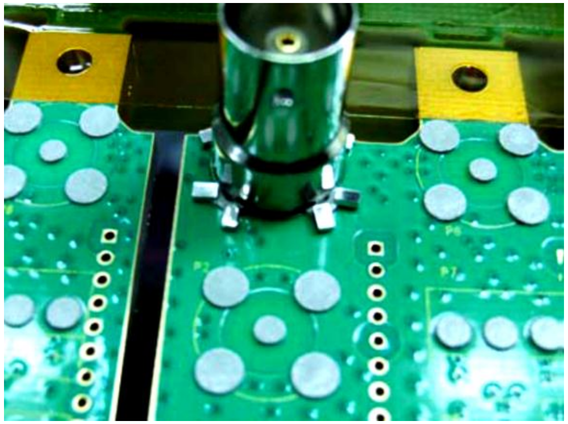
Paste-In-Hole (PIH)



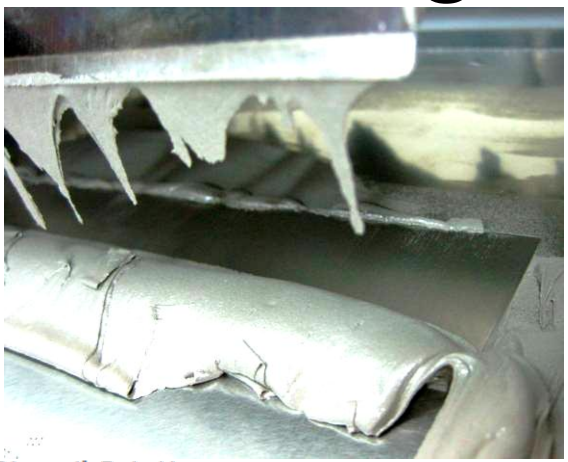
Over Print

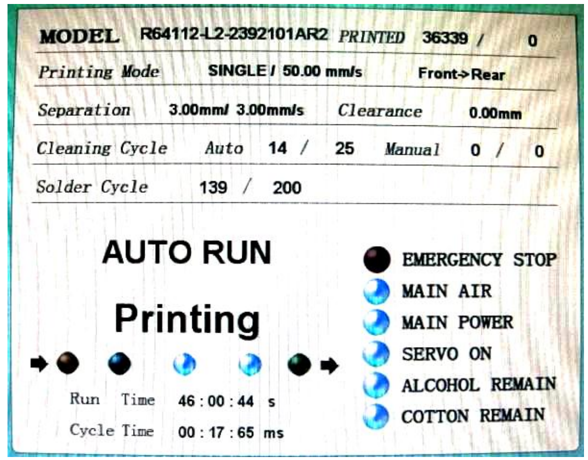


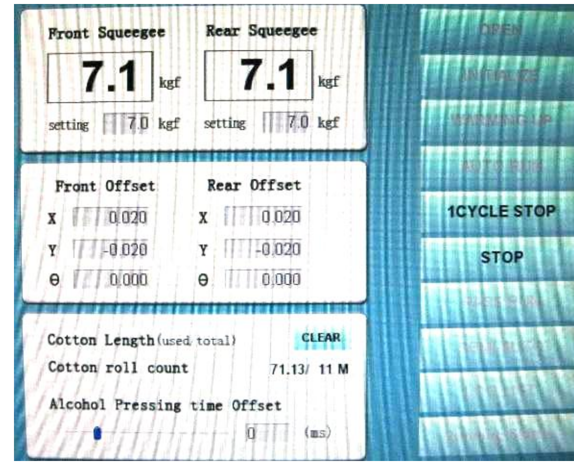
PITH+ (w Preform)



Printing Parameters- “Drop In”





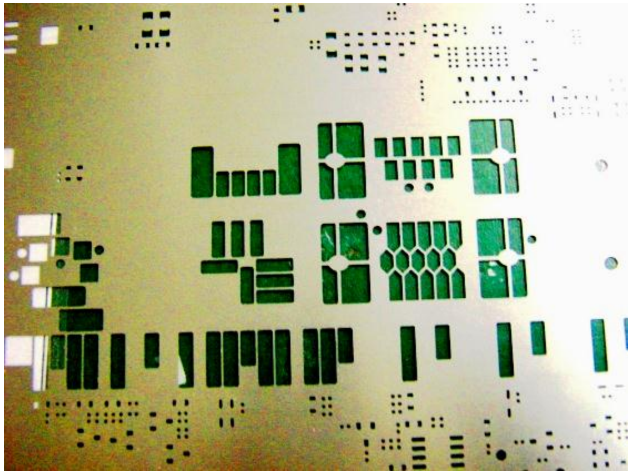


Stencil Printing

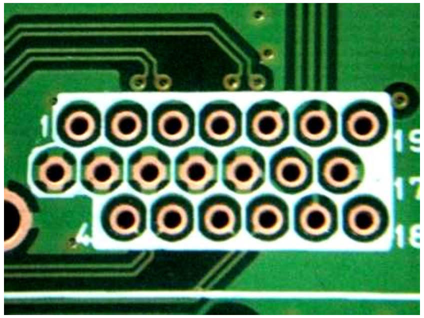
	Present	Previous		
Print Gap (mm)	0	0		
Print Speed (mm/s)	45	60		
Print Pressure (x 0.1MPa)	1.8	Semi Auto		
Separation Distance (mm)	3	2		
Separation Delay (s)	0.1	0		
Separation Speed (mm/s)	1	Max		
Printer Model	Hitachi NP-04M	Stencil	Laser Cut, 5 mils (127 µm)	
Relative Humidity (%)	55%	Temperature (°C)	23°C	
Squeegee Material & Width	Stainless Steel, 10" (254mm)	Underwipe Solvent	-NA-	

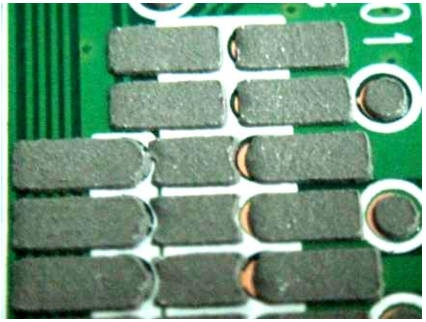
Paste-In-Hole (PITH) & PITH+ - How Its Done

Paste-In-Hole

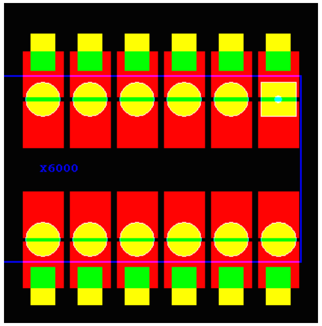


Large Overprint Apertures

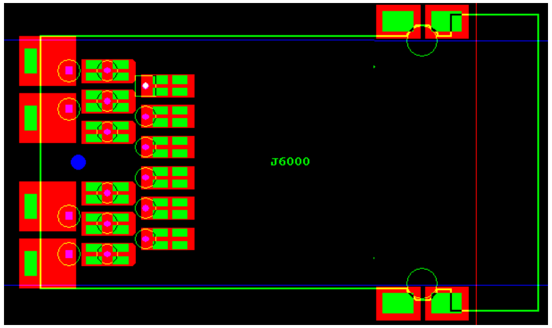




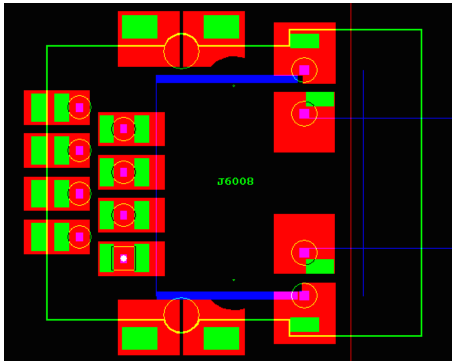
Paste-In-Hole + Preform



DIP Socket

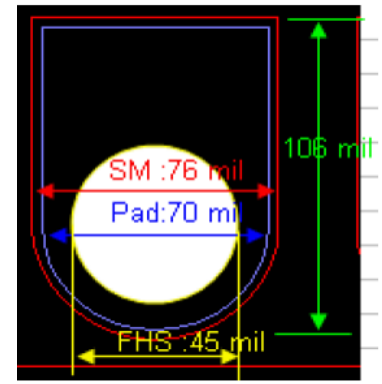


RJ45 Connector



RJxx Connector

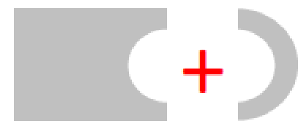
PIH+ Worked Example

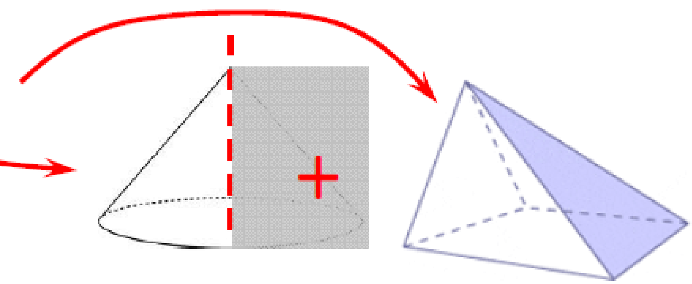


U105 PIH Calculation

Lead count = 12

Cu pad area	Rectangle	4550.00	
	Outer circle	3846.50	
	Hole size	1589.63	
	Annular ring	2256.88	
	Final area	4883.63	
PTH volume	Top fillet volume	22437.92	53083.33
	PTH volume	230495.63	
	Total joint volume	306016.88	
Solder paste vol	Aperture area	4883.63	
	Stencil thickness	5.00	
	Total paste volume	24418.13	
Preform volume	Joint volume req'd	306016.88	
	Paste volume cont'n	12209.06	
	Component lead volume	71140.63	
	Solder vol shortfall	222667.19	0.00022267
	Nearest preform sizes	**0805 x 2 pcs**	





Conversion to in^3 — 1" cube / mil cube: 0.000000001

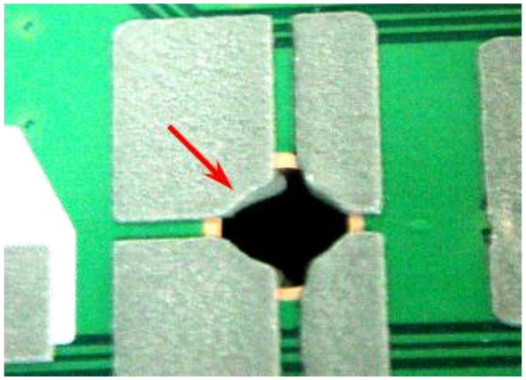
			Preform Vol	Preform Dimensions
Preforms needed	T&R 0805	**24 per**	0.000113	79x51x28 mils

PITH+ Stencil Aperture Design

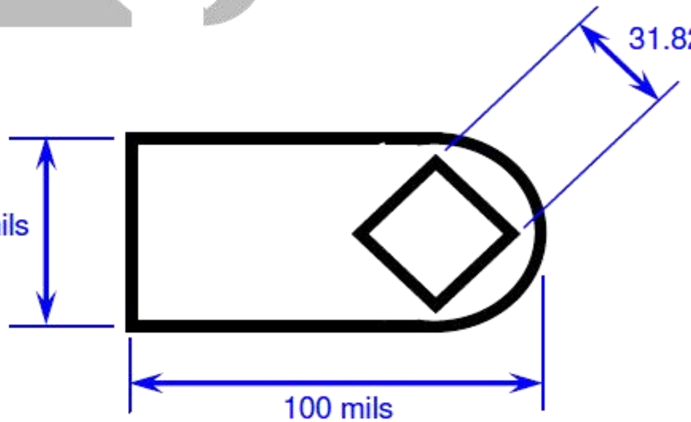
U105 PIH Stencil Aperture Design

Lead count = 12

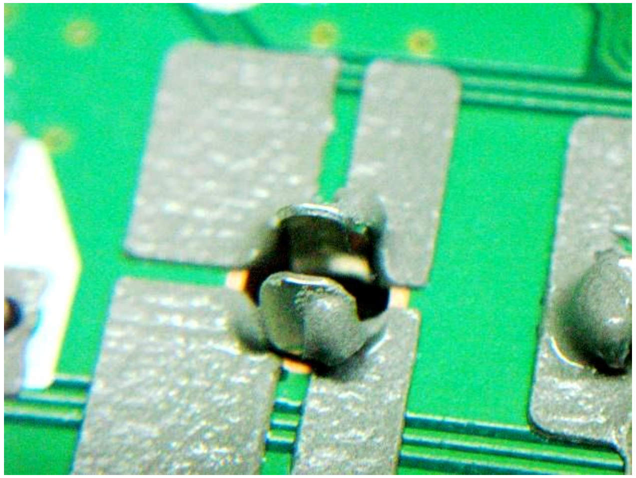
Cu pad area	Rectangle	4550.00
	Outer circle	3846.50
	Hole size	1589.63
	Annular ring	2256.88
	Final area	4883.63
Stencil Aperture	Rectangle	4550.00
	Notch	506.25
	Pad circle	1923.25
	Notch	506.25
	Final Area	5460.75

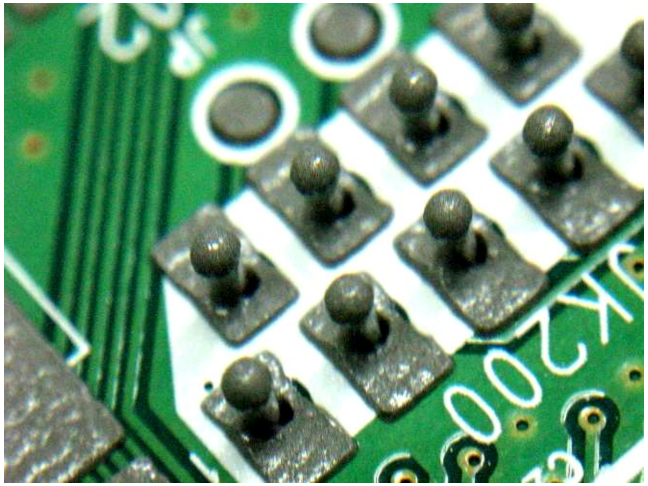


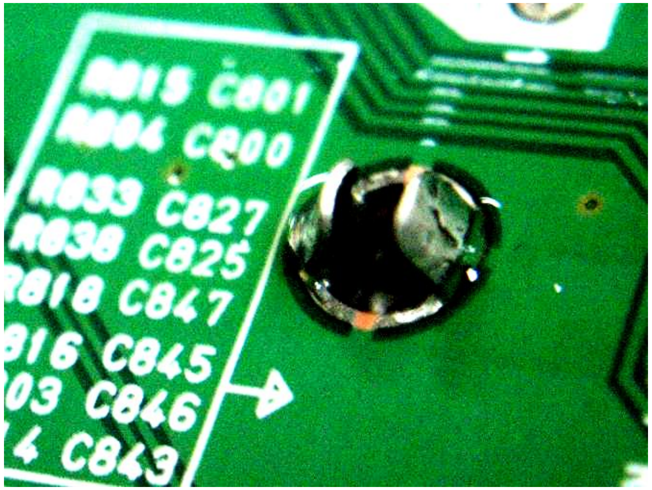
Extra paste helps initiate lead wetting

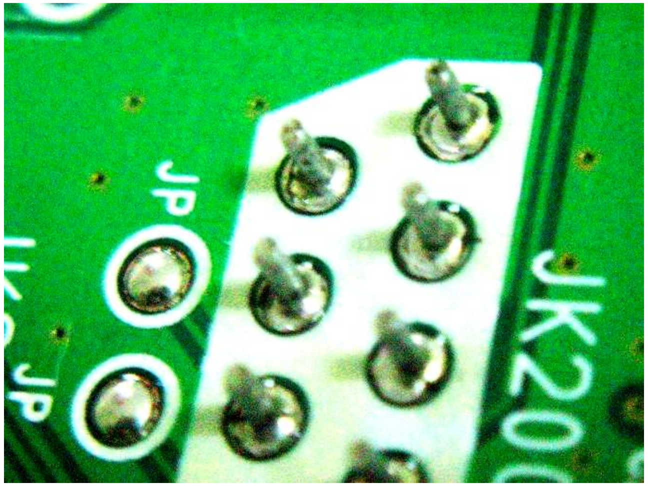


Common PITH Defects - Hole Fill, Chicken Drumstick!

