Update from Liverpool

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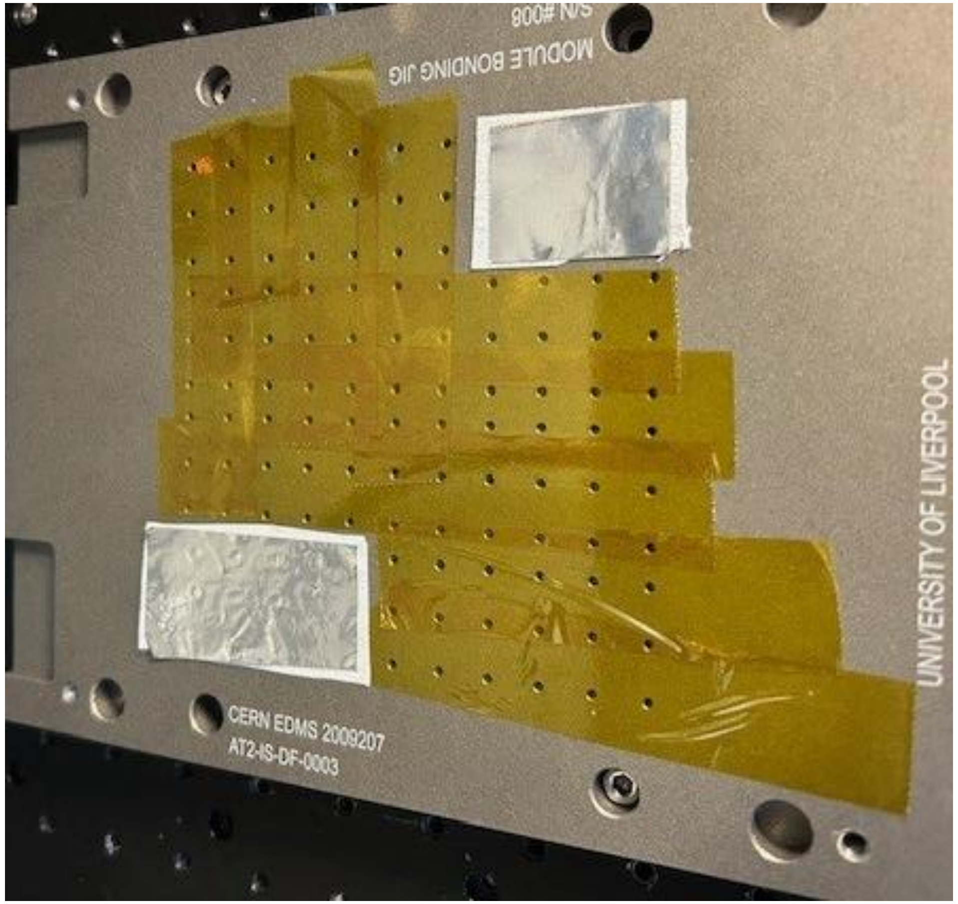
Wire-bonding tests on LTU foils

New tests: Vacuum with Diffuser

- As demonstrated by the Birmingham team, wire bonding performs better under vacuum when a diffuser is used
- Two diffuser options were tested: a thick and a thin version → to evaluate performance and compare with bonding on a glued PCB surface



Cleaning

- A PCB cleaning agent, Safewash, was used to reduce contamination that could affect wire bonding
- A soft toothbrush was used to gently clean the surface and remove residues such as fingerprints
- The standard PCB cleaner used in previous tests was unsuitable due to the foil's fragility

- Delamination was observed in the multilayer foil during the cleaning process!
  - Likely caused by the solvent, rinsing with deionised water, and drying with compressed air

Standard parameter

- Standard settings (full details in backup slide):
  - Ultrasonic: 22%
  - Bond force: 22 cN
  - Deformation: 40%
  - Overtravel: 25 µm
- Each test was with 20 wires
- 100 µm wire spacing, 1500 µm bond length → ~30° pull angle
- Two diffuser types were tested
  - **Thick (0.225 mm) and Thin (0.068 mm)**

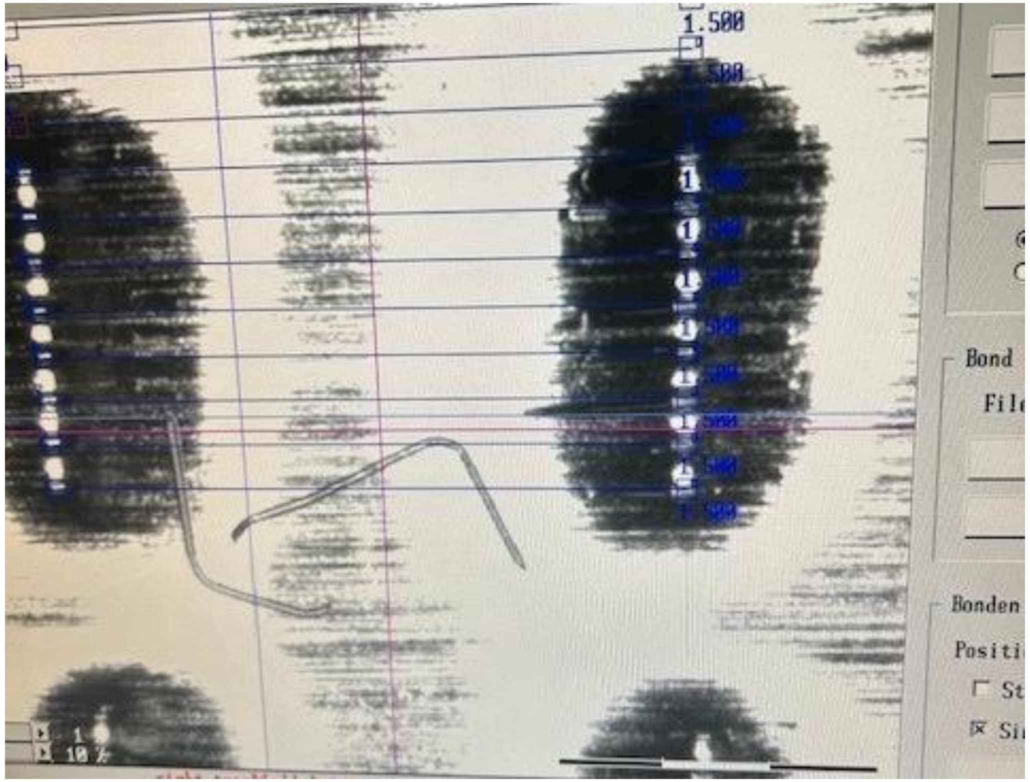
- A gold reference board was bonded to establish baseline pull strength and standard deviation

