HESSE MECHATRONICS

Wire Bonding onto Niobium for Superconducting Applications

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Agenda – Wire Bonding onto Niobium

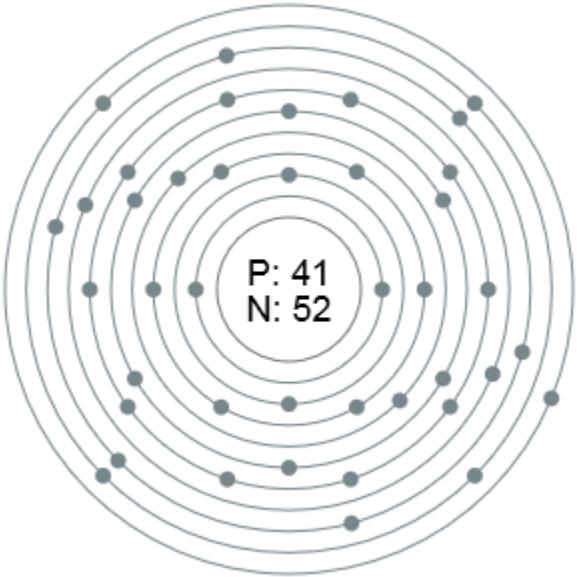
- Reason for this work
- Setup and test conditions
- Bondability and test results
- Conclusions
- Future work

Reason for this work

- Idea started at MTTS in Tampa FL in 2014.
- This initial work is the first of two-three experiments.
- Intial work was with 20 mil Al.
- Reason to use large diameter wire was to reduce induction to help produce nice, clean signals in the 10GHz range.
- Applications include: superconducting of flex cables, data centers, quantum computing, autonomous vehicles, etc.
- Future work will be for 1 mil Al. Project will start soon.

Why Niobium?

- Nb is great for superconducting applications.
- Nb is a refractory material - one that retains its strength at high temperatures.