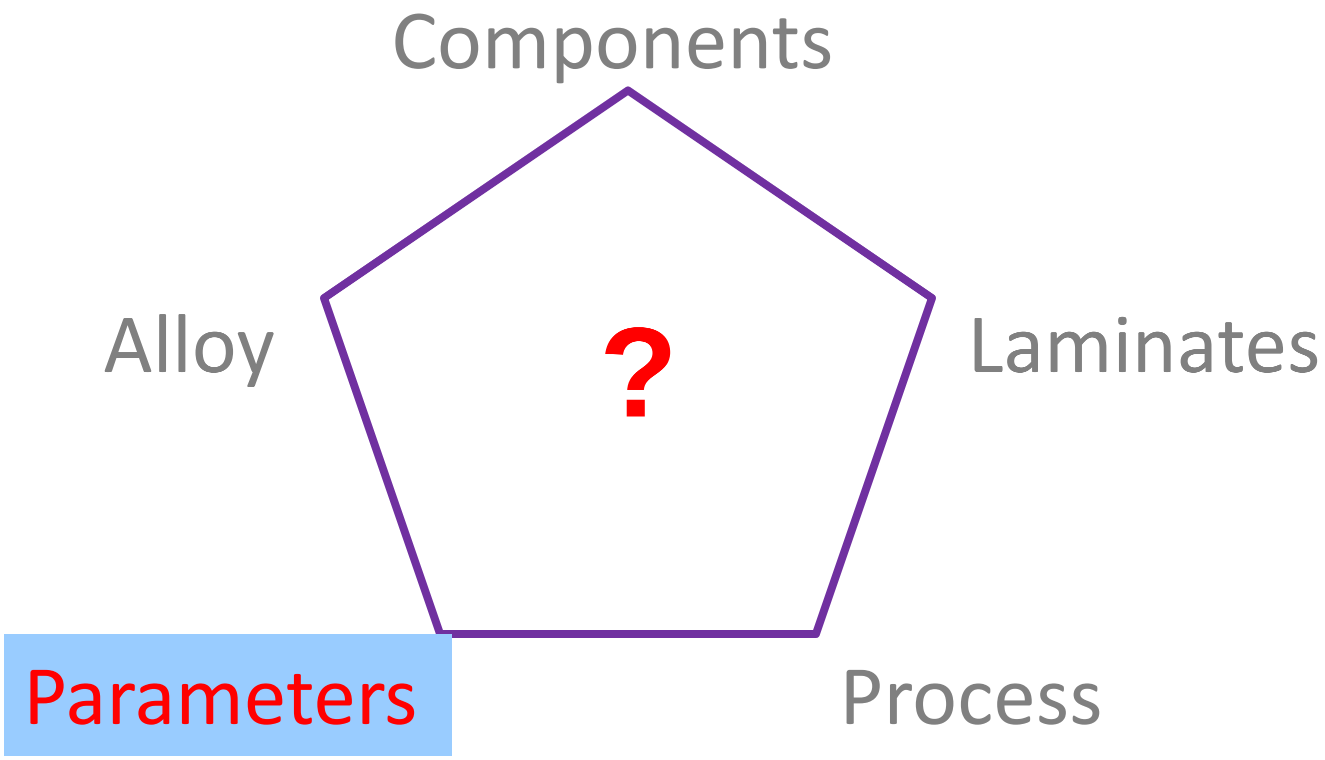








Low Temperature Conversion

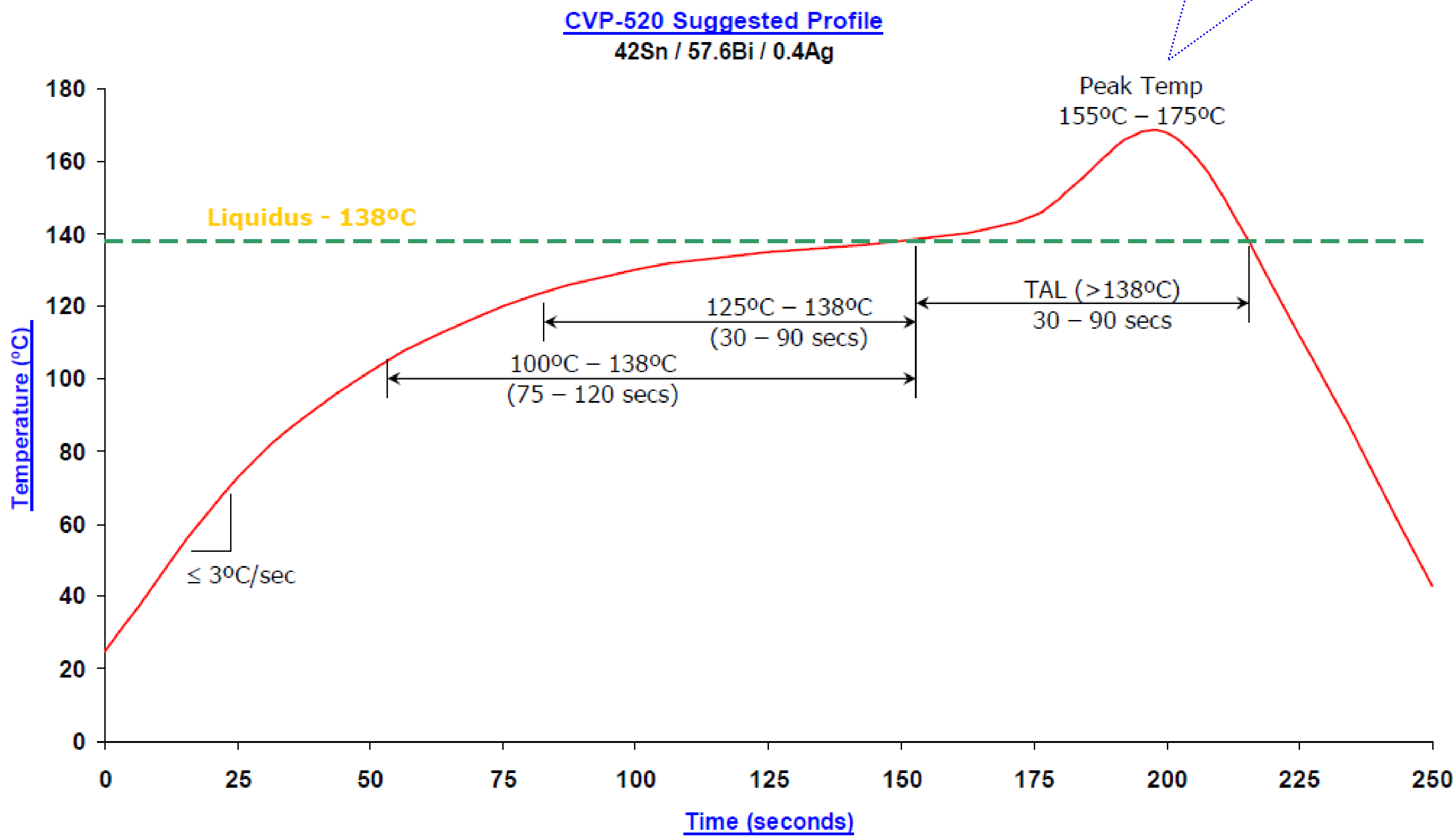


Parameters At A Glance

- **Printing**
  - Can be drop-in
  - Stencil design changes minimal with PITH & PITH+ preform
- **Placement**
  - Standard SMT
  - Preforms placed as if passives (0402, 0201…)
- **Reflow Soldering**
  - Peak 170-190º C
  - If soak required, 110-120º C

Typical Reflow Profile

Avoid high peak, TAL compensation



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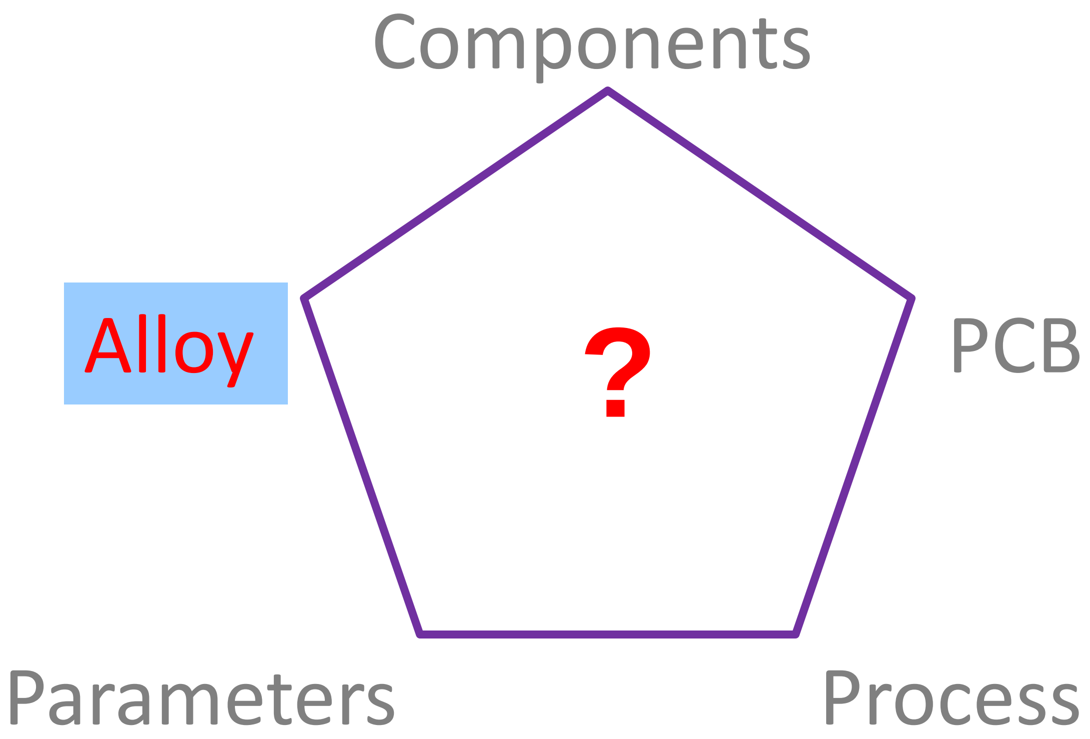
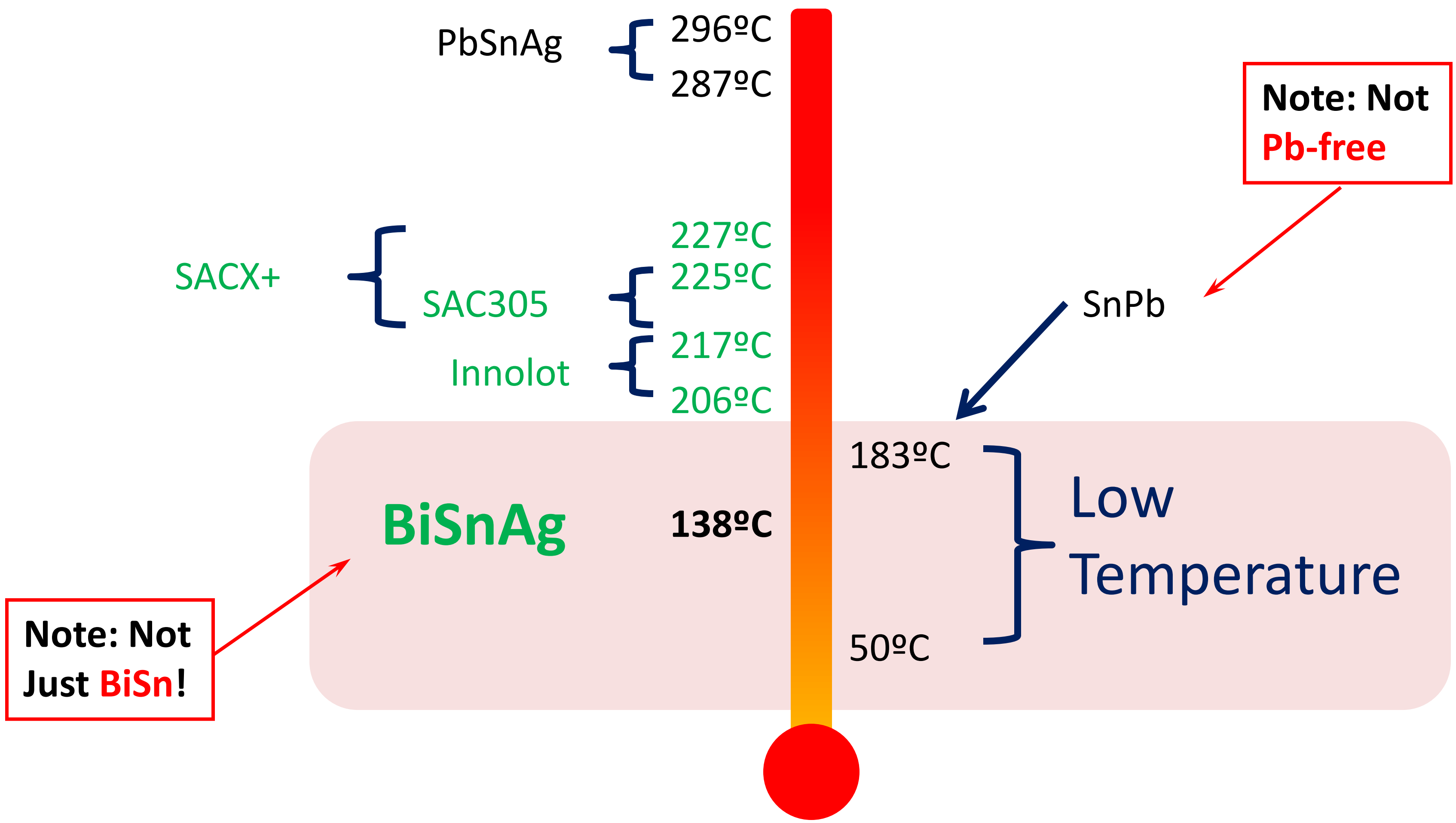
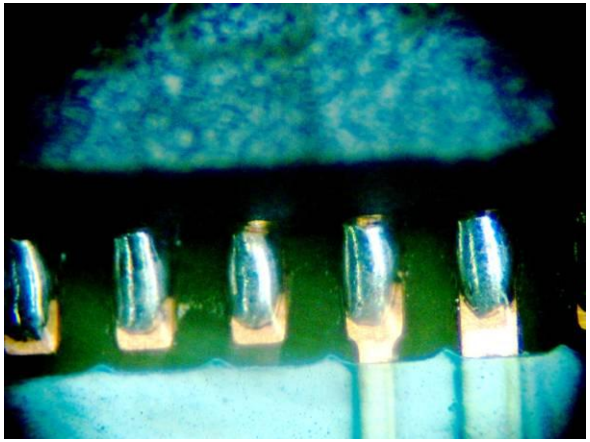