Samples	Mean [g]	STDEV [g]	STDEV [%]	Max [g]	Min [g]	Peel
17	10.13	0.43	4%	10.98	9.31	0%
Failure typ	Samples	%				
0 = No Rec	0	0%				
1= Source	17	100%				
2= Dest He	0	0%				
3= Span Br	0	0%				
4= Source	0	0%				
5= Destina	0	0%				

Wire-bonding tests on LTU foils
- Thick diffuser

Failures on single layer

- The highest failure rate occurred with the thick diffuser on single-layer foils
- Dark rings were observed around many bond feet, suggesting insufficient support, similar to issues seen in previous tests without proper gluing
- This may indicate suboptimal vacuum contact in that area



Pull test matrix

Single Layer – US % Ultrasonic

Mean	(CN) Bondforce	22	25	25	28	28	30	30	32	32
	22	7.3								
	22		6.83							
	25			Began to fail at Wirebonding						
	25									
	28									
	28									
	30									
	30									
	32									

Multi Layer – US % Ultrasonic

Mean	(CN) Bondforce	22	25	25	28	28	30	30	32	32
	22	11.47								
	22		10.9							
	25			10.19						
	25				10.87					
	28					9.64				
	28						10.42			
	30							10.25		
	30								10.8	
	32									9.97

Initial test

Single Layer – US % Ultrasonic

Std Dev	(CN) Bondforce	22	25	25	28	28	30	30	32	32
	22	1.18								
	22		1.79							
	25			Began to fail at Wirebonding						
	25									
	28									
	28									
	30									
	30									
	32									

Multi Layer – US % Ultrasonic

Std Dev	(CN) Bondforce	22	25	25	28	28	30	30	32	32
	22	0.83								
	22		1.24							
	25			1.65						
	25				1.19					
	28					1.59				
	28						1.49			
	30							1.78		
	30								1.36	
	32									1.84

- Single-layer foils failed catastrophically under test conditions
- Multi-layer foils yielded promising results, though some cases exhibited excessive standard deviation
- Tests were repeated to confirm reproducibility
  - Consistent outcomes were observed across different test areas

US % Ultrasonic

Mean	(CN) Bondforce	22	25	25	28	28	30	30	32	32
	22	Failed								
	22									
	25									
	25									
	28									
	28									
	30									
	30									
	32									

US % Ultrasonic

Mean	(CN) Bondforce	22	25	25	28	28	30	30	32	32
	22	11.11								
	22		11.78							
	25			11.1						
	25				11.95					
	28					11.11				
	28						11.87			
	30							11.87		
	30								12.07	
	32									11.18

Single Layer – US % Ultrasonic

Std Dev	(CN) Bondforce	22	25	25	28	28	30	30	32	32
	22	Failed								
	22									
	25									
	25									
	28									
	28									
	30									
	30									
	32									

Multi Layer – US % Ultrasonic

Std Dev	(CN) Bondforce	22	25	25	28	28	30	30	32	32
	22	2.24								
	22		0.43							
	25			0.79						
	25				0.34					
	28					1.09				
	28						0.53			
	30							0.68		
	30								0.58	
	32									1.39

Repeated test

30% and 50% deformations

30% deformation

Single Layer					
		US%			
Mean		25	28	28	30
	25	Failed			
	25				
	28				
CN	28				

Multi Layer					
		US%			
Mean		25	28	28	30
	25	10.62			
	25		11.78		
	28			11.71	
CN	28				11.91

Single Layer					
		US%			
Std Dev		25	28	28	30
	25	Failed			
	25				
	28				
CN	28				

Multi Layer					
		US%			
Std Dev		25	28	28	30
	25	1.26			
	25		0.55		
	28			0.7	
CN	28				1.03

50% deformation

Single Layer					
		US%			
Mean		25	28	28	30
	25	4.32			
	25		3.4		
	28			Began to Fail	
CN	28				

Multi Layer					
		US%			
Mean		25	28	28	30
	25	12.18			
	25		12.52		
	28			12.14	
CN	28				12.14

Single Layer					
		US%			
Std Dev		25	28	28	30
	25	1.34			
	25		1.05		
	28			Began to Fail	
CN	28				

Multi Layer					
		US%			
Std Dev		25	28	28	30
	25	0.28			
	25		0.38		
	28			0.68	
CN	28				0.6

- Single layer
  - Improved bonding success at 50% deformation compared to 30%
- Multi layer
  - Achieved the best mean and standard deviation at 50% deformation