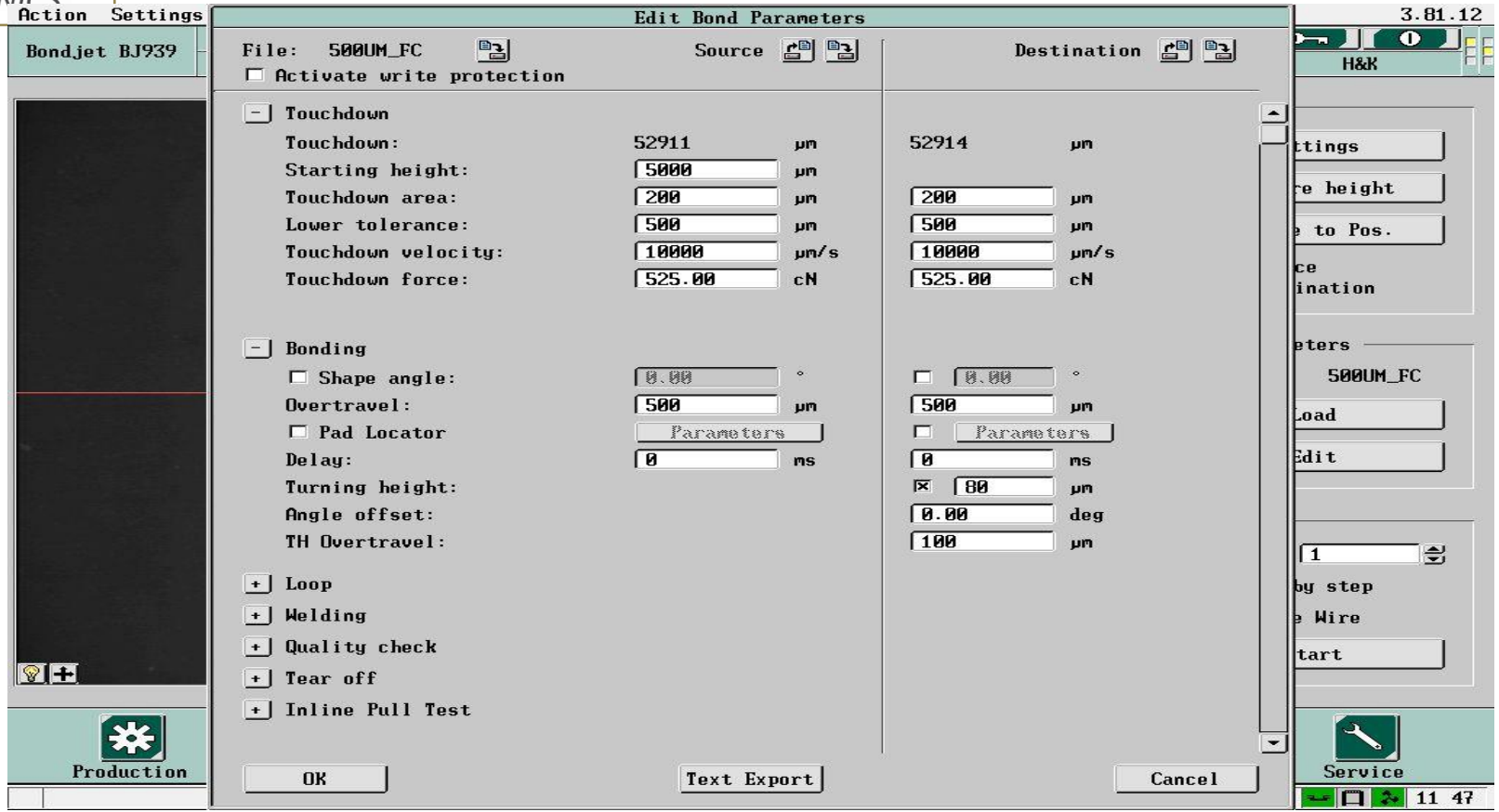
Setup and Test Conditions

Bonder	BJ939-0123			
Bondhead	HBK07-0087			
Bonding temperature	Ambient			
Workholder type	Vacuum clamping			
Software	3.81.13			
Wire	Heraeus 20 mil ALW-59P BL=500-800 EL=12-18%			
Wedge	DeWeyl MISIVG-20-1/8-2.733-70MP			