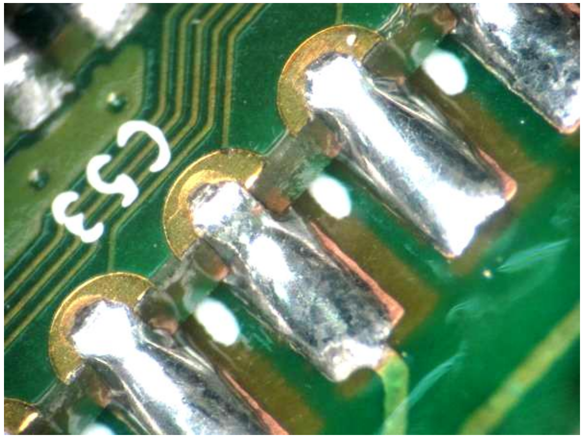
Commonly Used Alloys



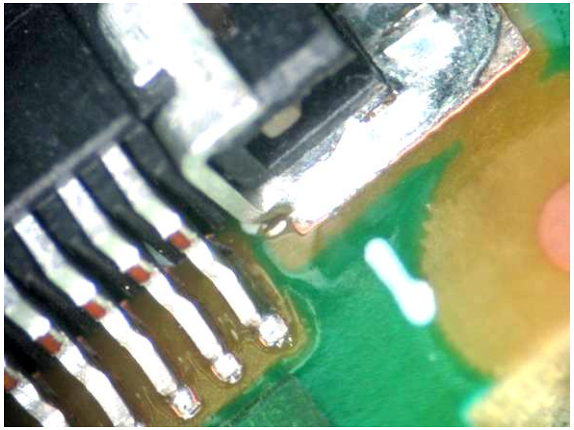
Shiny, Strong Fillets



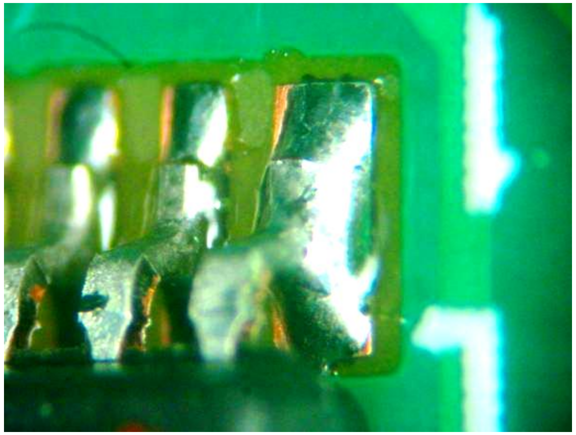
QFN



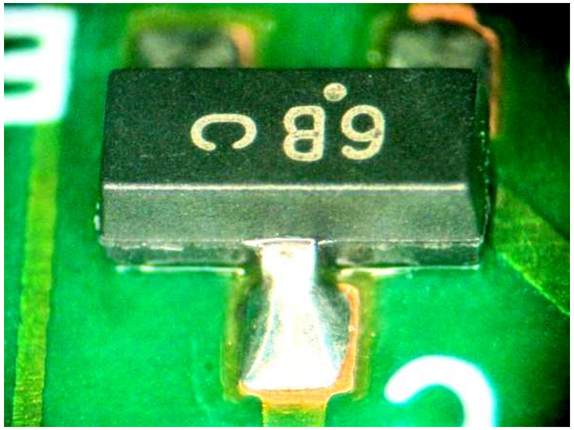
Bluetooth Module



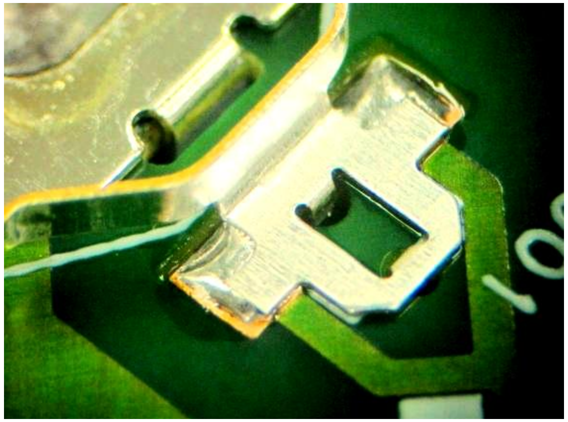
Connector



SOIC

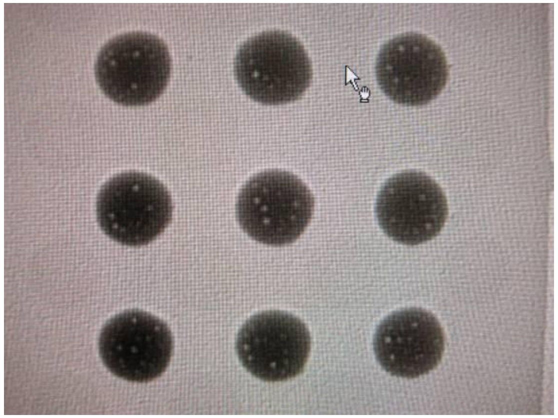


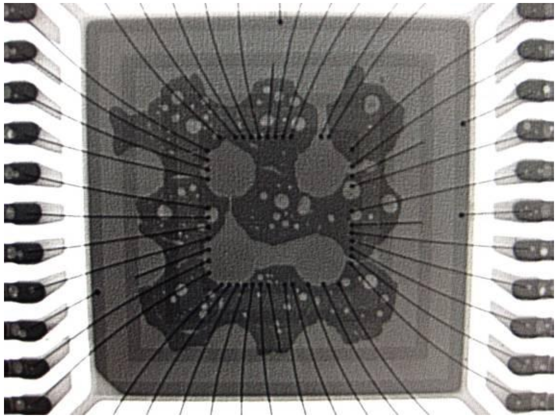
SOT

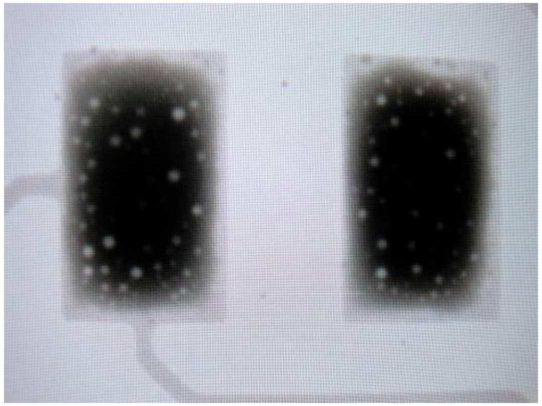


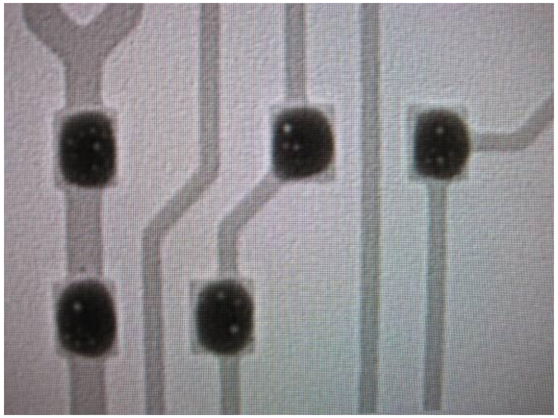
Button Cell Battery Holder

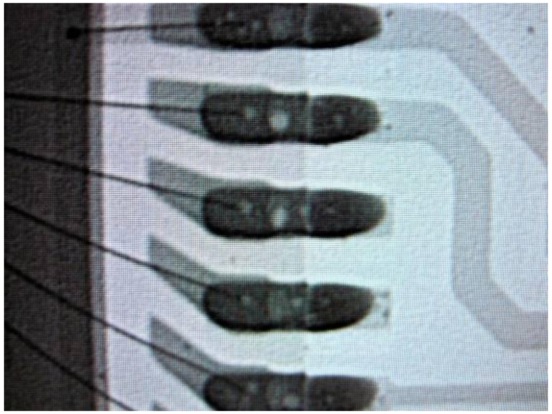
Void Performance? Soak Profile Helpful

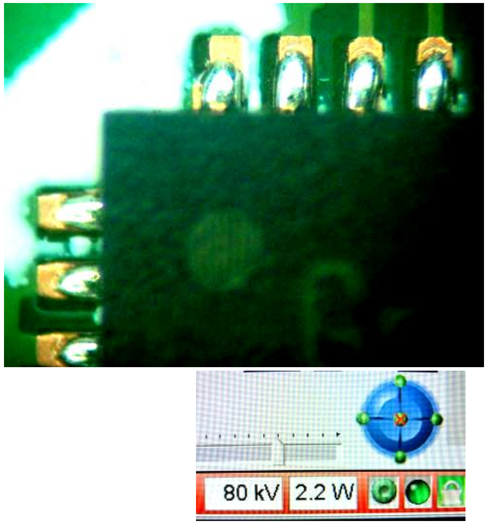

QFN Thermal Pad - Bare


QFN Thermal Pad - Actual


QFN Terminations - Bare


Chip Resistor & Cap - Bare


QFN Terminations - Actual



Conclusion – Low Temp Alloy Use

- Substantial cost savings over regular processes
  - Materials
  - Energy
  - Eliminate Wave/Selective Soldering
- Printing is normally a Drop In
- Major process for high volume consumer electronics for 5 years

Thank You!

Agenda - Low Temperature Conversion

1) Introduction & Agenda
2) Value Created
3) Converting Components
4) Laminate Conversion
5) Processes Involved in Conversion
6) Hands-On Exercise - Rework
7) Specifically Reflow Parameters
8) Alloy Data – Strength & Voids

Low Temperature – Alpha Value Propositions

Halogen Free / Zero Halogen	Reduced cost of entry barrier	☑
Wave Solder Replacement	Process simplification, cost savings	☑
2nd Side Reflow	Product improvement	☑
Manual Soldering Elimination	Quality consistency improvement, reliability & repeatability	☑
PCB Material Cost Reduction	Improved materials' thermal compatibility	☑

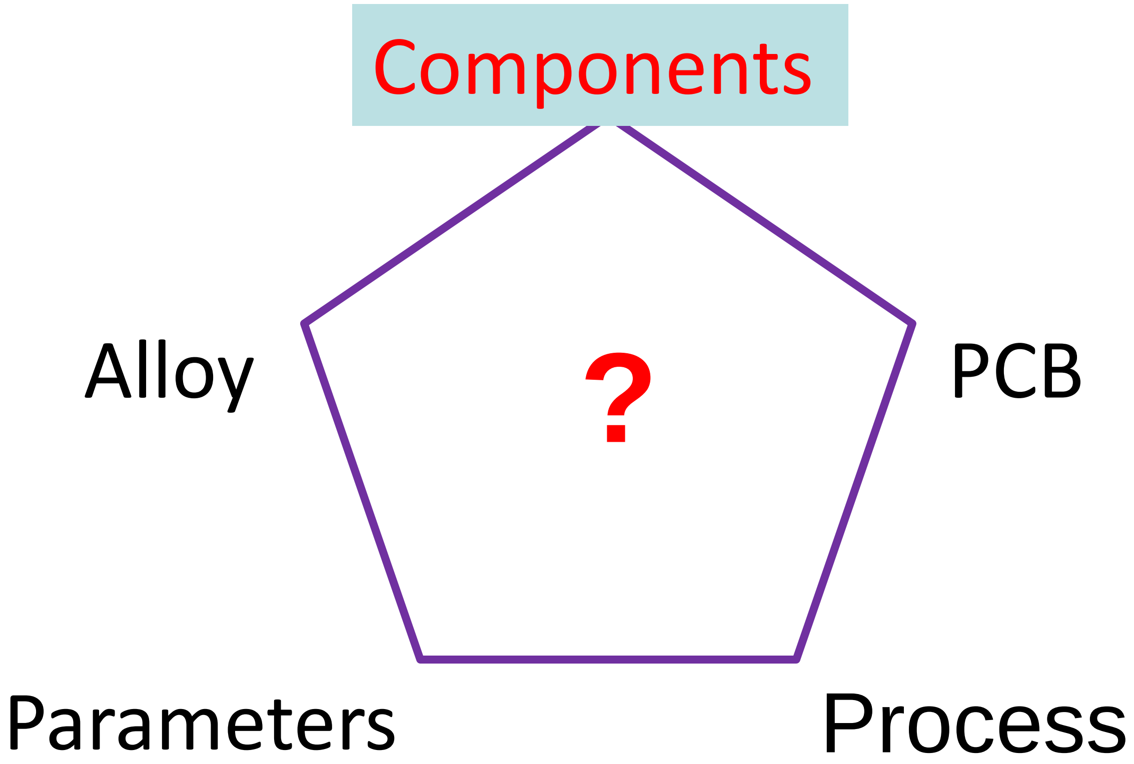
Areas of Value Creation

1) Cost Savings
   I. Components
   II. PCB
   III. Electricity (Heat)
   IV. Wave Solder Replacement

} Major Savings Here

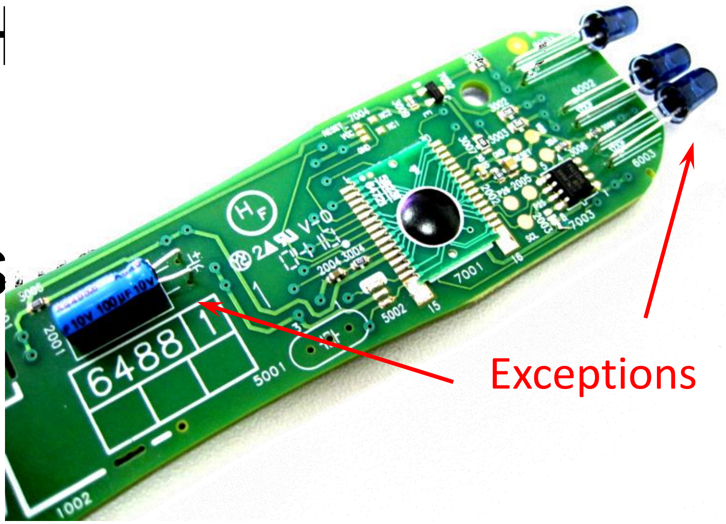
2) Process Gains
   I. Less Thermally Induced Issues

Low Temperature Conversion



Connector Price By Temperature

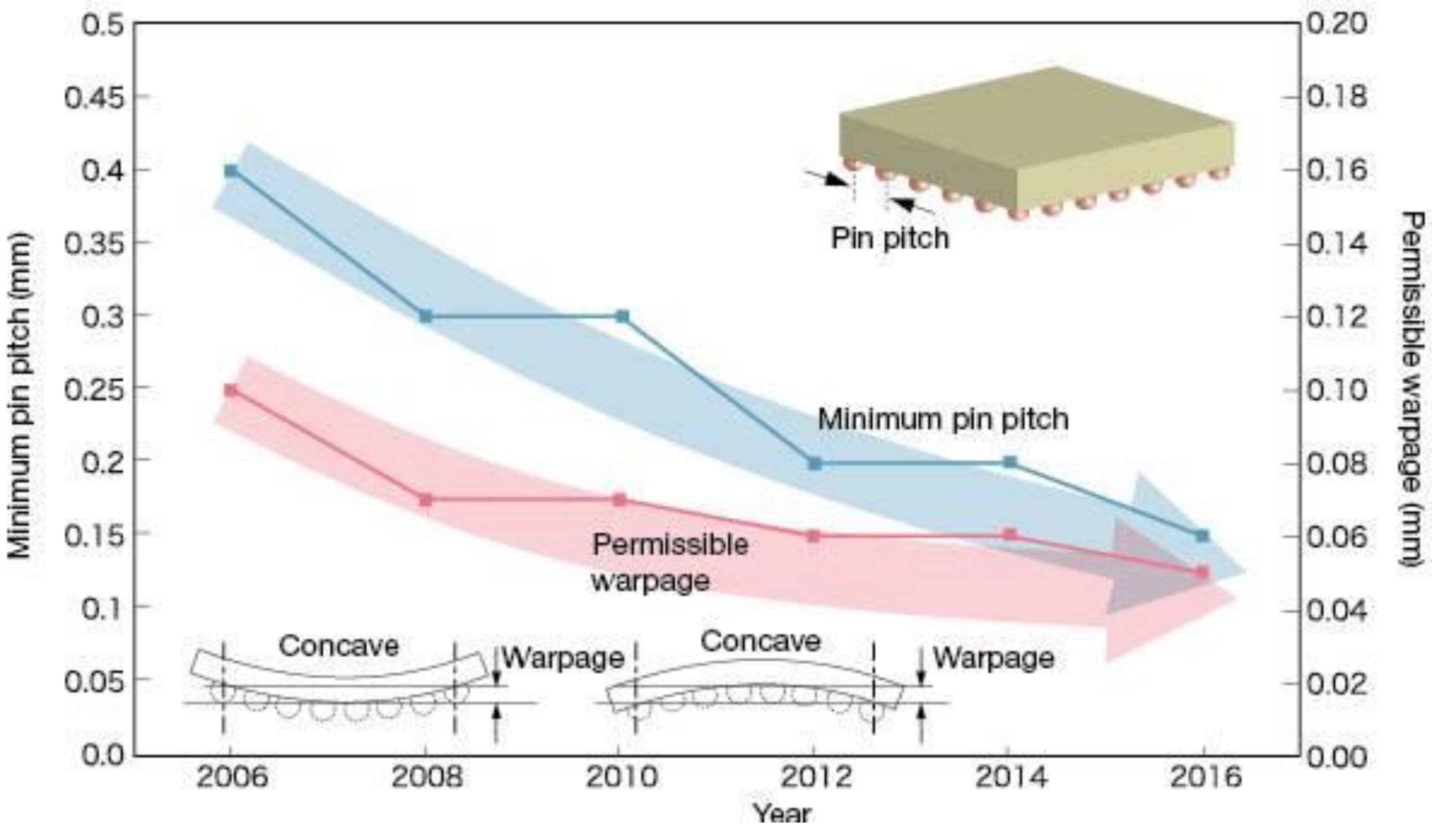
- Molex Shrouded Header (105ºC)
  - USD 0.84
- Molex Shrouded H
  - USD 1.23
- 46% More Expens