15 µm overtravel

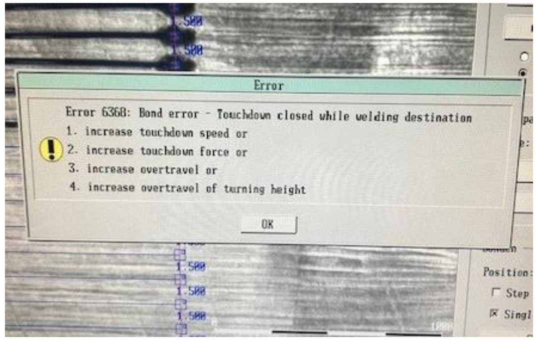
Single Layer								
		US%						
Mean		25	25	28	28	30	30	32
	22							
	25		8.09					
	25			8.97				
	28				3.8			
	28							
	30					Began to Fail in Wirebonding		
CN	30							

Multi Layer								
		US%						
Mean		25	25	28	28	30	30	32
	22	11.2						
	25		11.93					
	25			11.94				
	28				10.98			
	28							
	30					Began to Fail in Wirebonding		
CN	30							

Single Layer								
		US%						
Std Dev		25	25	28	28	30	30	32
	22							
	25		1.69					
	25			1.1				
	28				1.09			
	28							
	30					Began to Fail in Wirebonding		
CN	30							

Multi Layer								
		US%						
Std Dev		25	25	28	28	30	30	32
	22	1.19						
	25		0.22					
	25			0.63				
	28				1.58			
	28							
	30					Began to Fail in Wirebonding		
CN	30							

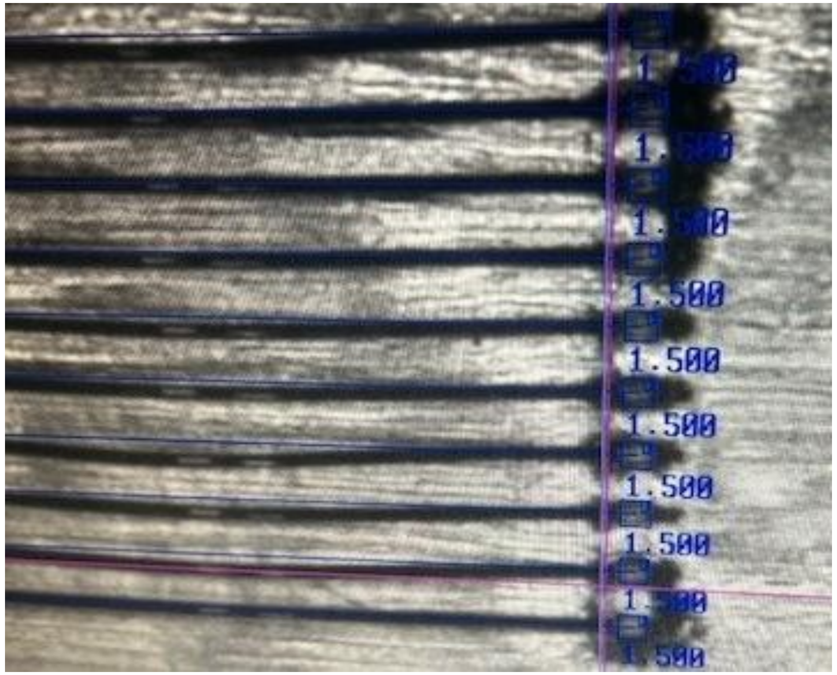
- The same trend persisted: single-layer foils performed poorly, while multi-layer foils showed good outcomes
- Both configurations began to fail with higher parameter settings

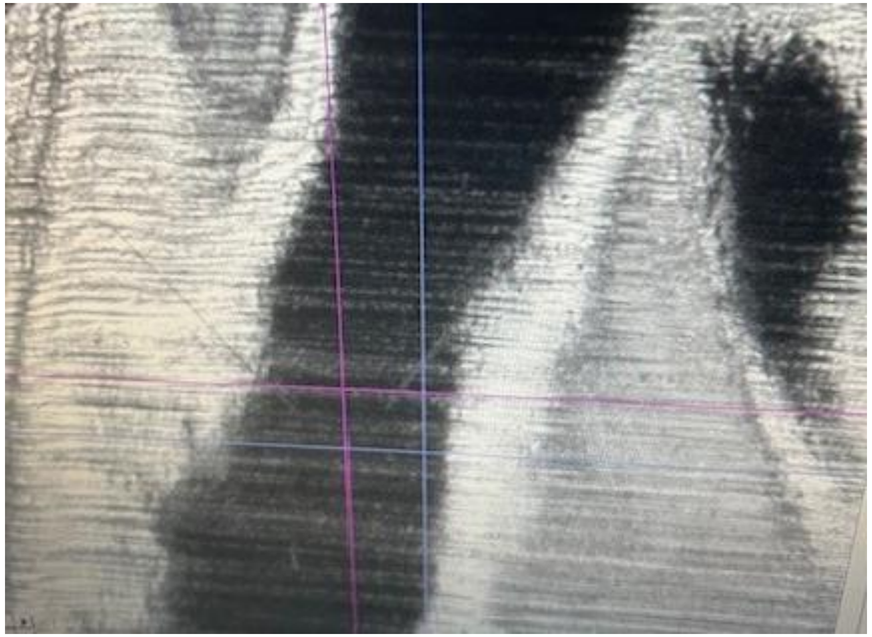


Wire-bonding tests on LTU foils
- Thinner diffuser

Failures on single layer

- Significantly fewer wire failures occurred when using the thinner diffuser
- The previously observed dark regions around bond feet disappeared, suggesting improved vacuum conditions that support better bonding
- A residual shadow on the single-layer foil indicated incomplete vacuum flattening
- Maintaining flatness is challenging for single-layer foils due to their flexibility





Pull test matrix

		US % Ultrasonic								
Mean		22	25	25	28	28	30	30	32	32
(CN) Bondforce	22	8.08								
	22		11.08							
	25			8.13						
	25				8.89					
	28					5.66				
	28						7.94			
	30									
	30								Failed	
	32									