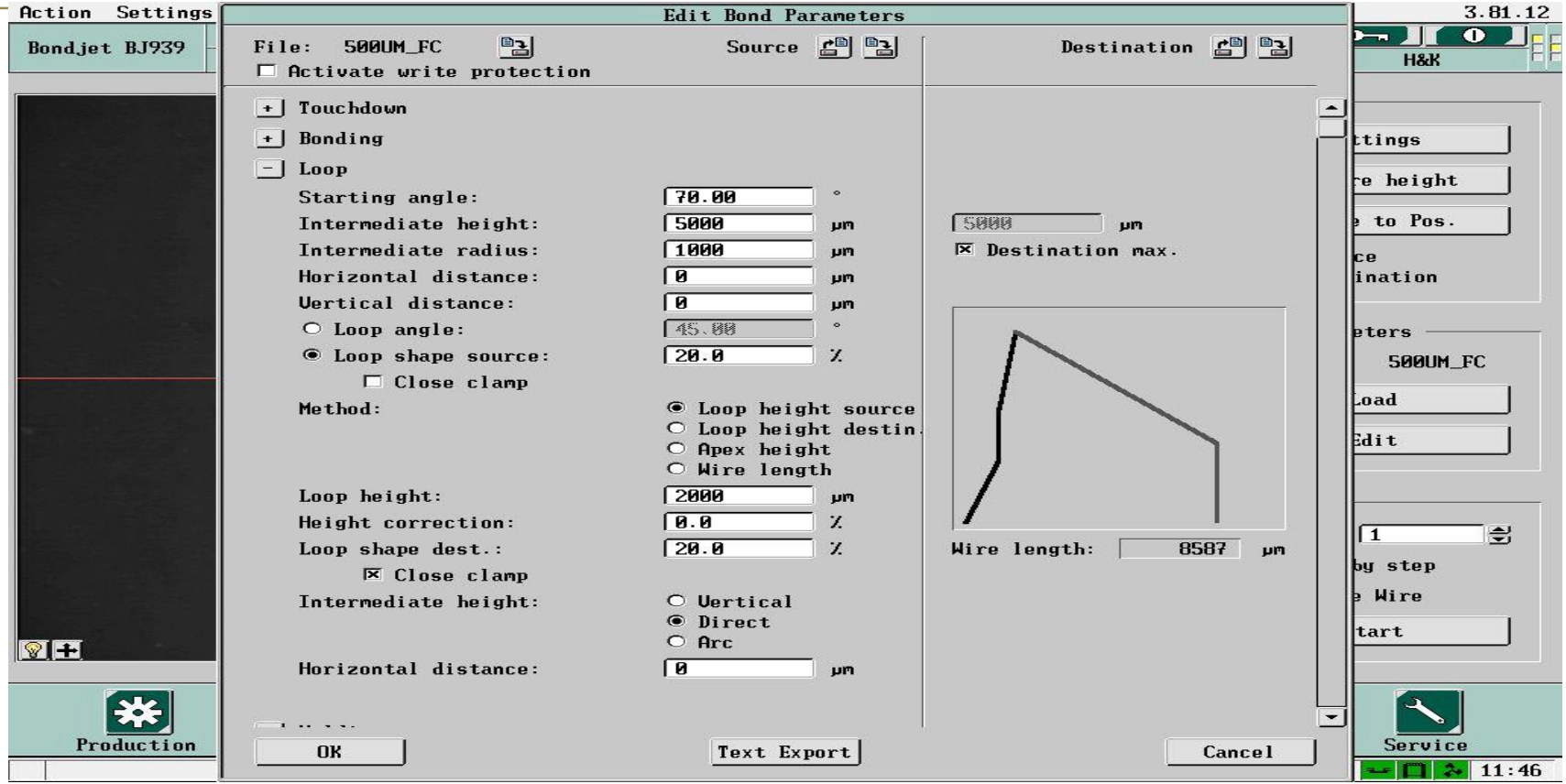
Nb Samples

- Sputter the Nb in a high vacuum.
- Expect that the sputtered films have a columnar growth mode (still needs more characterization).
- Nb seems to be porous – reacts with oxygen.
- Nb
- AlNb
- AuNb
- All samples were prepared on wafers.
- Thickness layers for Al and the Au were in the 50nm range.
- Nb thickness was in the 250nm range.