Some components just cannot be converted & needs manual soldering

Source: Online component catalogs (like RS, DigiKey, Farnell)

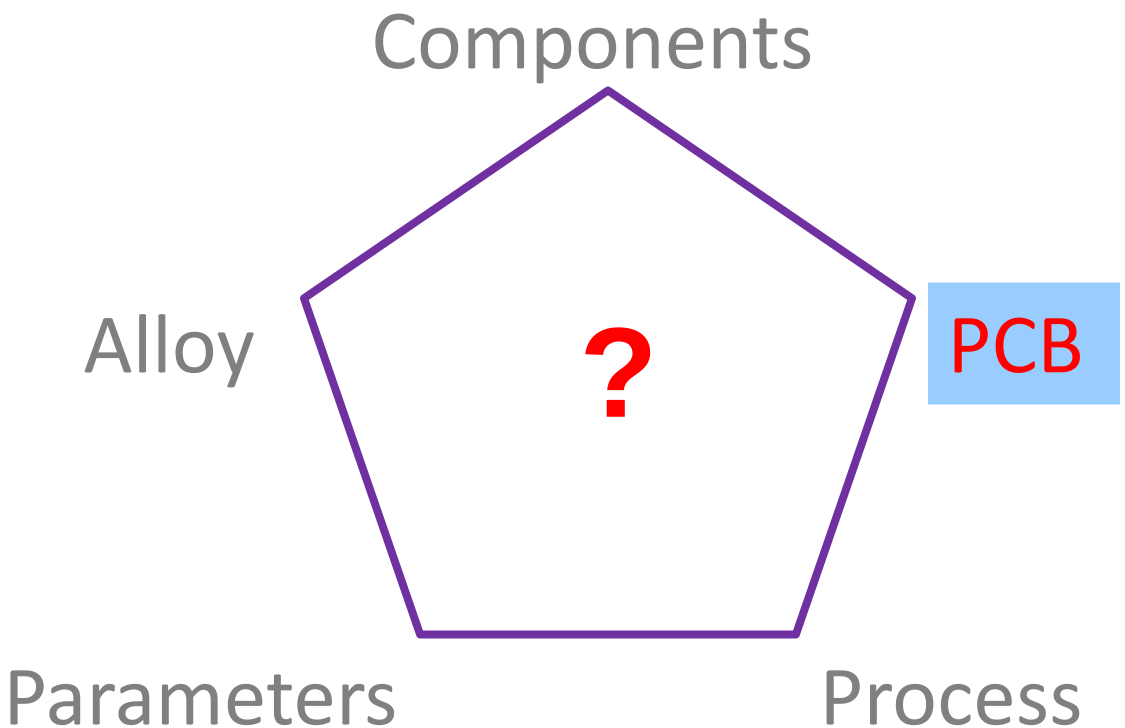
Component Warpage Concerns



Only 0.05mm Permissible warpage in 0.15mm pitch FBGA – JEITA roadmap

FBGA – Fine Pitch Ball Grid Array

Low Temperature Conversion



PCB ….. Cheap ⇨ Cheaper

Philips Home Control case study – potentially save >US$108,000 / annum through the use of low temperature processing (CVP-520)!

VIU

Since this was a feasibility study of PCB materials only, the potential savings are estimated below PCB cost difference was estimated at 10% between materials based on various PCB suppliers.

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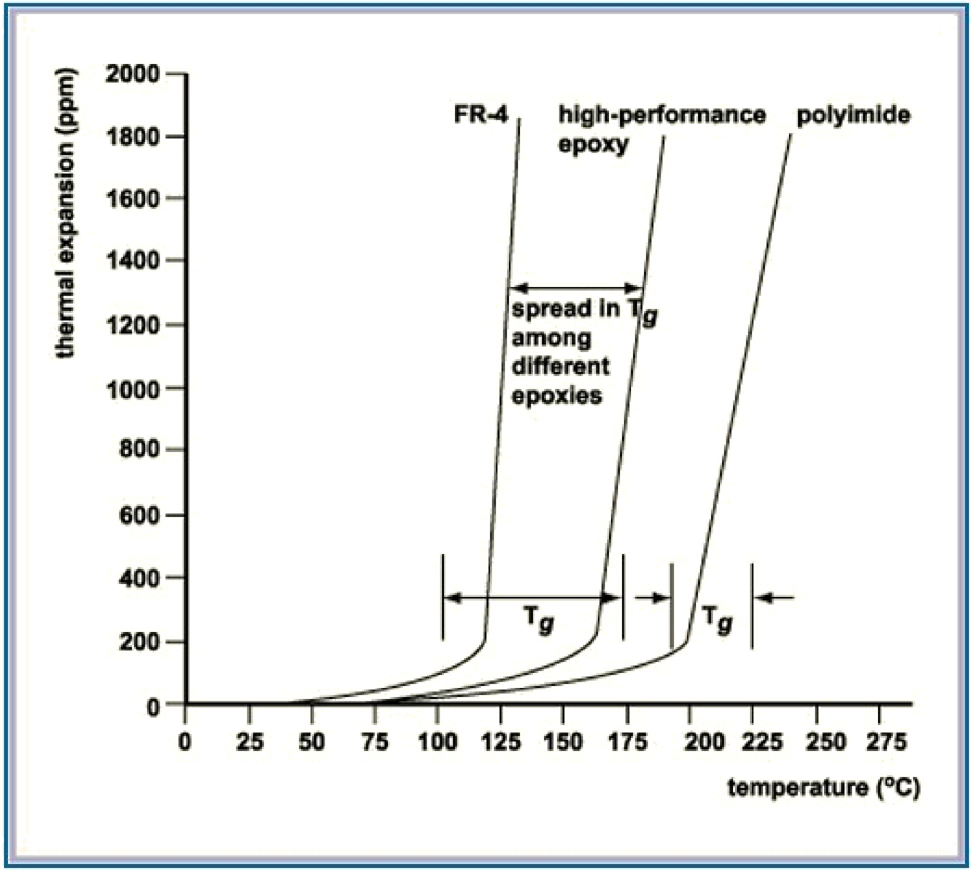
Data extracted from technical report TW110511 by TW Mok on the feasibility of using even cheaper PCB laminates

The comparison above is not even between FR-4 & XPC

PCB Warpage Concerns



Halogen Free PCBs Stiff Enough Are $$$

FR-1 vs XPC – Stiffness Under Heat

GRADE :- RL *FR1* ANSI /NEMA TYPE FR1

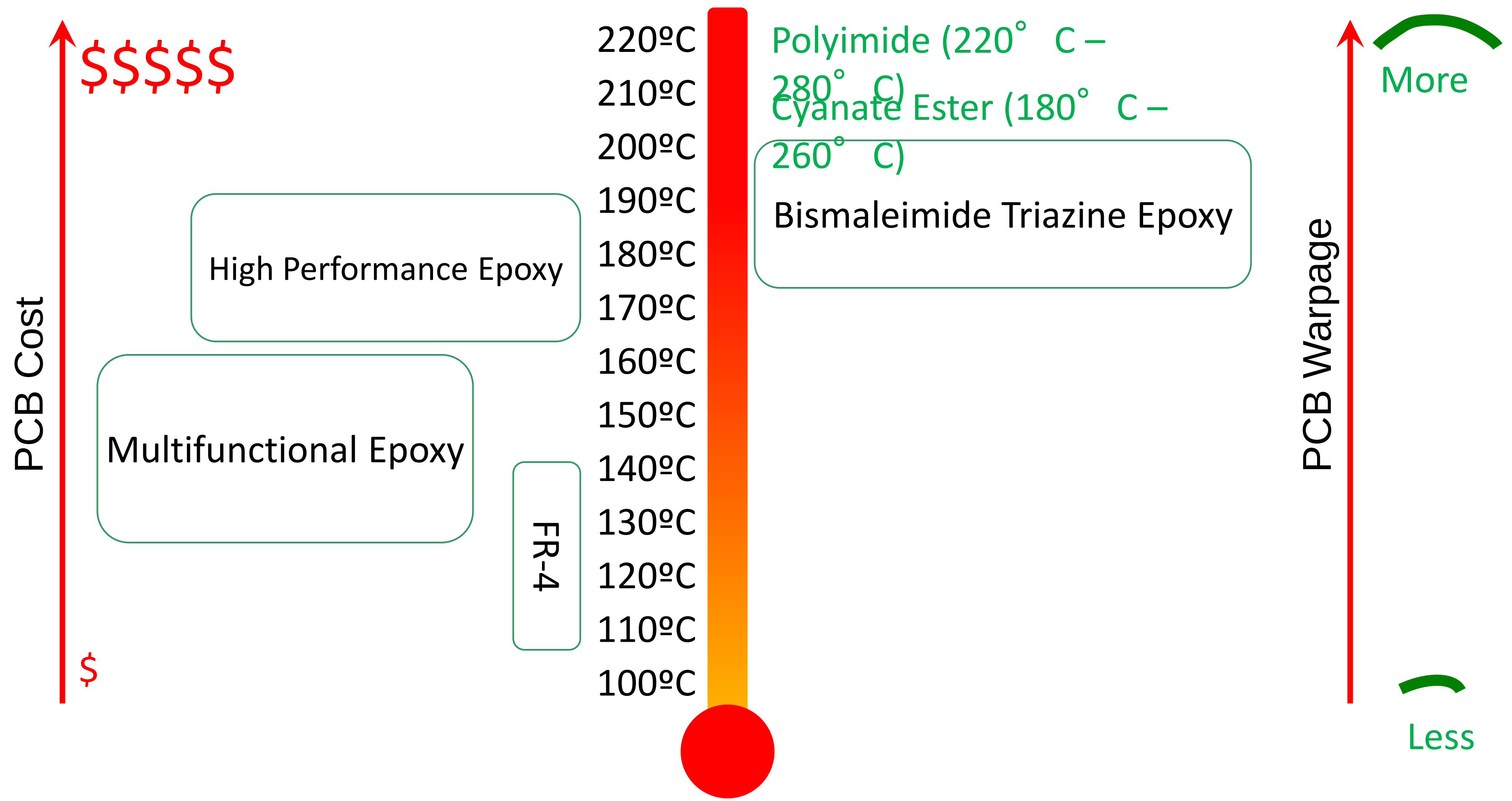
Bow and Twist (304mm x 304mm)	As is	mm/M	**10(with Cladding)**

XPC twists > double FR-1

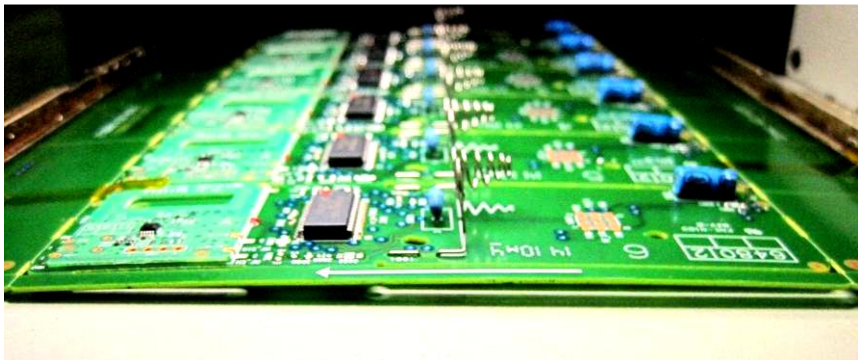
GRADE :- RL *XPC* ANSI /NEMA TYPE XPC

Bow and Twist (304mm x 304mm)	As is	mm/M	**25(with Cladding)**

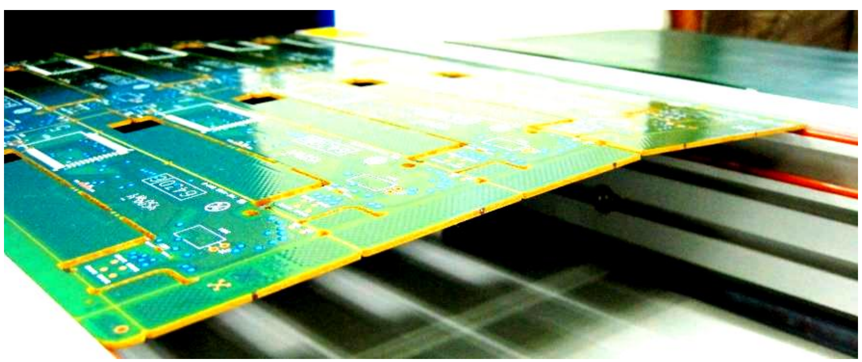
PCB Tg Revisited – Cost & Material Impact



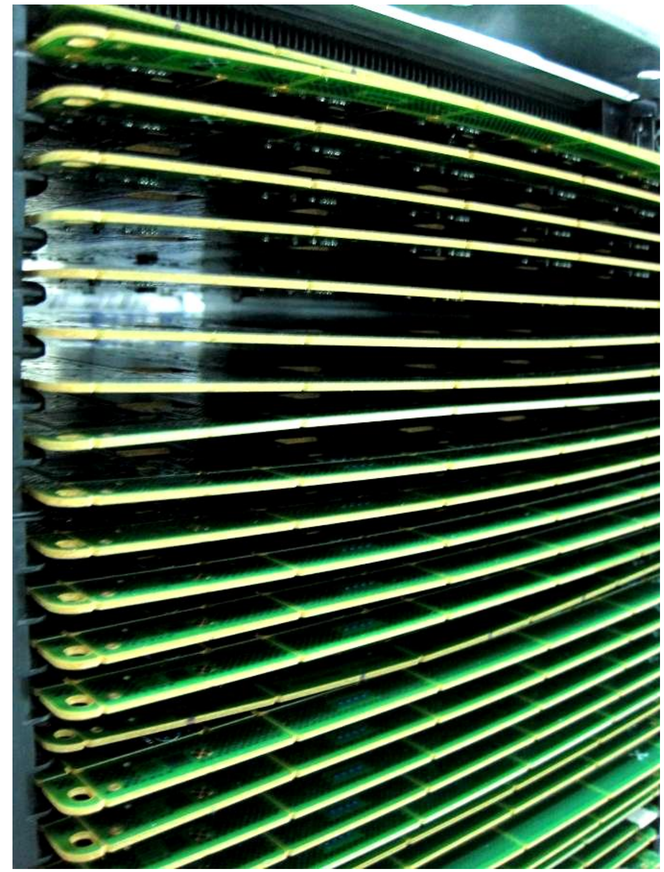
Warpage? Really?