		US % Ultrasonic								
Mean		22	25	25	28	28	30	30	32	32
(CN) Bondforce	22	8.4								
	22		11.81							
	25			11.81						
	25				11.21					
	28					10.15				
	28						11.96			
	30							11.23		
	30								12.02	
	32									10.15

Initial test

Single Layer										
		US % Ultrasonic								
Std Dev		22	25	25	28	28	30	30	32	32
(CN) Bondforce	22	2.13								
	22		0.92							
	25			2.35						
	25				1.81					
	28					1.65				
	28						2.39			
	30									
	30								Failed	
	32									

Multi Layer										
		US % Ultrasonic								
Std Dev		22	25	25	28	28	30	30	32	32
(CN) Bondforce	22	1.72								
	22		1.26							
	25			1.03						
	25				1.58					
	28					1.22				
	28						0.75			
	30							1.18		
	30								1.03	
	32									1.81

- The thinner diffuser led to significant improvements over the thicker version, although single-layer failures still occurred at higher parameter settings
- Single-layer results showed mean pull strength below 9 g and standard deviation above 1.3 g considered as a failure
- Multi-layer foil performance remained good
- Results were validated with repeated testing

		US % Ultrasonic								
Mean		22	25	25	28	28	30	30	32	32
(CN) Bondforce	22	9.88								
	22		10.83							
	25			8.53						
	25				9.74					
	28					6.61				
	28						7.95			
	30							5.89		
	30								5.66	
	32									5.68

		US % Ultrasonic								
Mean		22	25	25	28	28	30	30	32	32
(CN) Bondforce	22	11.65								
	22		12.12							
	25			11.95						
	25				11.96					
	28					11.77				
	28						11.43			
	30							10.99		
	30								12.16	
	32									11.04

Single Layer										
		US % Ultrasonic								
Std Dev		22	25	25	28	28	30	30	32	32
(CN) Bondforce	22	1.63								
	22		1.4							
	25			1.61						
	25				2.15					
	28					1.84				
	28						2.94			
	30							2.1		
	30								1.95	
	32									1.32

Multi Layer										
		US % Ultrasonic								
Std Dev		22	25	25	28	28	30	30	32	32
(CN) Bondforce	22	0.49								
	22		0.34							
	25			0.47						
	25				0.73					
	28					1				
	28						1.41			
	30							1.38		
	30								0.75	
	32									1.99

Repeated test

30% and 50% deformations

30% deformation

Single Layer					
		US%			
Mean		25	28	28	30
CN	25	7.32			
	25		9.51		
	28			6.96	
	28				8.76

Multi Layer					
		US%			
Mean		25	28	28	30
CN	25	10.47			
	25		11.72		
	28			10.3	
	28				11.43

Single Layer					
		US%			
Std Dev		25	28	28	30
CN	25	2.19			
	25		1.72		
	28			2.34	
	28				1.91

Multi Layer					
		US%			
Std Dev		25	28	28	30
CN	25	1.07			
	25		0.72		
	28			1.83	
	28				1.02

50% deformation

Single Layer					
		US%			
Mean		25	28	28	30
CN	25	10.27			
	25		10.44		
	28			9.08	
	28				10.23

Multi Layer					
		US%			
Mean		25	28	28	30
CN	25	12.67			
	25		12.63		
	28			12.18	
	28				12.07

Single Layer					
		US%			
Std Dev		25	28	28	30
CN	25	1.91			
	25		2.11		
	28			1.93	
	28				1.89

Multi Layer					
		US%			
Std Dev		25	28	28	30
CN	25	0.44			
	25		0.44		
	28			0.75	
	28				1.06

- Single layer
  - Improved bonding at 50% deformation compared to 30%, but the standard deviation remained outside acceptable limits
- Multi layer
  - Consistently achieved optimal results both in mean strength and standard deviation
  - Achieved the best at 50% deformation compared to the 30% and standard settings

15 µm overtravel

Single Layer								
		US%						
Mean		25	25	28	28	30	30	32
CN	22	10.67						
	25		9.42					
	25			9.24				
	28				8.27			
	28					8.58		
	30						Overtravel Issue	
	30							

Multi Layer								
		US%						
Mean		25	25	28	28	30	30	32
CN	22	11.99						
	25		10.63					
	25			12.06				
	28				11.89			
	28					11.23		
	30						9.4	
	30							10.74

Single Layer								
		US%						
Std Dev		25	25	28	28	30	30	32
CN	22	1.03						
	25		1.45					
	25			2.1				
	28				1.54			
	28					2.33		
	30						Overtravel Issue	
	30							

Multi Layer								
		US%						
Std Dev		25	25	28	28	30	30	32
CN	22	0.86						
	25		1.55					
	25			0.55				
	28				0.9			
	28					1.28		
	30						1.57	
	30							1.33

- Overtravel issues persisted at higher parameter settings
- Multi-layer foils continued to deliver strong performance, consistent with previous observations