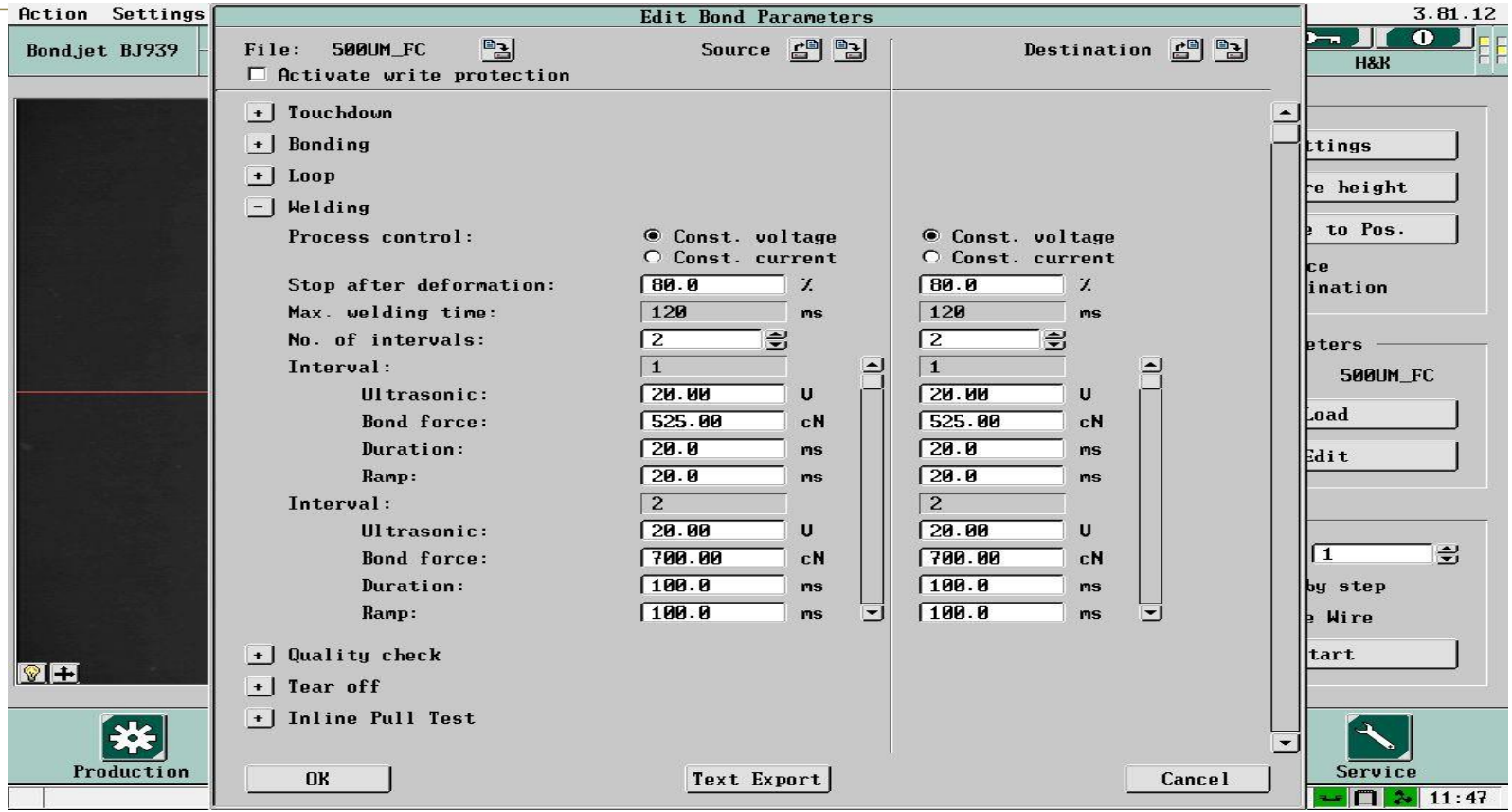
Test Conditions - Touchdown Parameters



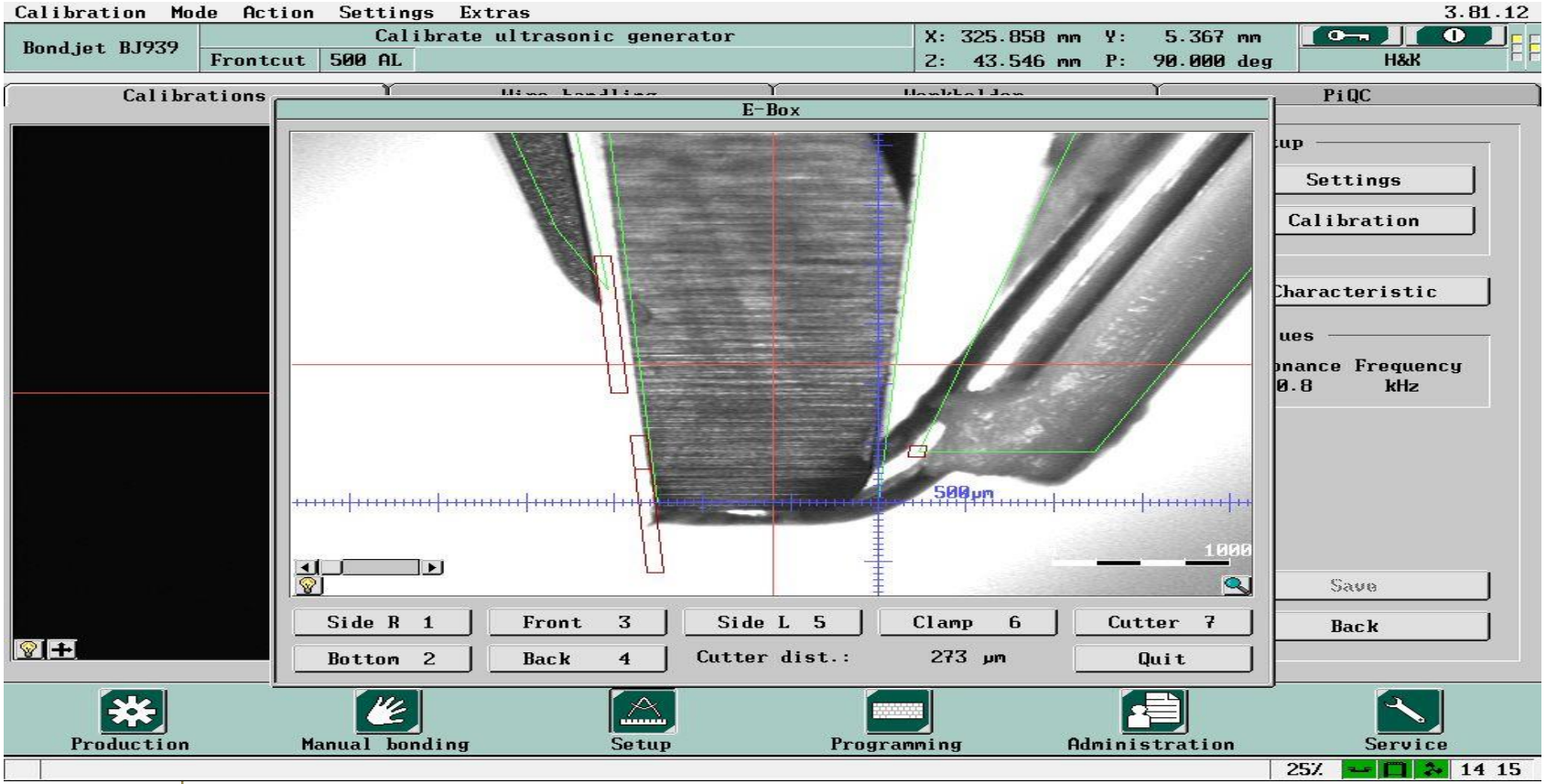