FR-1, 1.2mm Thick, 245° C Peak

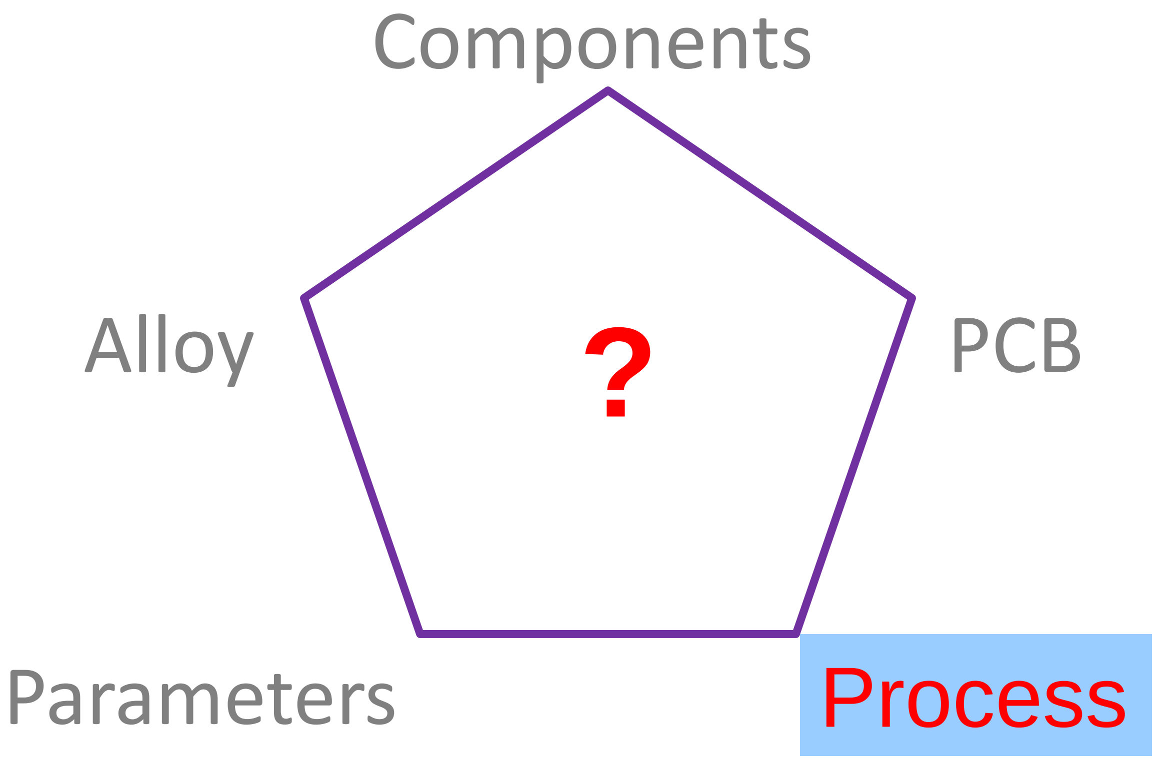


XPC, 1.2mm Thick, 245° C Peak



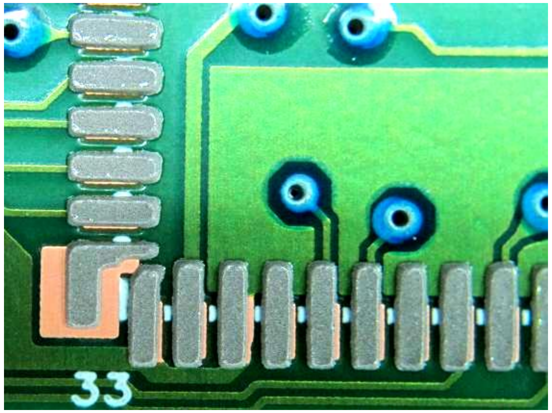
XPC, 1.2mm Thick, 240° C Peak

Low Temperature Conversion

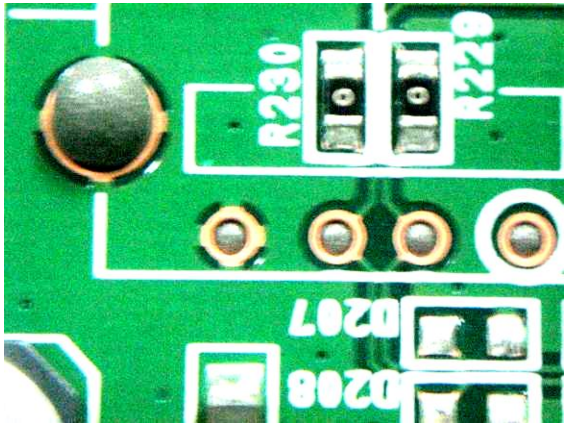


Stencil Printing – Multiple Applications

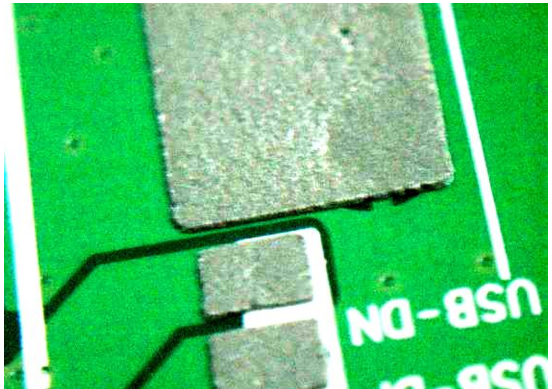
<u>Conventional</u>



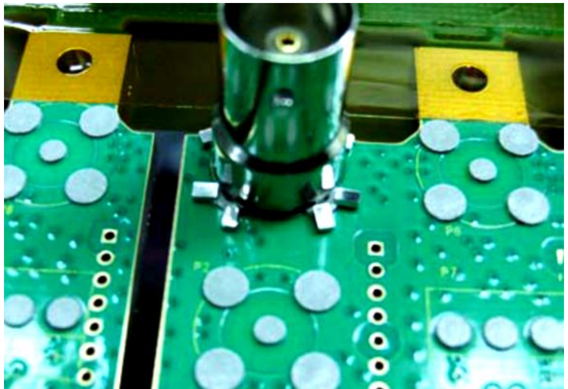
<u>Paste-In-Hole (PIH)</u>



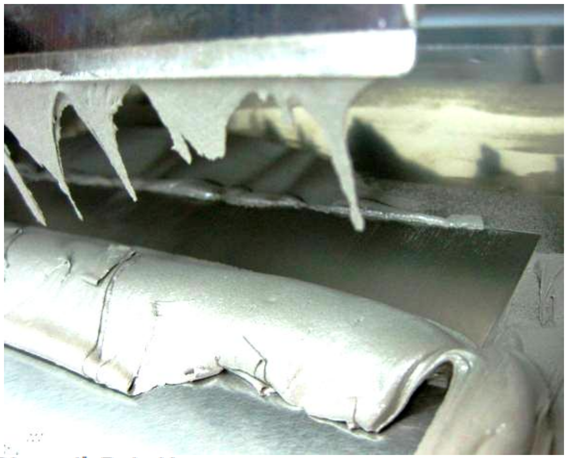
<u>Over Print</u>



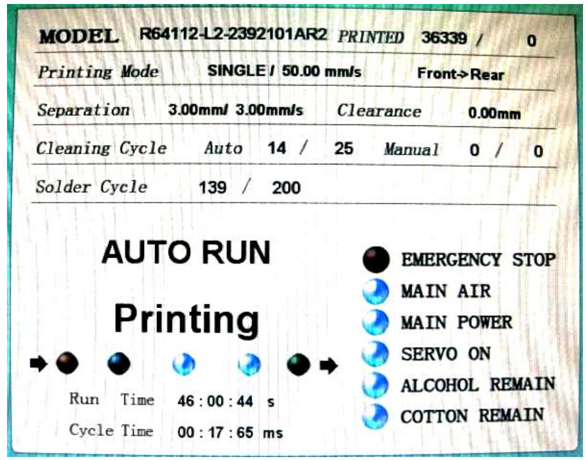
<u>PIH+ (w Exactalloy)</u>

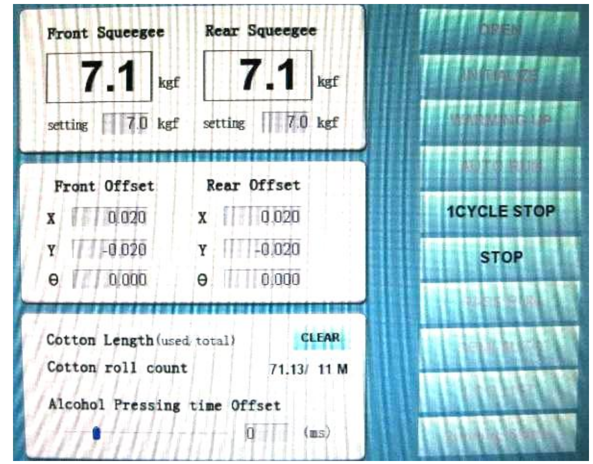


Printing Parameters



Stencil Printing

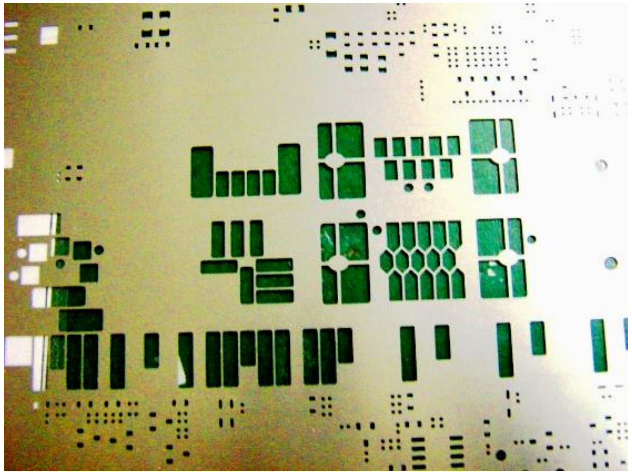




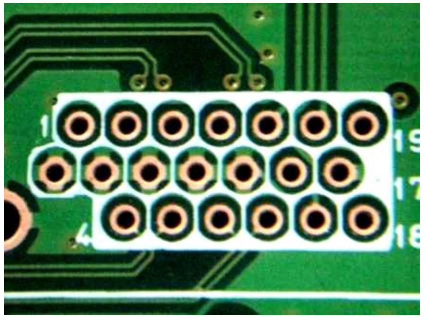
	Present	Previous		
Print Gap (mm)	0	0		
Print Speed (mm/s)	45	60		
Print Pressure (x 0.1MPa)	1.8	Semi Auto		
Separation Distance (mm)	3	2		
Separation Delay (s)	0.1	0		
Separation Speed (mm/s)	1	Max		
Printer Model	Hitachi NP-04M	Stencil	Laser Cut, 5 mils (127 µm)	
Relative Humidity (%)	55%	Temperature (^{o}C)	23^{o}C	
Squeegee Material & Width	Stainless Steel, 10" (254mm)	Underwipe Solvent	-NA-	

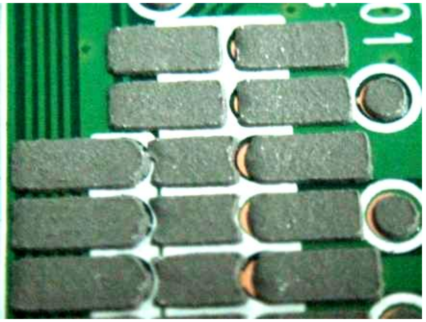
Paste-In-Hole (PIH) & PIH+ - How Its Done

Paste-In-Hole

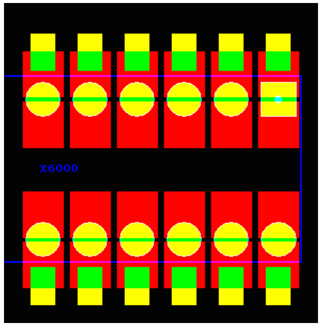


Beware - Aperture Damage!