Wire-bonding tests on LTU foils
- Comparisons

Parameter matrix & 15 µm overtravel

Parameter Matrix

	Glued on PCB			Thicker Diffuser			Thinner Diffuser			Glued on PCB			Thicker Diffuser			Thinner Diffuser		
	Single Layer			Single Layer			Single Layer			Multi Layer			Multi Layer			Multi Layer		
Parameters	No of Wires	Mean	Std Dev	No of Wires	Mean	Std Dev	No of Wires	Mean	Std Dev	No of Wires	Mean	Std Dev	No of Wires	Mean	Std Dev	No of Wires	Mean	Std Dev
22US% 22CN	20	11.18	0.69	17	7.3	1.18	17	9.88	1.63	19	10.73	1.77	19	11.11	2.24	15	11.65	0.49
25US% 22CN	20	11.46	0.18	17	6.83	1.79	18	10.83	1.4	20	10.45	1.32	20	11.78	0.43	20	12.12	0.34
25US% 25CN	19	11.26	0.59				20	8.53	1.61	19	11.04	0.67	20	11.1	0.79	20	11.95	0.47
28US% 25CN	20	11.21	0.62				20	9.74	2.15	19	11.03	0.25	20	11.95	0.34	20	11.96	0.73
28US% 28CN	20	11.33	0.36				12	6.61	1.84	20	11.04	0.88	20	11.11	1.09	20	11.77	1
30US% 28CN	20	11.04	0.8		Failed		17	7.95	2.94	20	11.06	0.69	20	11.87	0.53	20	11.43	1.41
30US% 30CN	16	10.49	0.82				17	5.89	2.1	20	11.03	0.49	20	11.87	0.68	20	10.99	1.38
32US% 30CN	20	10.99	0.65				13	5.66	1.95	20	10.8	0.82	20	12.07	0.58	20	12.16	0.75
32US% 32CN	20	10.66	0.77				6	5.68	1.32	20	9.45	1.2	20	11.18	1.39	20	11.04	1.99

15 µm Overtravel

	Glued on PCB			Thicker Diffuser			Thinner Diffuser			Glued on PCB			Thicker Diffuser			Thinner Diffuser		
	Single Layer			Single Layer			Single Layer			Multi Layer			Multi Layer			Multi Layer		
Parameters	No of Wires	Mean	Std Dev	No of Wires	Mean	Std Dev	No of Wires	Mean	Std Dev	No of Wires	Mean	Std Dev	No of Wires	Mean	Std Dev	No of Wires	Mean	Std Dev
25US% 22CN	20	11.21	0.47		Failed		18	10.67	1.03	20	11.48	0.44	17	11.27	1.19	19	11.99	0.86
25US% 25CN	20	10.89	0.88	20	8.09	1.69	20	9.42	1.45	20	10.96	1.09	20	11.93	0.22	20	10.63	1.55
28US% 25CN	20	11.34	0.39	18	8.97	1.1	17	9.24	2.1	20	11.34	0.65	20	11.94	0.63	20	12.06	0.55
28US% 28CN	20	10.79	0.94	11	3.8	1.09	15	8.27	1.54	20	11.09	0.43	17	10.98	1.58	20	11.89	0.9
30US% 28CN	20	11.06	0.82				15	8.58	2.33	19	11.09	0.64				20	11.23	1.28
30US% 30CN	20	11.3	0.65		Failed			Failed		18	10.82	0.76		Failed		17	9.4	1.57
32US% 30CN	20	11.25	0.38							20	11.06	0.66				11	10.74	1.33

30% & 50% deformation

30% Deformation

	Glued on PCB			Thicker Diffuser			Thinner Diffuser			Glued on PCB			Thicker Diffuser			Thinner Diffuser		
	Single Layer			Single Layer			Single Layer			Multi Layer			Multi Layer			Multi Layer		
Parameters	No of Wires	Mean	Std Dev	No of Wires	Mean	Std Dev	No of Wires	Mean	Std Dev	No of Wires	Mean	Std Dev	No of Wires	Mean	Std Dev	No of Wires	Mean	Std Dev
25US% 25CN	20	10.98	0.94				15	7.32	2.19	19	10.44	1.34	20	10.62	1.26	20	10.47	1.07
28US% 25CN	20	11.39	0.26		Failed		18	9.51	1.72	20	11.12	0.79	20	11.78	0.55	20	11.72	0.72
28US% 28CN	20	10.71	0.79				14	6.96	2.34	20	10.33	0.91	20	11.71	0.7	20	10.3	1.83
30US% 28CN	20	11.21	0.87				18	8.76	1.91	20	11.03	0.57	20	11.91	1.03	20	11.43	1.02

50% Deformation

	Glued on PCB			Thicker Diffuser			Thinner Diffuser			Glued on PCB			Thicker Diffuser			Thinner Diffuser		
	Single Layer			Single Layer			Single Layer			Multi Layer			Multi Layer			Multi Layer		
Parameters	No of Wires	Mean	Std Dev	No of Wires	Mean	Std Dev	No of Wires	Mean	Std Dev	No of Wires	Mean	Std Dev	No of Wires	Mean	Std Dev	No of Wires	Mean	Std Dev
25US% 25CN	20	11.14	0.76	12	4.32	1.34	20	10.27	1.91	19	11.39	0.4	20	12.18	0.28	18	12.67	0.44
28US% 25CN	20	11.24	0.86	5	3.4	1.05	20	10.44	2.11	20	11.42	0.28	20	12.52	0.38	19	12.63	0.44
28US% 28CN	20	10.77	1.01		Failed		19	9.08	1.93	19	11.07	0.66	20	12.14	0.68	20	12.18	0.75
30US% 28CN	20	10.58	1.04				20	10.23	1.89	18	11.05	0.63	20	12.14	0.6	20	12.07	1.06