Test Setup – Looping



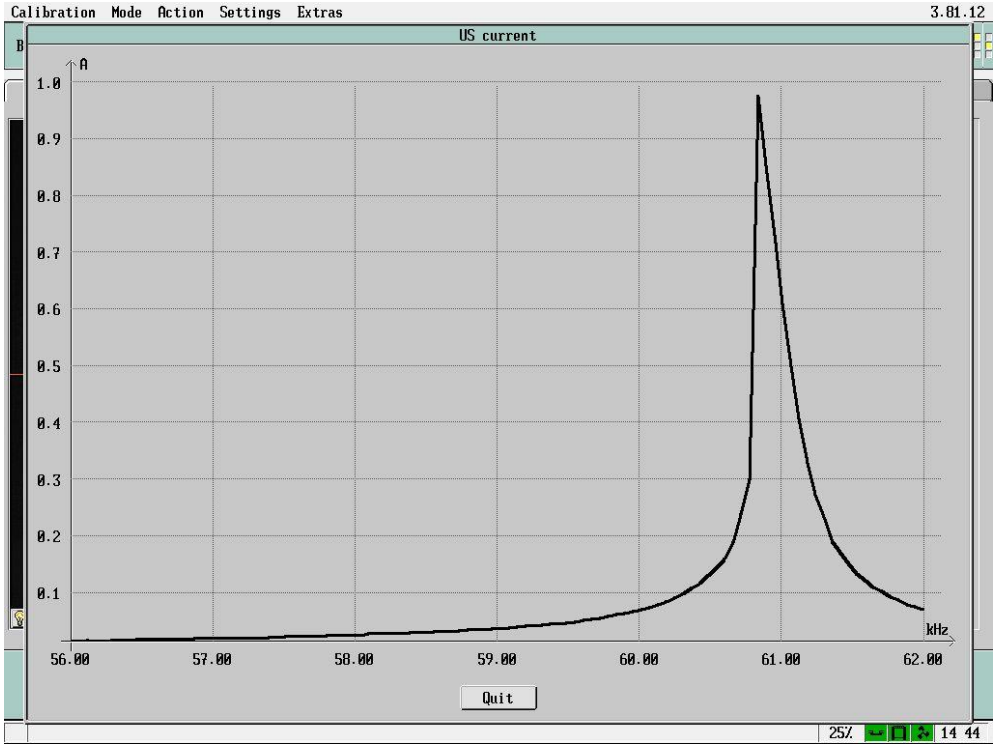
Test Setup – Bonding Parameters