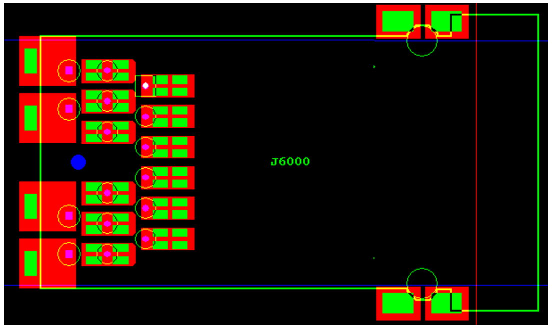




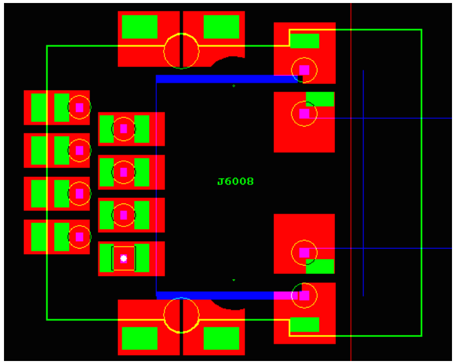
Paste-In-Hole + Preform



DIP Socket

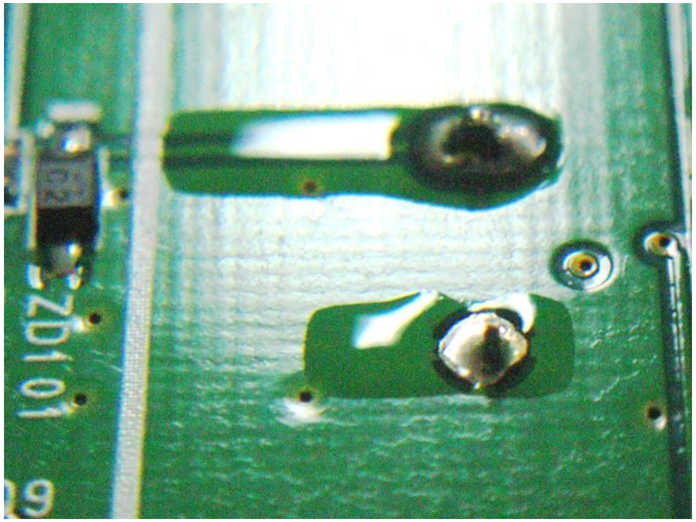


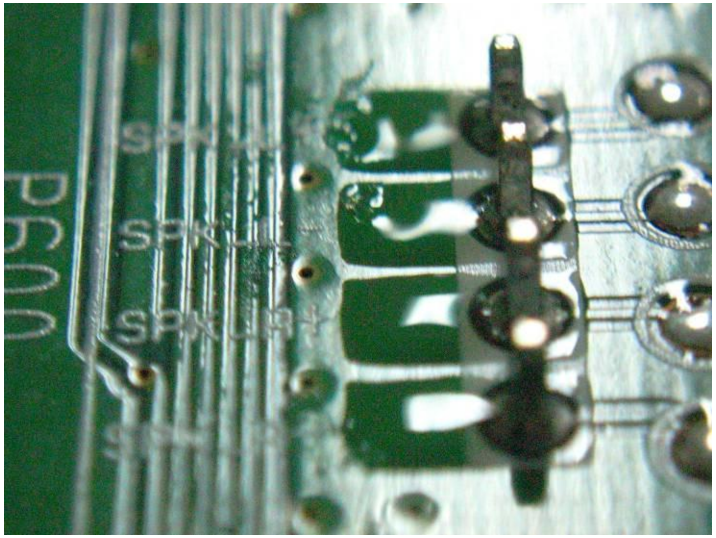
RJ45 Connector

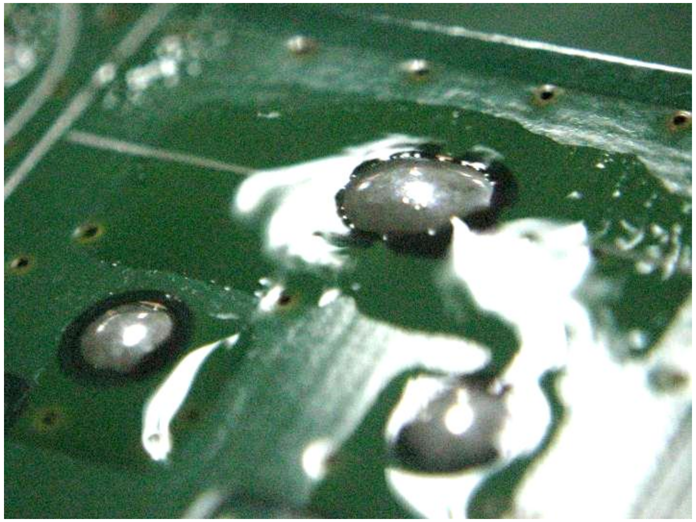


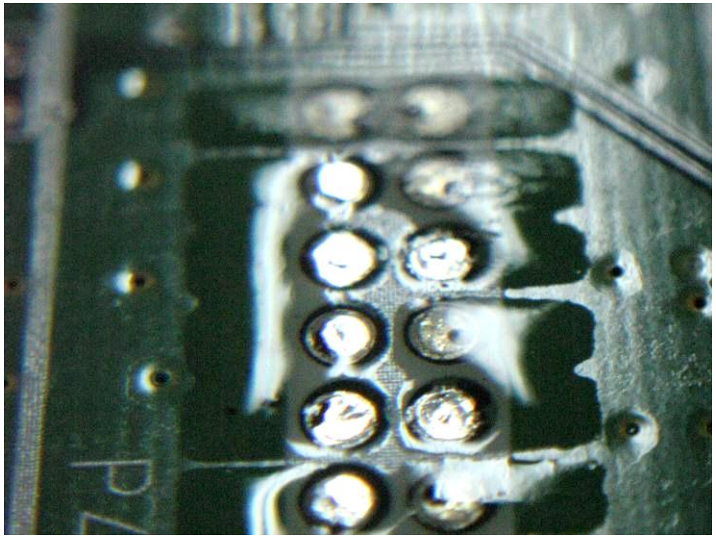
RJxx Connector

Overprinting vs PIH+ - Flux Residue









PIH+ Worked Example

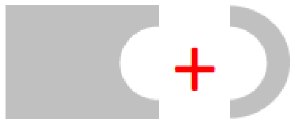
U105 PIH Calculation

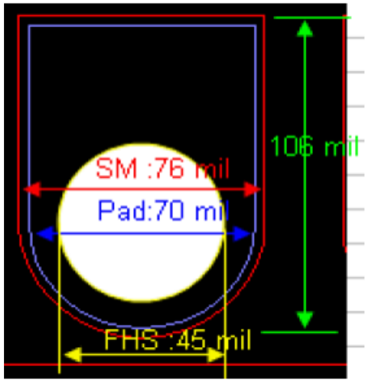
Lead count = 12

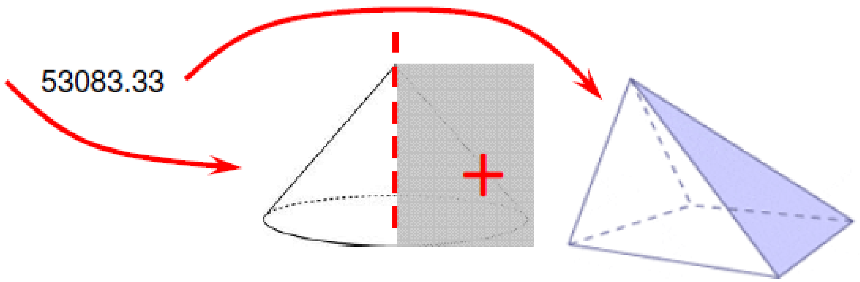
Cu pad area	Rectangle	4550.00	
	Outer circle	3846.50	
	Hole size	1589.63	
	Annular ring	2256.88	
	Final area	4883.63	
PTH volume	Top fillet volume	22437.92	53083.33
	PTH volume	230495.63	
	Total joint volume	306016.88	
Solder paste vol	Aperture area	4883.63	
	Stencil thickness	5.00	
	Total paste volume	24418.13	
Preform volume	Joint volume req'd	306016.88	
	Paste volume cont'n	12209.06	
	Component lead volume	71140.63	
	Solder vol shortfall	222667.19	0.00022267 **Conversion to in^3**
	Nearest preform sizes	**0805 x 2 pcs**	

1" cube	mil cube
	0.000000001

			Preform Vol	Preform Dimensions
Preforms needed	T&R 0805	**24 per**	0.000113	79x51x28 mils





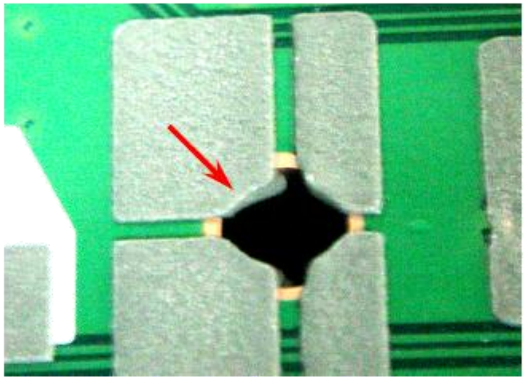


PIH+ Stencil Aperture Design

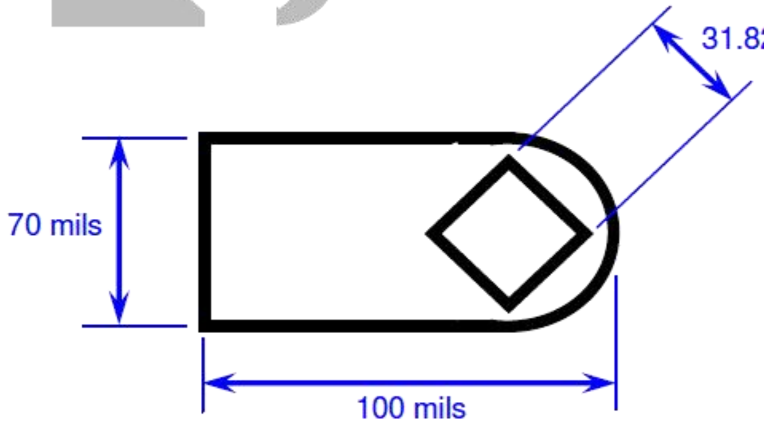
U105 PIH Stencil Aperture Design

Lead count = 12

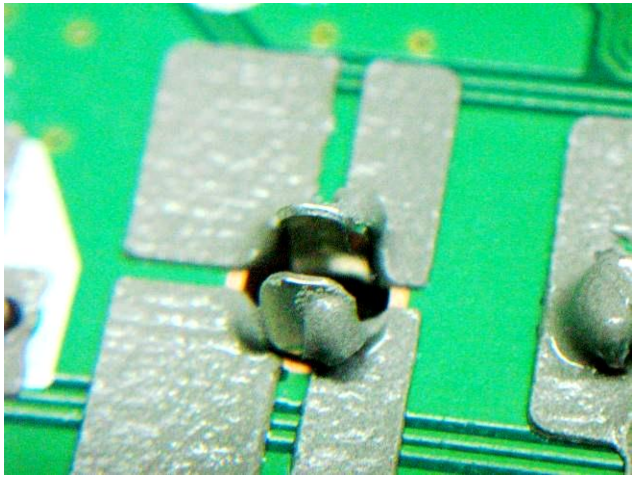
Cu pad area	Rectangle	4550.00
	Outer circle	3846.50
	Hole size	1589.63
	Annular ring	2256.88
	Final area	4883.63
Stencil Aperture	Rectangle	4550.00
	Notch	506.25
	Pad circle	1923.25
	Notch	506.25
	Final Area	5460.75

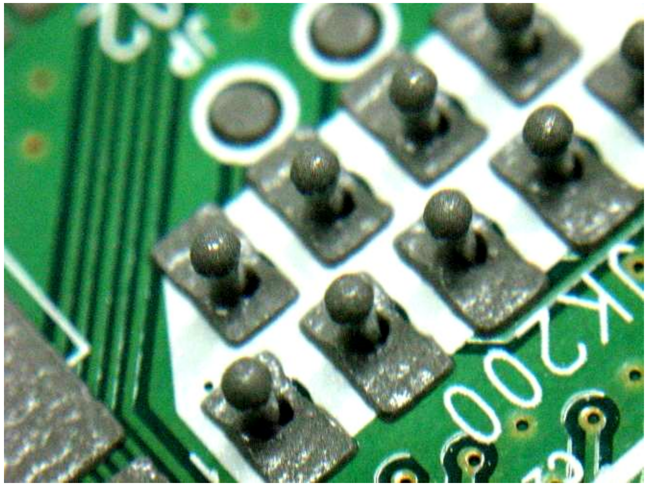


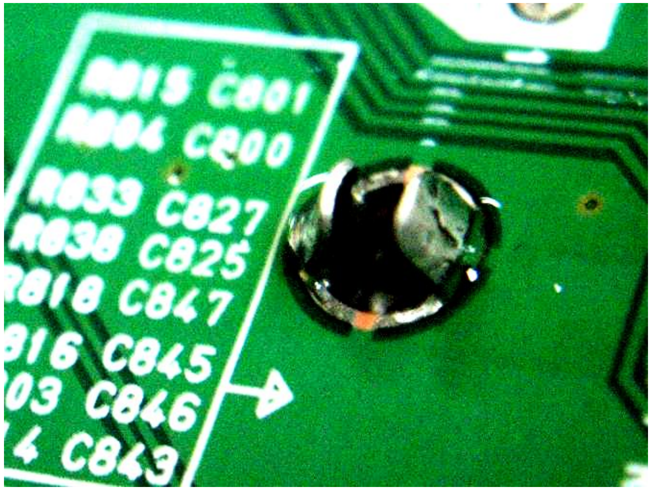
Extra paste helps initiate lead wetting

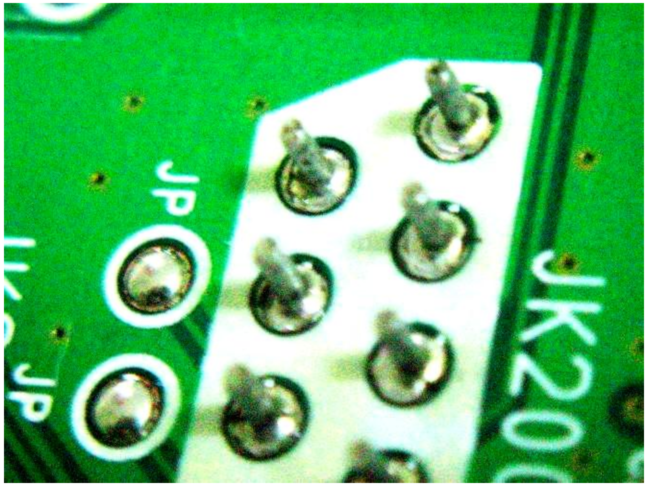


Common PIH Defects - Hole Fill, Chicken Drumstick!









Wave Solder Replacement

Single or Double Sided SMT + Wave Solder

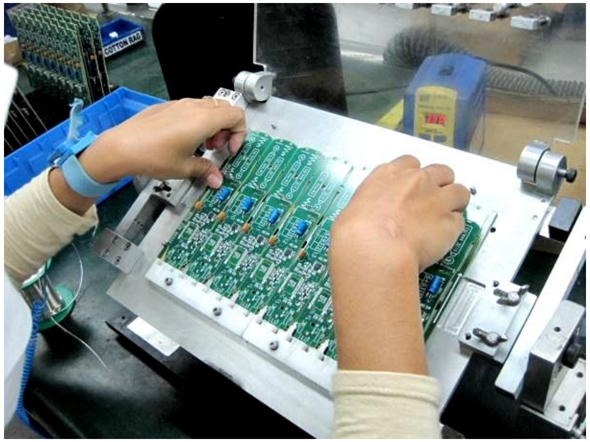
Single or Double Sided SMT (PIH or PIH+)

Best opportunity with only few Through-Hole components cases

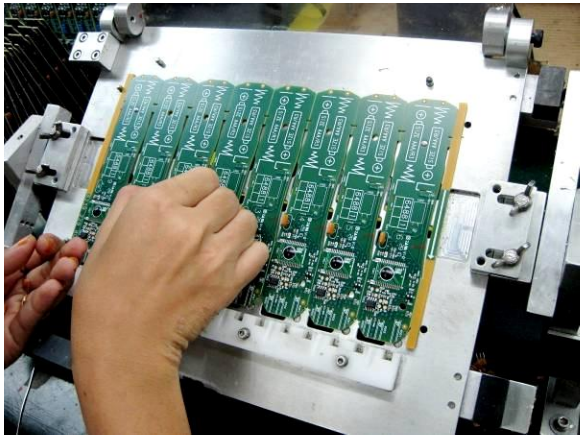
W/S Replacement – Alpha Value Proposition

- Savings In:
  - **Space** – Footprint Of M/c, T/u, Inspection
  - **Machines** – W/S, Soldering Stations
  - **Manpower** – Operator, Tech, Engr
  - **Maintenance** – Labor, Spares, Tools, Supplies
  - **Processes** – W/S, T/u, Inspection
  - Materials – Direct & Indirect

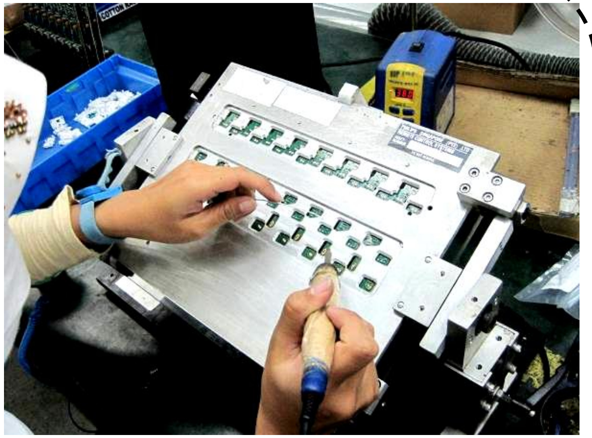
Manual Soldering Elimination



Load PCB Panel →



Manual Comp Insertion →



Flip & Solder

↓

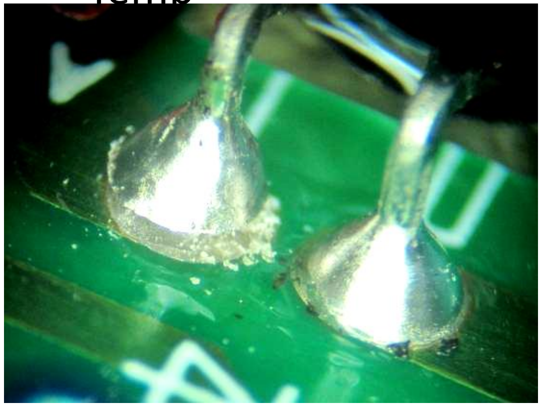
Single or Double Sided SMT (PIH or PIH+)

Soldering Tip Temperature – 400° C Best

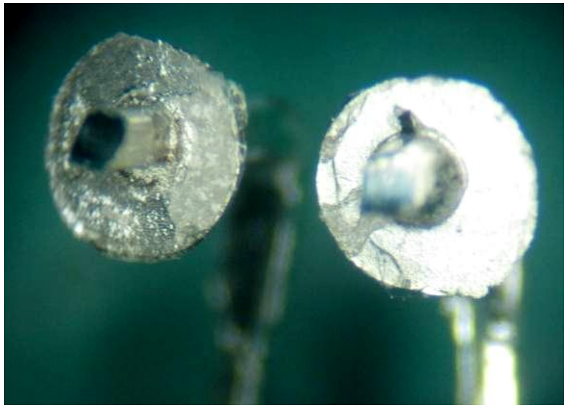
344° C Tip Temp

Pin 1 Clean Break!