Summary

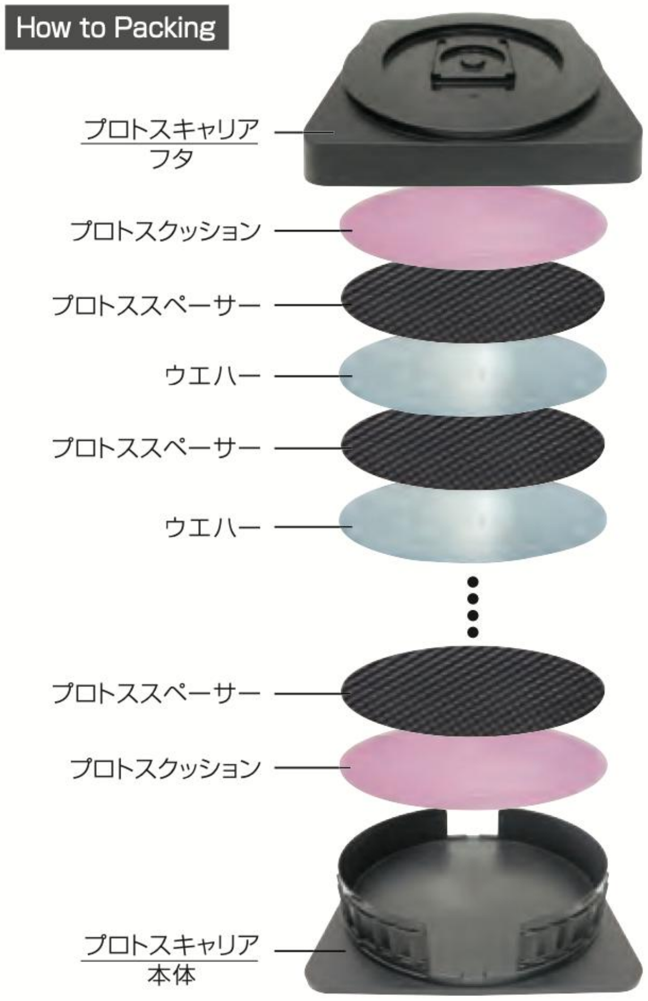
- Bonding quality was superior when foils were glued to a PCB, likely due to the added mechanical stability
- The thinner diffuser significantly improved vacuum-assisted bonding, though some stability challenges remain
- Multi-layer foils consistently offered easier and more reliable bonding, regardless of method
- The study demonstrated that acceptable mean strength and standard deviation values can be achieved

- Next steps:
    - Investigate further improvements for single-layer foils under vacuum. Any suggestions are welcome
        - Consider adjusting touchdown force or tail length
    - Plan comparative tests with alternative wire materials

Dummy parts and jigs

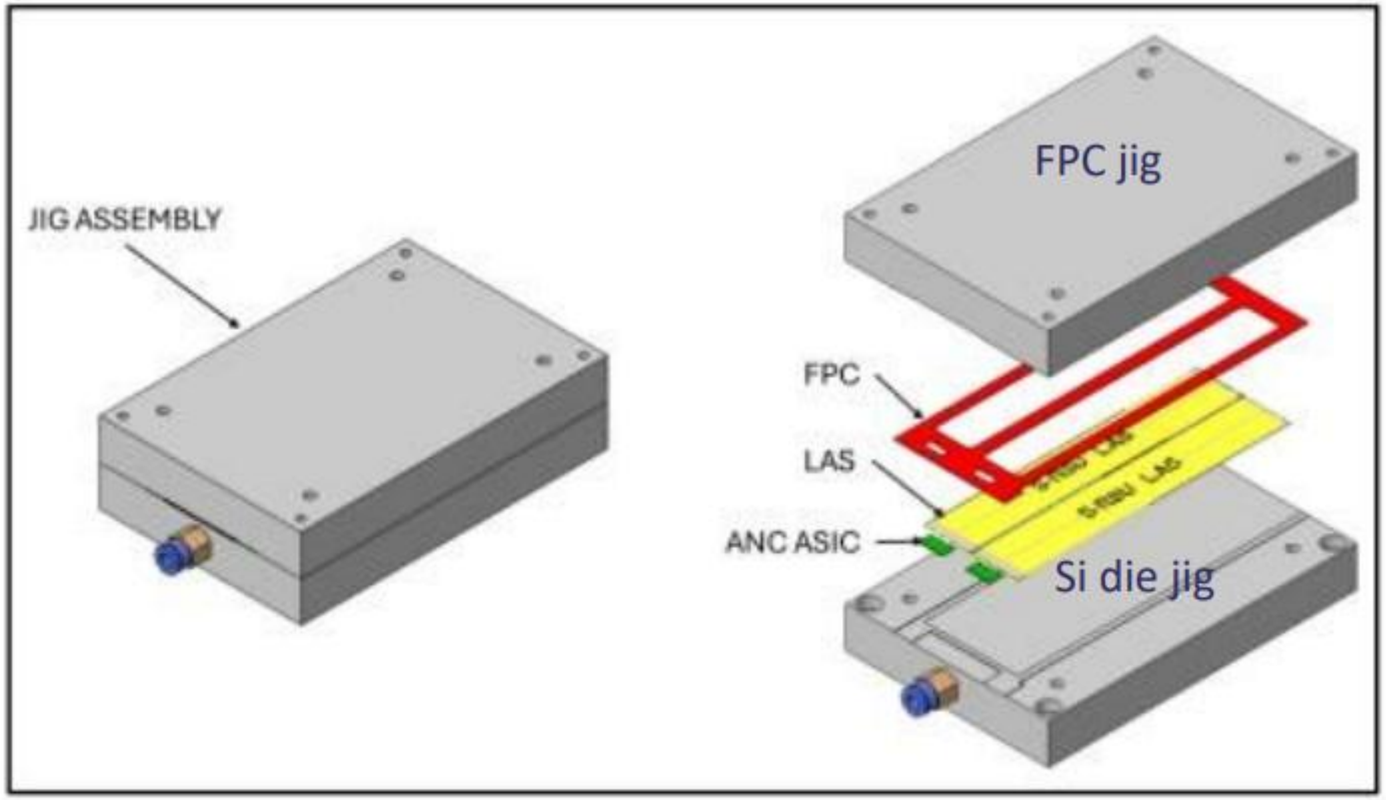
Dummy parts

- Packing charges are included in the quote
- Shipping will be billed separately at USD 350 per shipment
- Feedback from the supplier: “The current packaging is expected to be sufficient; we routinely ship samples internationally without issues.”



