Wire-bonding tests on LTU foils

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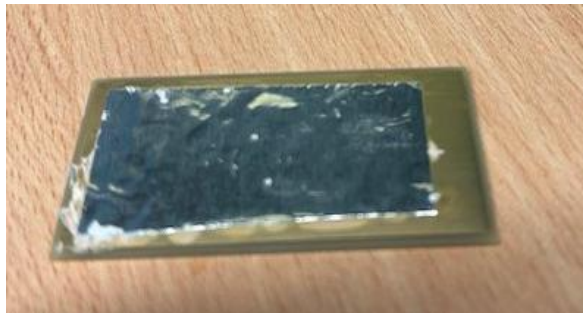
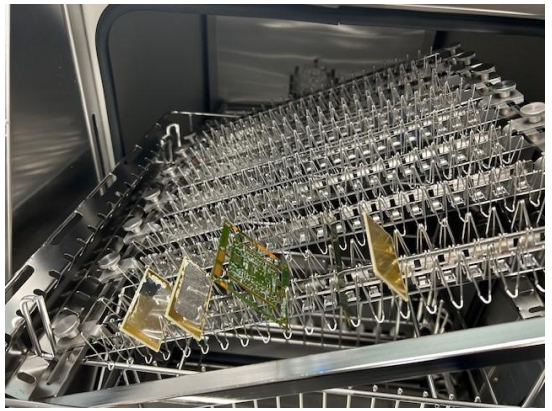
New tests: Foil onto PCB

- Foils glued onto FR4 PCB to improve vacuum contact during bonding
- Some glue spilled onto the top surface of the foil
- Cleaned with PCB cleaner (cleaning + 2 rinse cycles + drying)
- Glue residue on top side successfully removed



Single layer foil

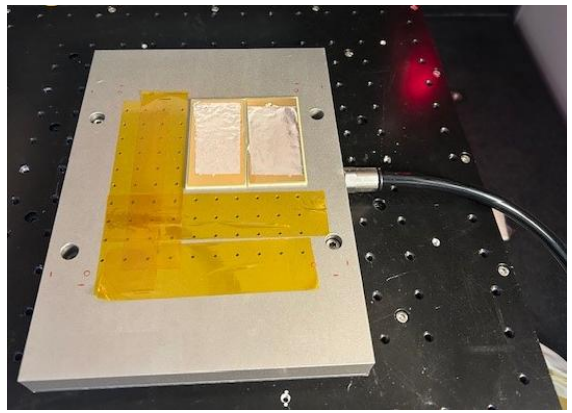
Multi layer foil



PCB cleaner

- Ran out of the wires used for the previous tests
  - CCC: Al-1%Si, 25 um diameter, El % 1-4, TS 15-18g
- New Heraeus wire will now be used
  - Al Si-M, 25 um diameter, EL > 1%, BL 15-17 cN
  - Personal experience: this wire is not as good as the previous wire
- Foil on jig
  - Vacuum contact significantly improved
  - Foils were held firmly on the jig throughout testing

New wire



Foils on jig

Standard parameter

- Standard settings (full details in backup slides):
  - Ultrasonic: 22%
  - Bond force: 22 cN
  - Deformation: 40%
  - Overtravel: 25 µm
- 100 µm wire spacing, 1500 µm bond length → ~30° pull angle
- Increased ultrasonic relative to bond force helped bonding
- See next slide for failure observations