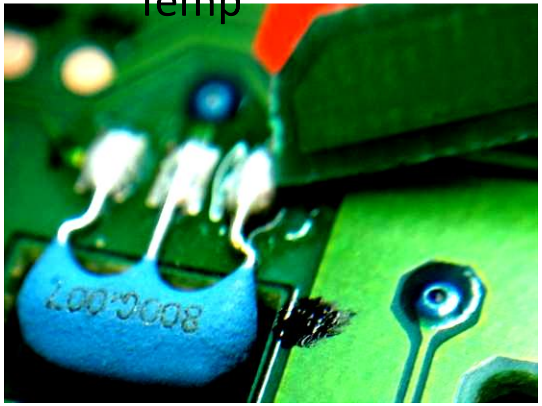
400° C Tip Temp



PTH Clean Break!



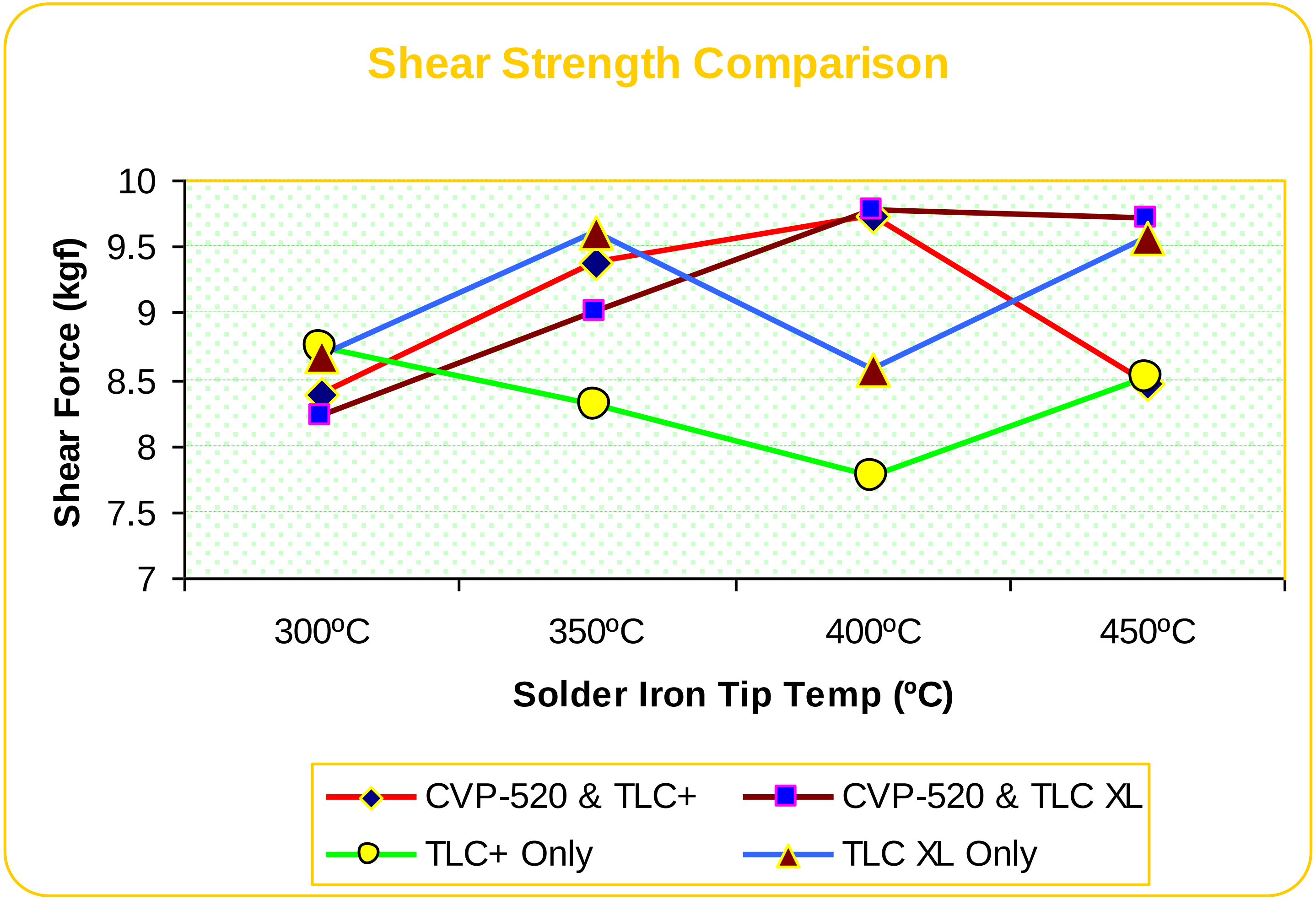
No Evidence Of Wetting!



Brute Push Test

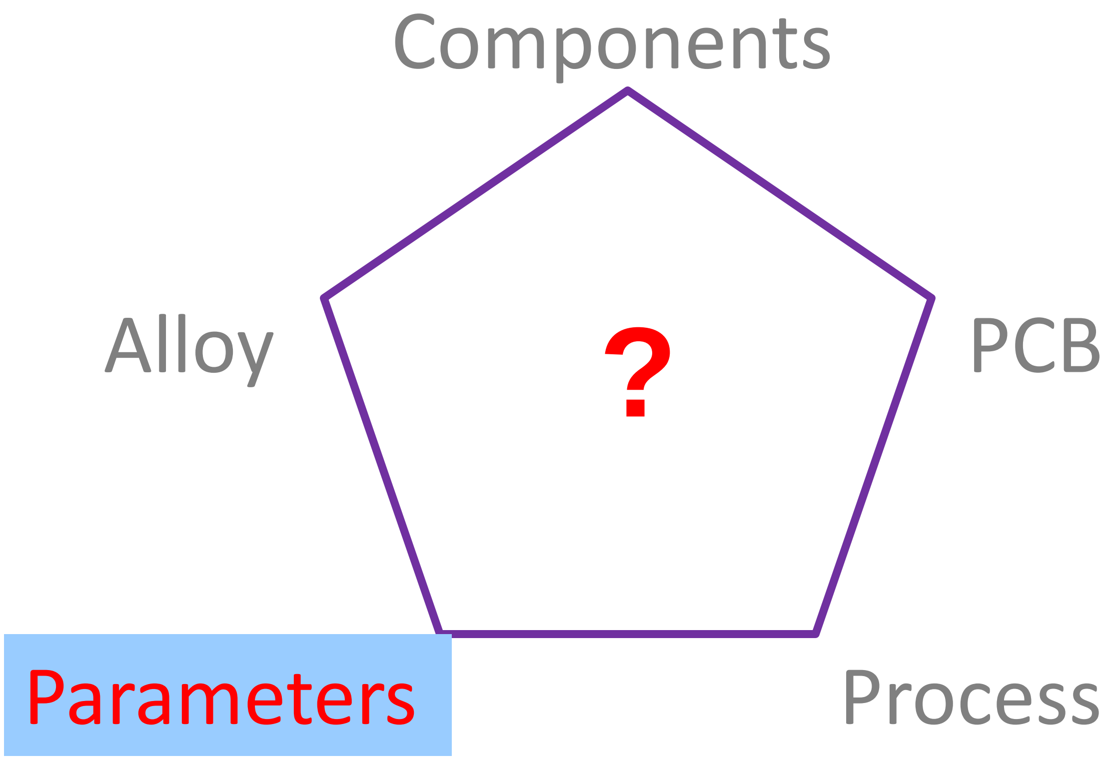
There is no BiSnAg wire, only SACX wire

Reworked Joint Strength



Taken from 3 shear readings each

Low Temperature Conversion

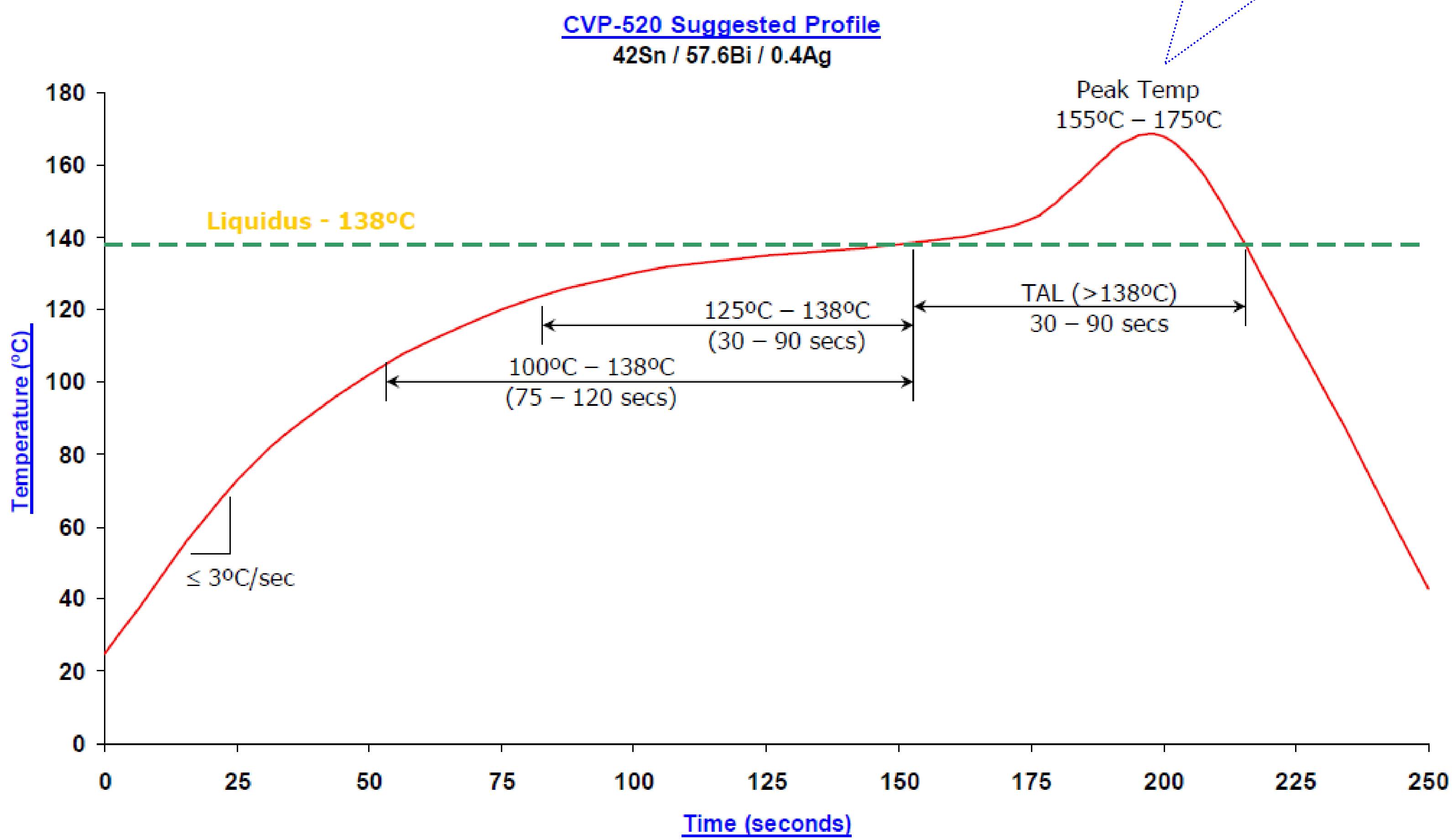


Parameters At A Glance

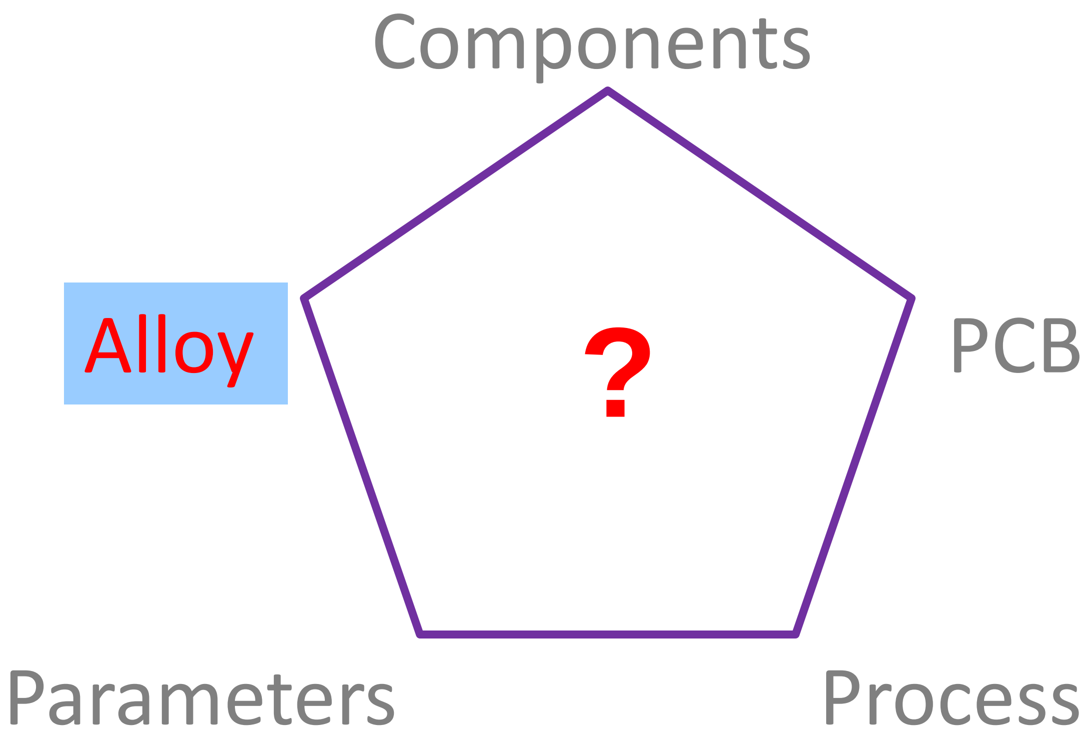
- **Printing**
  - Can be drop-in
  - Very minimal changes even with PIH & PIH+
- **Placement**
  - Standard SMT – None
  - PIH & PIH+ - As required to accommodate
- **Reflow Soldering**
  - Major temperature drop
- **Rework / Touch-up**
  - 400° C Solder Iron tip temperature