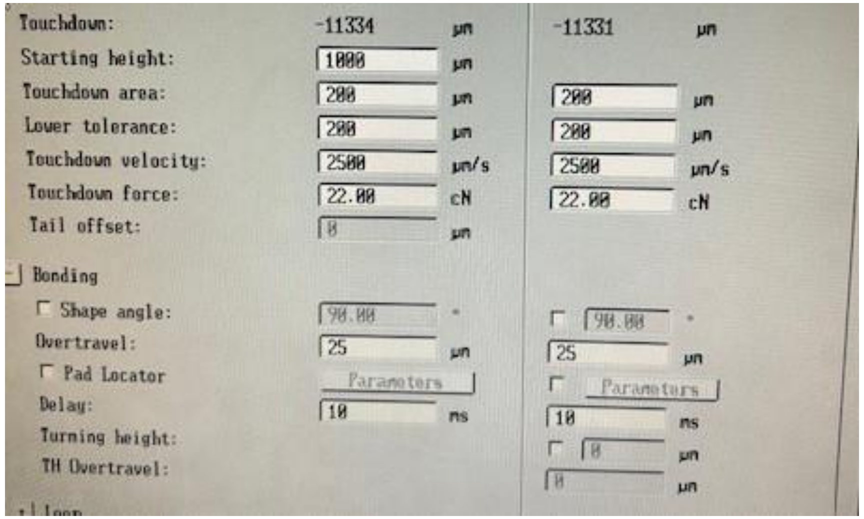
Jigs

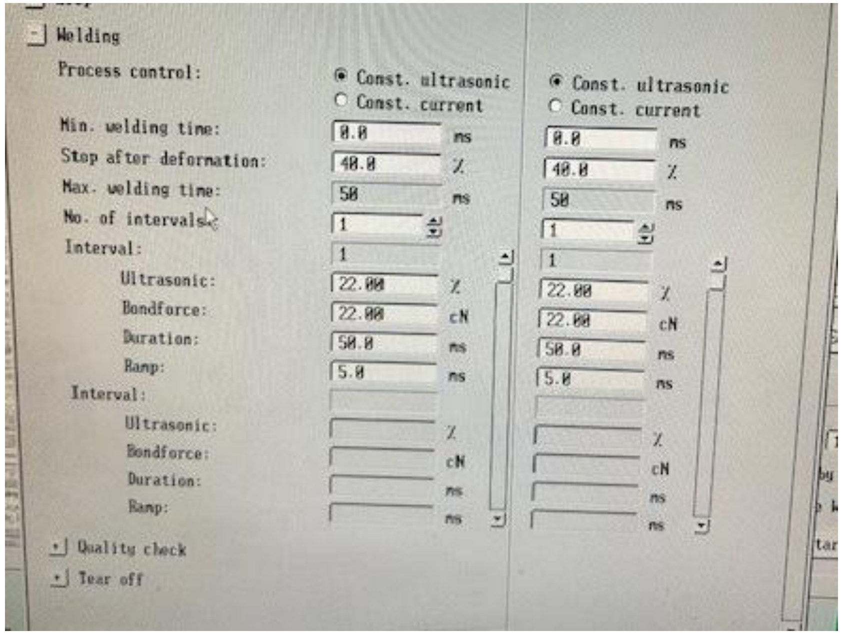
- Jig manufacturing could be scheduled for August or September
- The workshop has been occupied with other projects, but availability is improving
- The best way: send the CAD files (STEP format preferred) by email. Tim will review them and coordinate with the workshop accordingly