1			Single Layer			
2			US%			
3	Mean		22	25	22	25
4		22	9.2			
5		22		10.6		
6		25			5.7	
7	CN	25				9.7

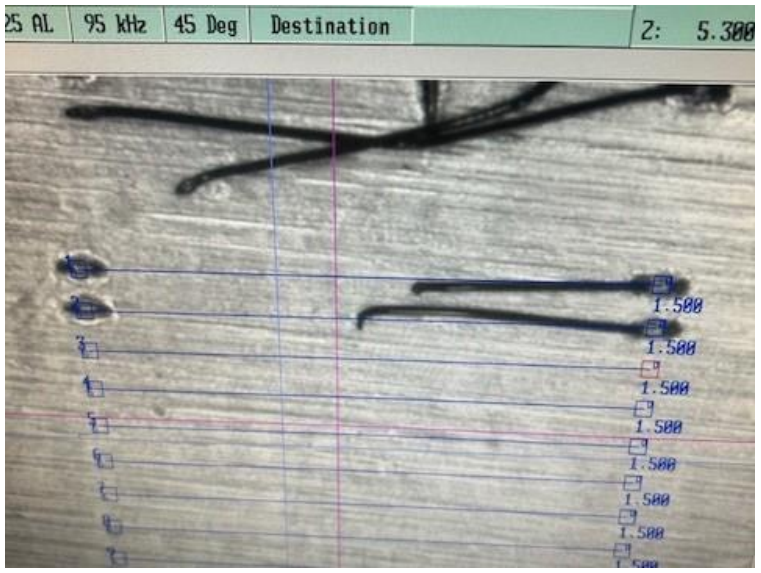
			Multi Layer			
			US%			
Mean		22	25	22	25	
	22	9.1				
	22		9.3			
	25			6		
CN	25					

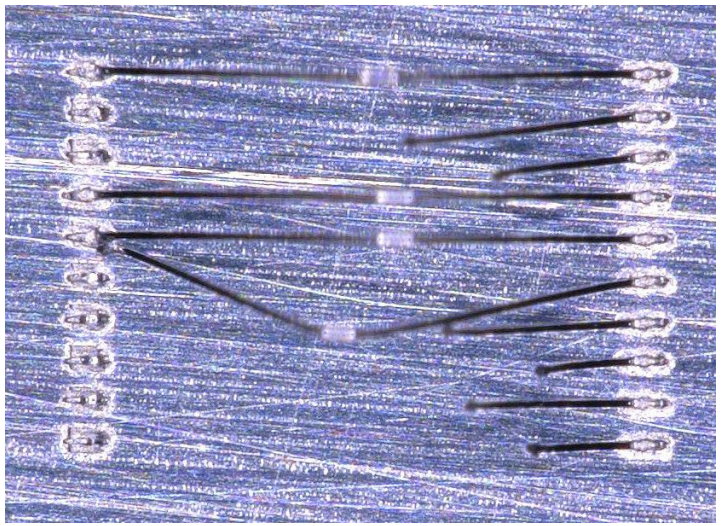
10			Single Layer			
11			US%			
12	Std Dev		22	25	22	25
13		22	1.73			
14		22		0.68		
15		25			2.92	
16	CN	25				1.26

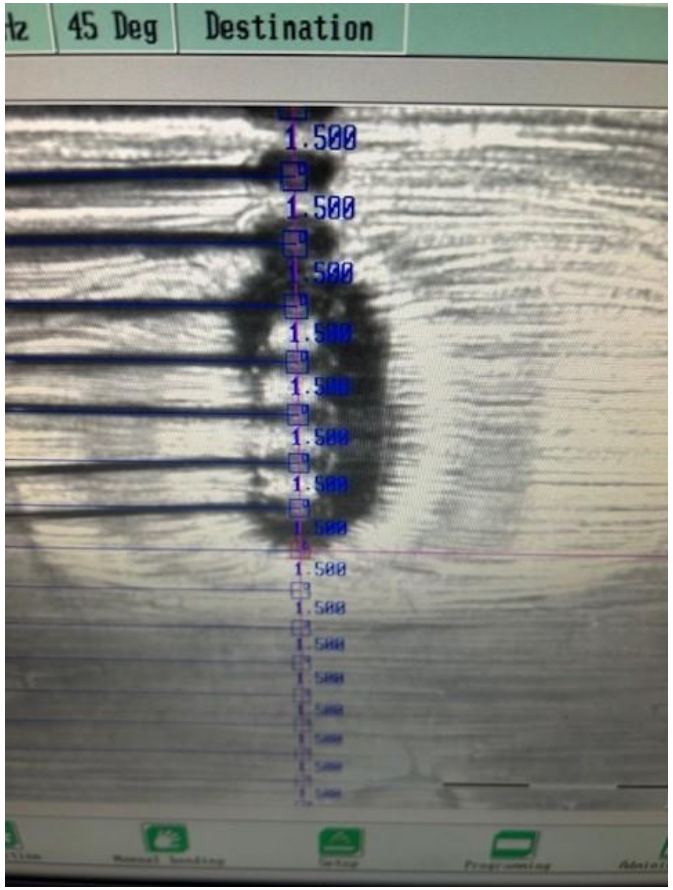
			Multi Layer			
			US%			
Std Dev		22	25	22	25	
	22	1.51				
	22		2.04			
	25			2.26		
CN	25					