Thermal Profile

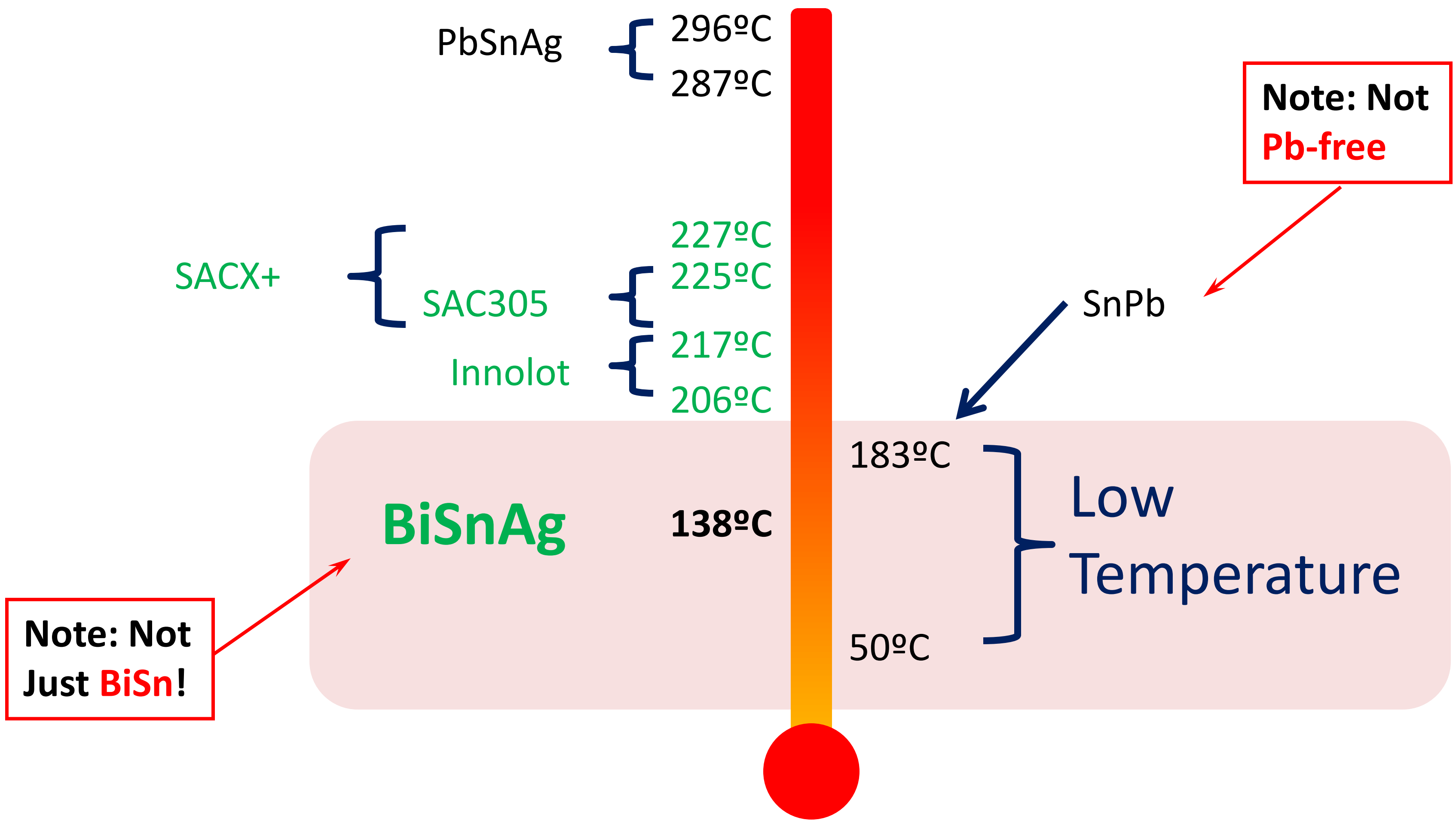
Avoid high peak,
TAL compensation



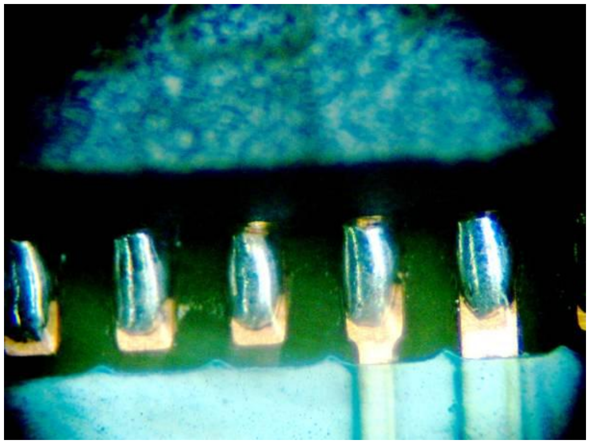
Low Temperature Conversion

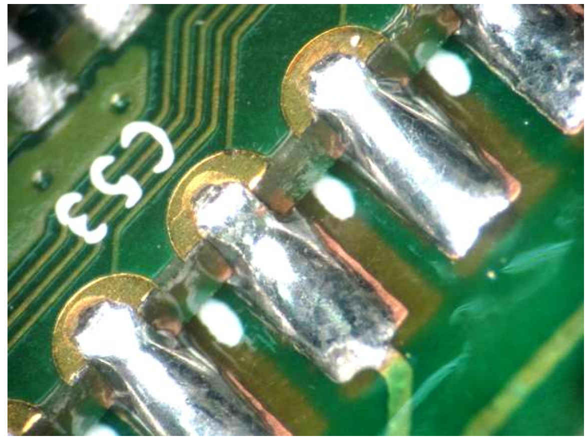


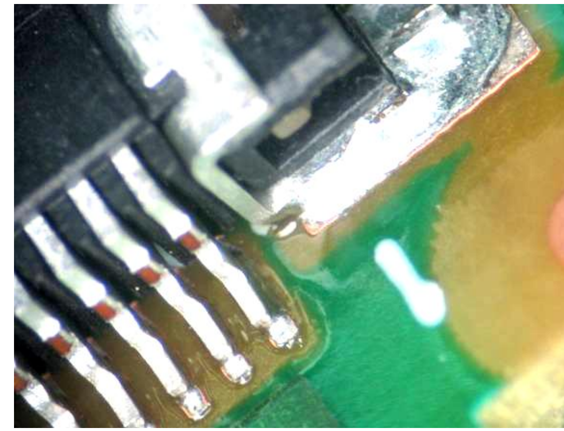
Knowing Solder

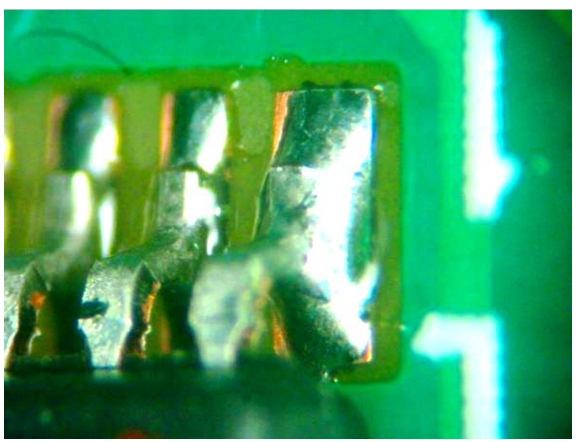


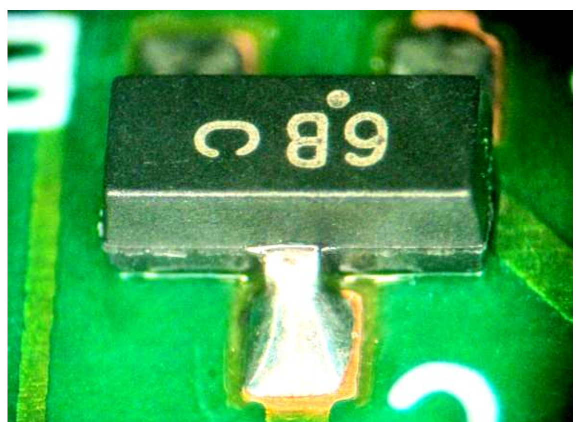
Shiny, Strong Fillets

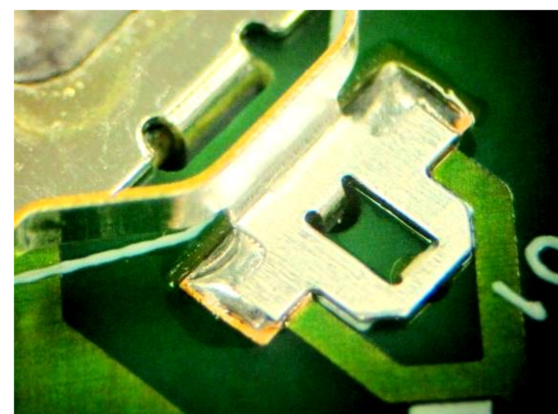

QFN


BlueTooth Module

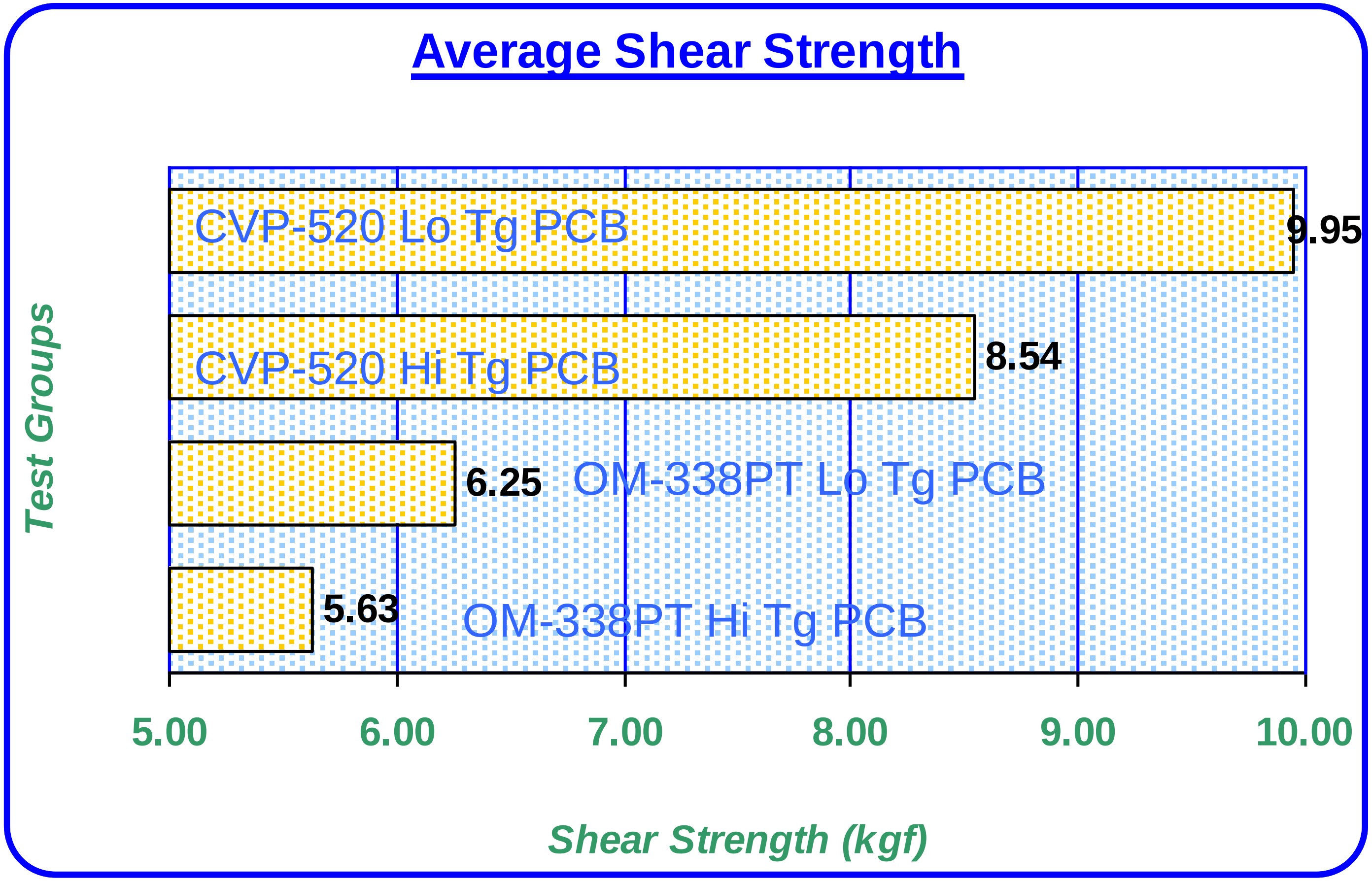

Connector


SOIC


SOT

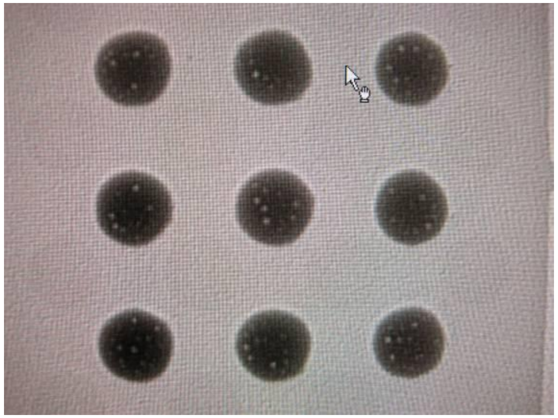

Button Cell Battery Holder

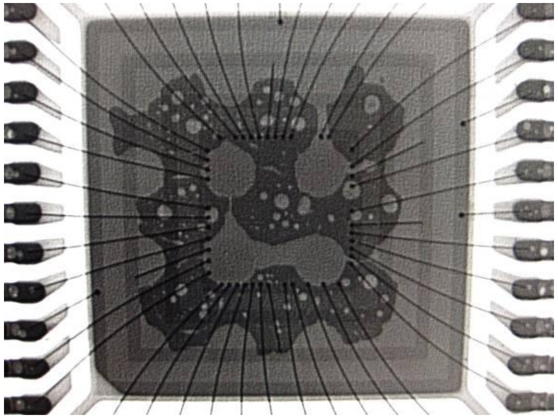
57.6Bi42Sn0.4Ag vs SAC-305

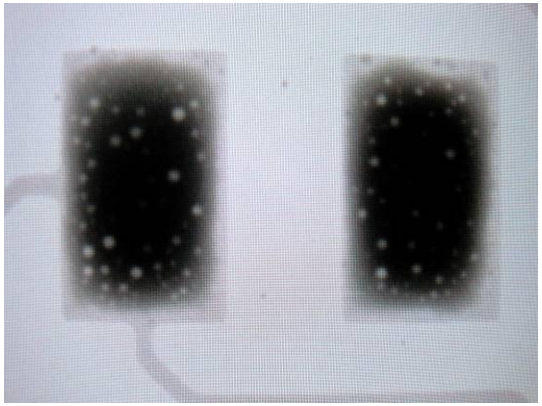


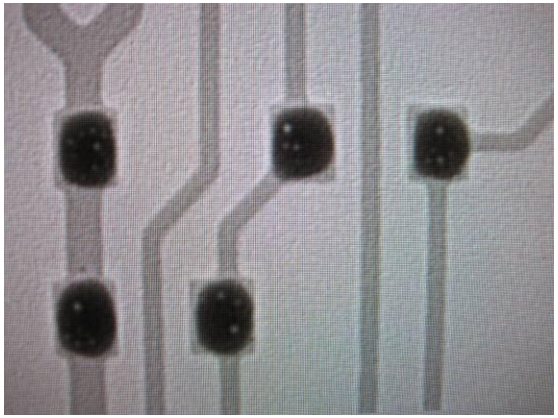
Taken from 7 shear readings each

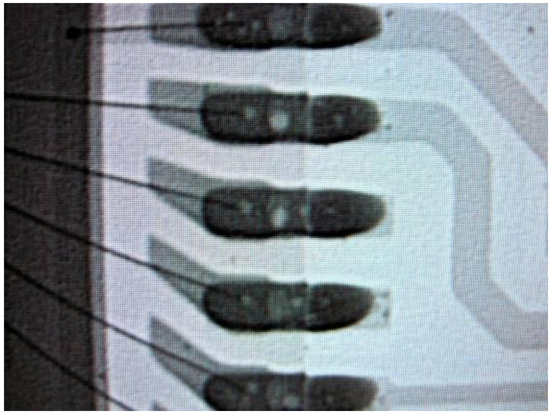
Void Performance?

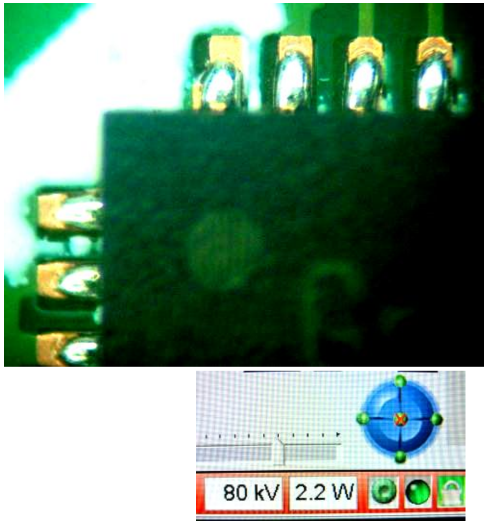

QFN Thermal Pad - Bare


QFN Thermal Pad - Actual


QFN Terminations - Bare


Chip Resistor & Cap - Bare


QFN Terminations - Actual



Conclusion – Low Temp Conversion

- Substantial cost savings over regular processes
- Savings can outweigh paste cost differences
- Can be mechanically stronger if done right
- Involves more than just changing pastes
- Beware of excessive flux residue
- Pick on plastic components / flex circuits
- Avoid high peak temperature

Thank You!