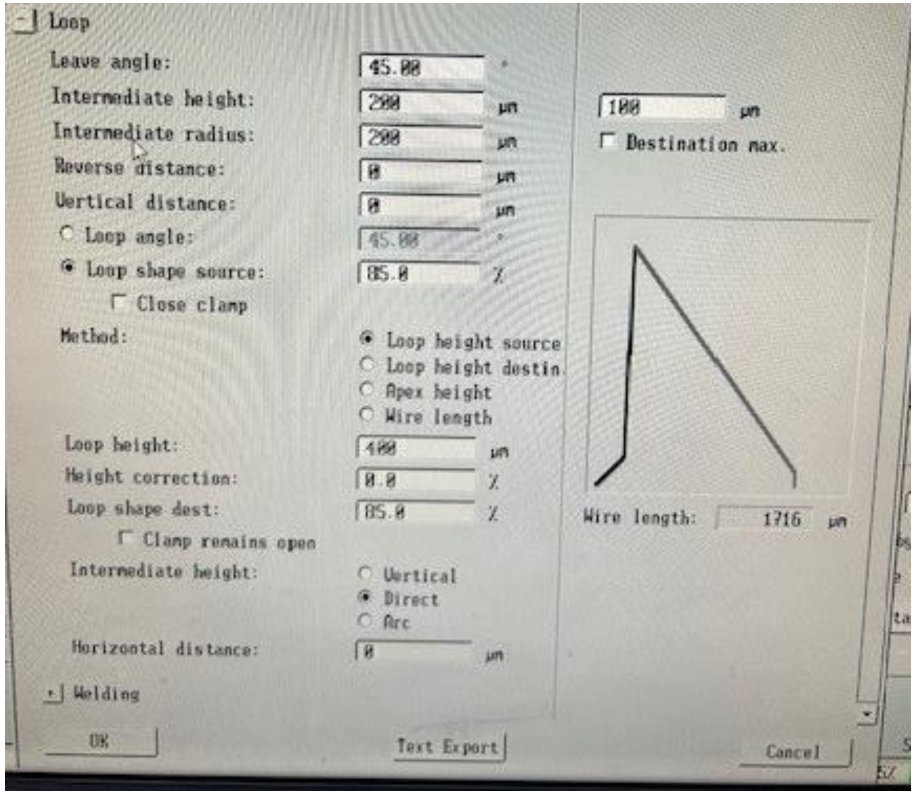


Backup

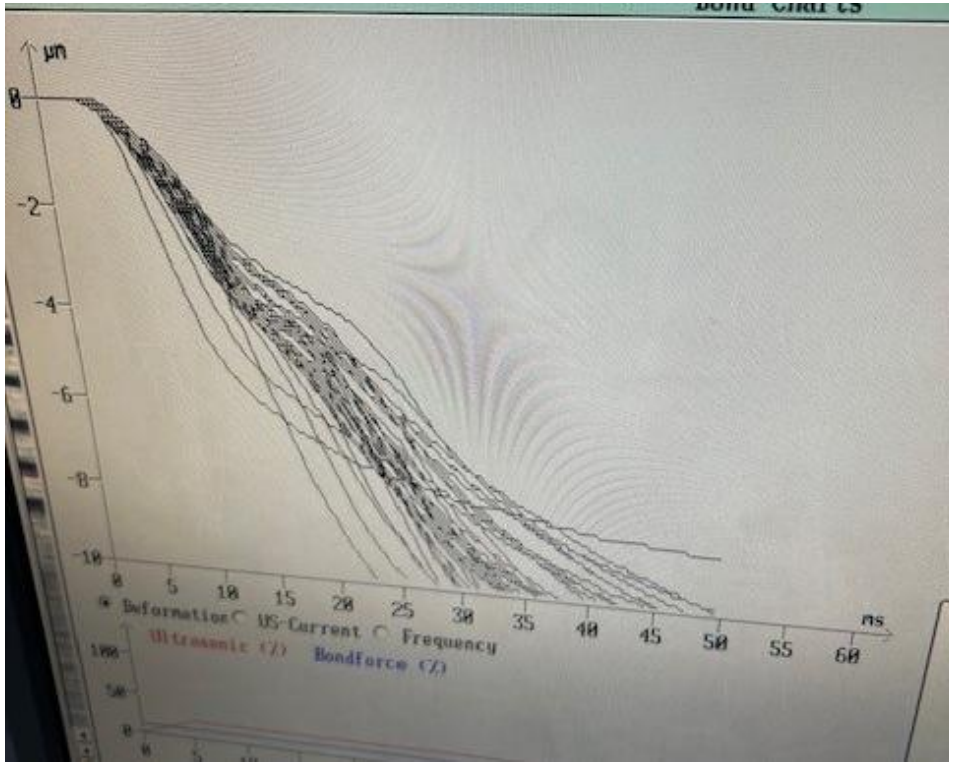
Standard bonding parameters



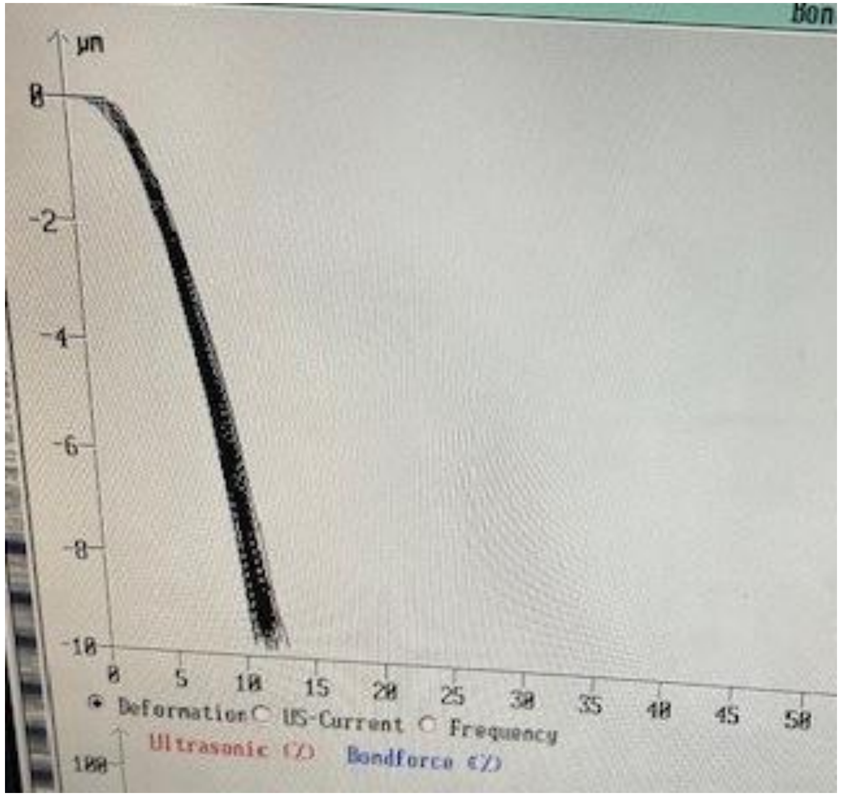




Deformations



22US%, 22CN



32US%, 32CN

- Both diffuser types exhibited similar deformation patterns
- Deformation—defined as the width of the bond foot—varied with time depending on parameter settings
- At lower settings (22% ultrasonic, 22 cN force), deformation required more time to reach target values
- At higher settings (32% ultrasonic, 32 cN force), deformation was achieved more quickly

Wire comparison

- Used
  - CCC: Al-1%Si, 25 µm, El % 1-4, TS 15-18g
- Currently using
  - Heraeus: AlSi-M, 25 µm, EL > 1%, BL 15-17 cN
- Planned (Not provided by Accelonix)
  - Tanaka TABN Type aluminium wire (Al–1%Si with nickel doping, 25 µm)
- Alternative (Accelonix in stock)
  - Heraeus H74-41 (around £400): Aluminum Wire 25µm, 100m, AlSi-S, EL 1,0-4,0%, BL 14-16g, 2x1" spool
    - Plan to use this soft wire for performance comparison