Failures

- Bond force or US <22 led to high failure rate → use parameters >22
- Failures also observed near black spots at source/destination
  - Likely due to insufficient glue support
  - Poor pull strengths in these regions
- Bonding was avoided in areas with uncleaned glue residue







Repeat standard test

	Single Layer					
			US%			
Mean		22	25	22	25	
	22	7.33				
	22		10.11			
	25					
CN	25				9.32	

	Multi Layer					
			US%			
Mean		22	25	22	25	
	22	9.7				
	22		7.17			
	25					
CN	25				10.32	

Repeated test

	Single Layer					
			US%			
Std Dev		22	25	22	25	
	22	2.12				
	22		1.31			
	25					
CN	25				1.42	

	Multi Layer					
			US%			
Std Dev		22	25	22	25	
	22	2.12				
	22		2.07			
	25					
CN	25				2	

- Standard bonding test repeated on a different foil area
- Aimed to verify reproducibility of bond quality

	Single Layer					
			US%			
Mean		22	25	22	25	
	22	9.2				
	22		10.6			
	25			5.7		
CN	25				9.7	

	Multi Layer					
			US%			
Mean		22	25	22	25	
	22	9.1				
	22		9.3			
	25			6		
CN	25					

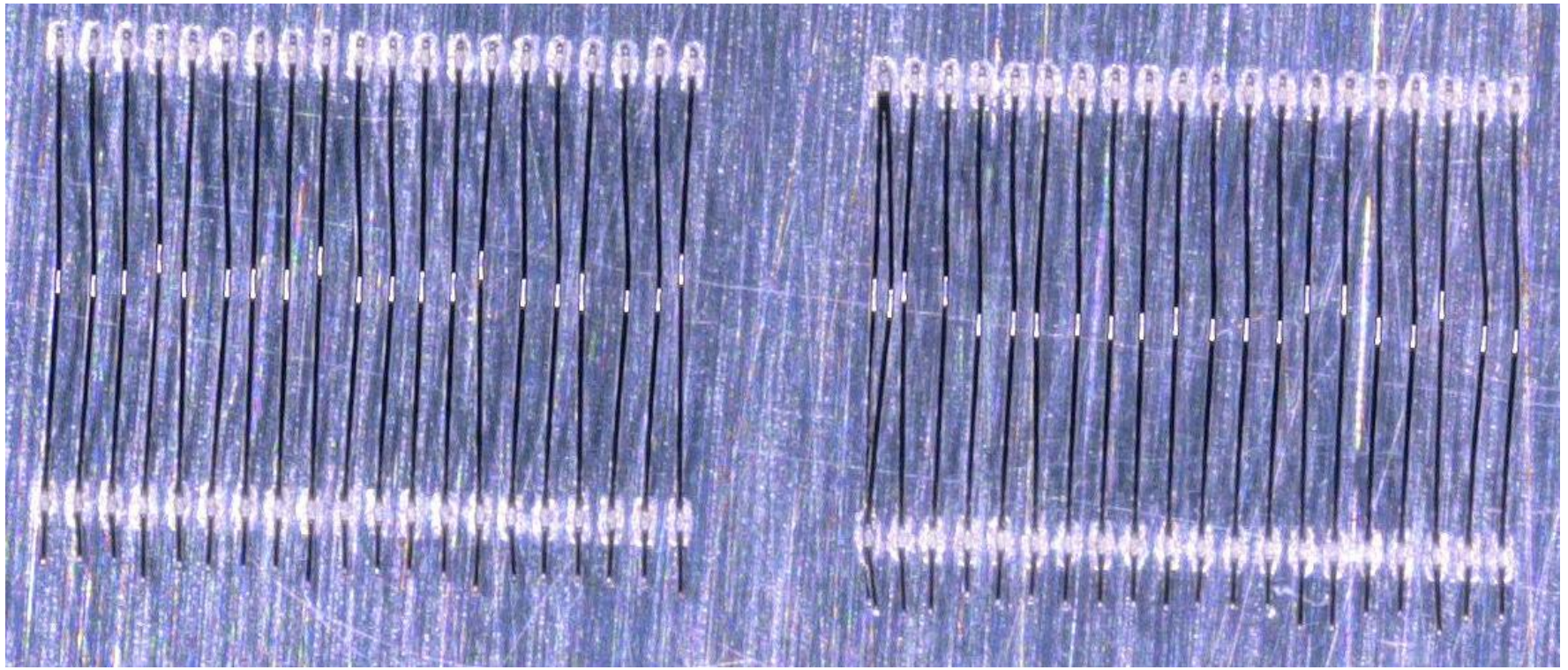
Initial test

	Single Layer					
			US%			
Std Dev		22	25	22	25	
	22	1.73				
	22		0.68			
	25			2.92		
CN	25				1.26	

	Multi Layer					
			US%			
Std Dev		22	25	22	25	
	22	1.51				
	22		2.04			
	25			2.26		
CN	25					

Longer tails

- Tail length was increased in later tests
- Result: fewer failed wires, stronger and more consistent pull results
- All tests after this point used longer tails



Pull test matrix

Single Layer

Mean		US % Ultrasonic								
		22	25	25	28	28	30	30	32	32
(CN) Bondforce	22	11.18								
	22		11.46							
	25			11.26						
	25				11.21					
	28					11.33				
	28						11.04			
	30							10.49		
	30								10.99	
	32									10.66

Multi Layer

Mean		US % Ultrasonic								
		22	25	25	28	28	30	30	32	32
(CN) Bondforce	22	10.73								
	22		10.45							
	25			11.04						
	25				11.03					
	28					11.04				
	28						11.06			
	30							11.03		
	30								10.8	
	32									9.45

Single Layer

Std Dev		US % Ultrasonic								
		22	25	25	28	28	30	30	32	32
(CN) Bondforce	22	0.69								
	22		0.18							
	25			0.59						
	25				0.62					
	28					0.36				
	28						0.8			
	30							0.82		
	30								0.65	
	32									0.77

Multi Layer

Std Dev		US % Ultrasonic								
		22	25	25	28	28	30	30	32	32
(CN) Bondforce	22	1.77								
	22		1.32							
	25			0.67						
	25				0.25					
	28					0.88				
	28						0.69			
	30							0.49		
	30								0.82	
	32									1.2

- Best results (mean and standard deviation) achieved with settings between 25–30
- Foil bondability improved significantly under these conditions

30% and 50% deformations

Single Layer					
		US%			
Mean		25	28	28	30
	25	10.98			
	25		11.39		
	28			10.71	
CN	28				11.21

Multi Layer					
		US%			
Mean		25	28	28	30
	25	10.44			
	25		11.12		
	28			10.33	
CN	28				11.03

30% deformation

Single Layer					
		US%			
Std Dev		25	28	28	30
	25	0.94			
	25		0.26		
	28			0.79	
CN	28				0.87

Multi Layer					
		US%			
Std Dev		25	28	28	30
	25	1.34			
	25		0.79		
	28			0.91	
CN	28				0.57

Single Layer					
		US%			
Mean		25	28	28	30
	25	11.14			
	25		11.24		
	28			10.77	
CN	28				10.58

Multi Layer					
		US%			
Mean		25	28	28	30
	25	11.39			
	25		11.42		
	28			11.07	
CN	28				11.05

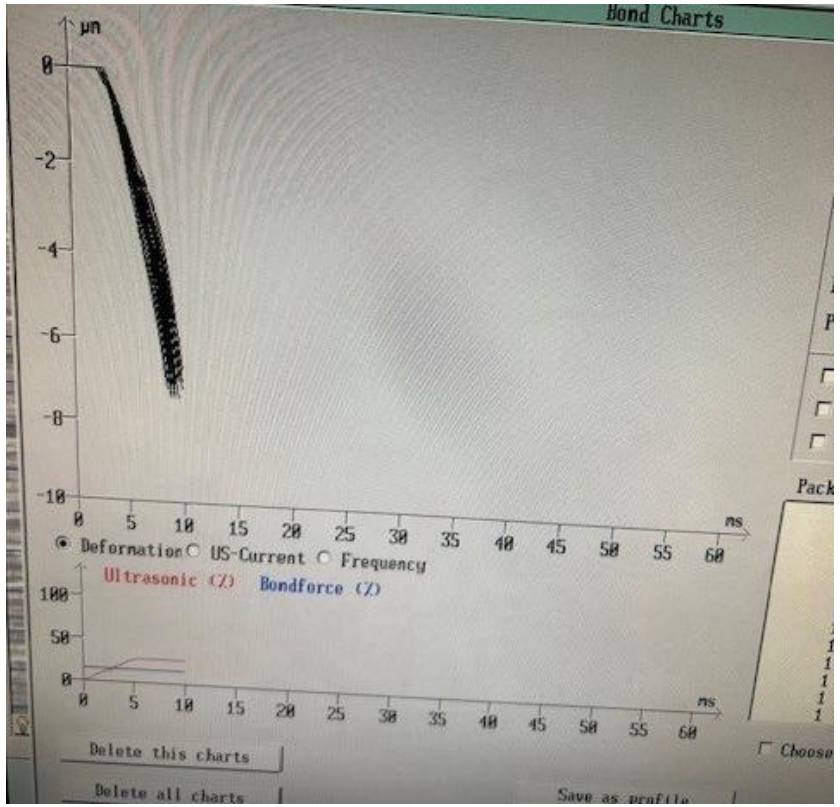
50% deformation

Single Layer					
		US%			
Std Dev		25	28	28	30
	25	0.76			
	25		0.86		
	28			1.01	
CN	28				1.04

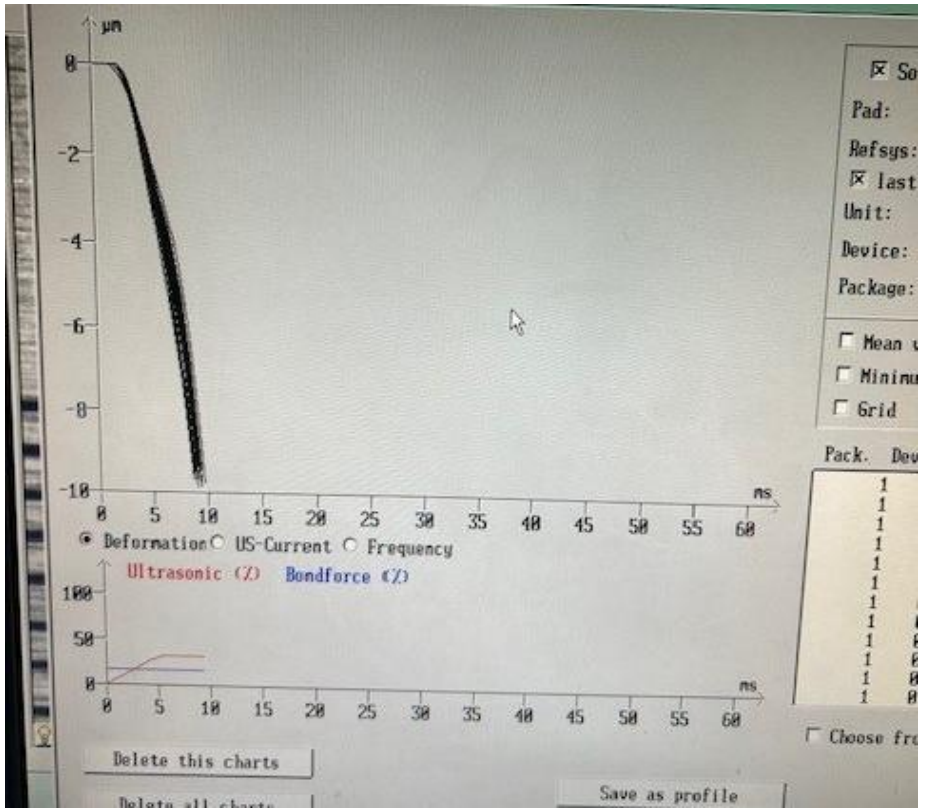
Multi Layer					
		US%			
Std Dev		25	28	28	30
	25	0.4			
	25		0.28		
	28			0.66	
CN	28				0.63

- Bond foot width estimation
  - 30% → ~32.5 µm
  - 40% → ~35 µm
  - 50% → ~37.5 µm
- 30% deformation
  - Appears comparable to best-case pull matrix results
- 50% deformation
  - Mean pull force similar to 30%, but improved standard deviation for multilayer foil

Deformations



30% deformation



50% deformation

- Deformation charts for 30% and 50% cases (US 30%, BF 30 cN)
- All wires reached maximum deformation within 10 ms → good bondability

15 µm overtravel

		US%						
Mean		25	25	28	28	30	30	32
	22	11.21						
	25		10.89					
	25			11.34				
	28				10.79			
	28					11.06		
	30						11.3	
CN	30							11.25

Single Layer

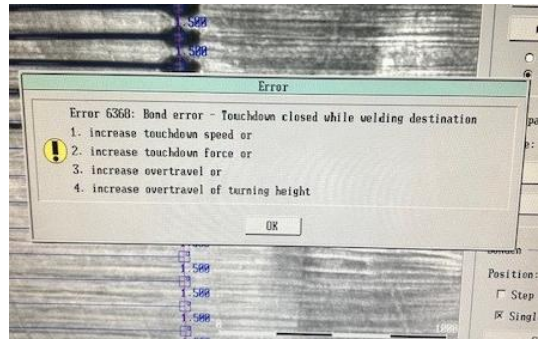
		US%						
Std Dev		25	25	28	28	30	30	32
	22	0.47						
	25		0.88					
	25			0.39				
	28				0.94			
	28					0.82		
	30						0.65	
CN	30							0.38

		US%						
Mean		25	25	28	28	30	30	32
	22	11.48						
	25		10.96					
	25			11.34				
	28				11.09			
	28					11.09		
	30						10.82	
CN	30							11.06

Multi Layer

		US%						
Std Dev		25	25	28	28	30	30	32
	22	0.44						
	25		1.09					
	25			0.65				
	28				0.43			
	28					0.64		
	30						0.76	
CN	30							0.66

- Inspired by positive results from James @ Birmingham: reduced overtravel to 15 µm
- Good bonding results achieved: strong mean force, low std deviation
- But: touchdown errors appeared at US or BF >30%



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

Summary

- Parameter optimisation led to stronger bonds and fewer failures
- Bonding on gold PCB and longer tails significantly improved foil stability
- Single-layer foils outperformed multilayer ones — likely due to their stiffer mechanical response, allowing more consistent bonding
- Detailed test results can be found here: https://cernbox.cern.ch/s/jCSqHk7Fm7xzpqr

- Next step
  - Repeat tests with vacuum + diffuser setup (Birmingham method)
  - Comparative tests with other type of wires

- Two gold PCBs can be sent to Birmingham for comparative testing if needed

Backup

Standard bonding parameters