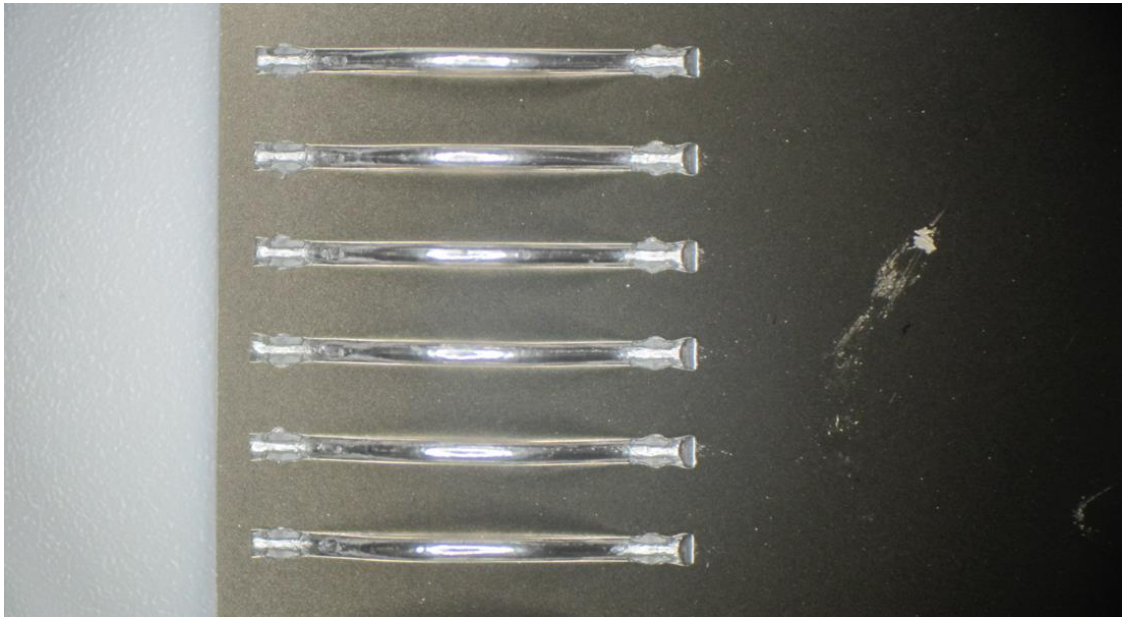
Test Setup – Bond Head Alignment



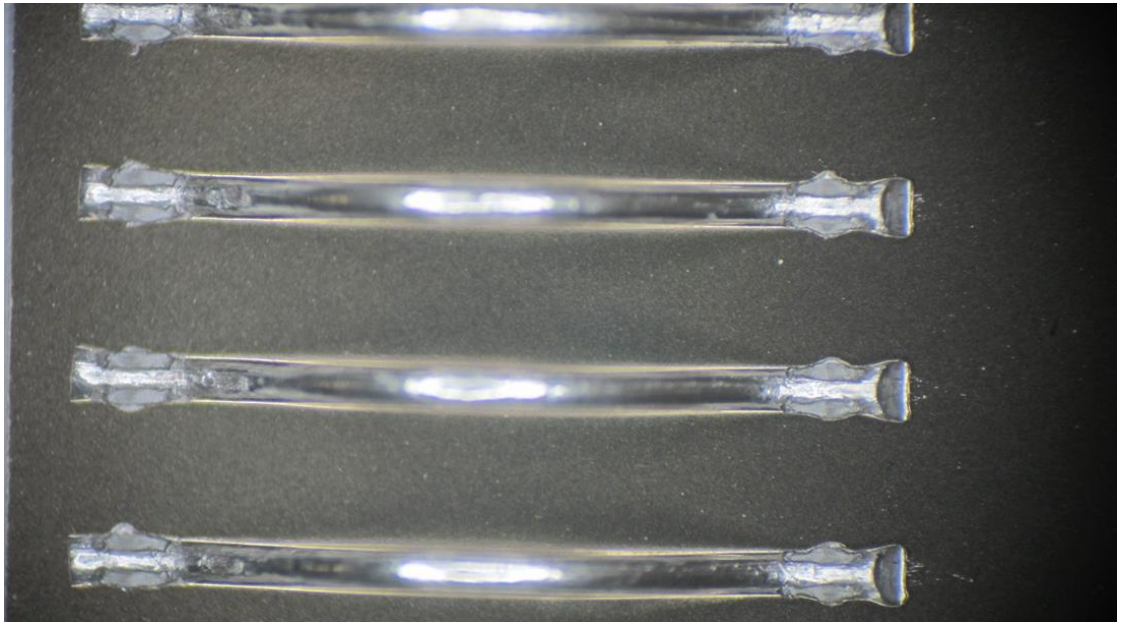
Ultrasonic Tuning



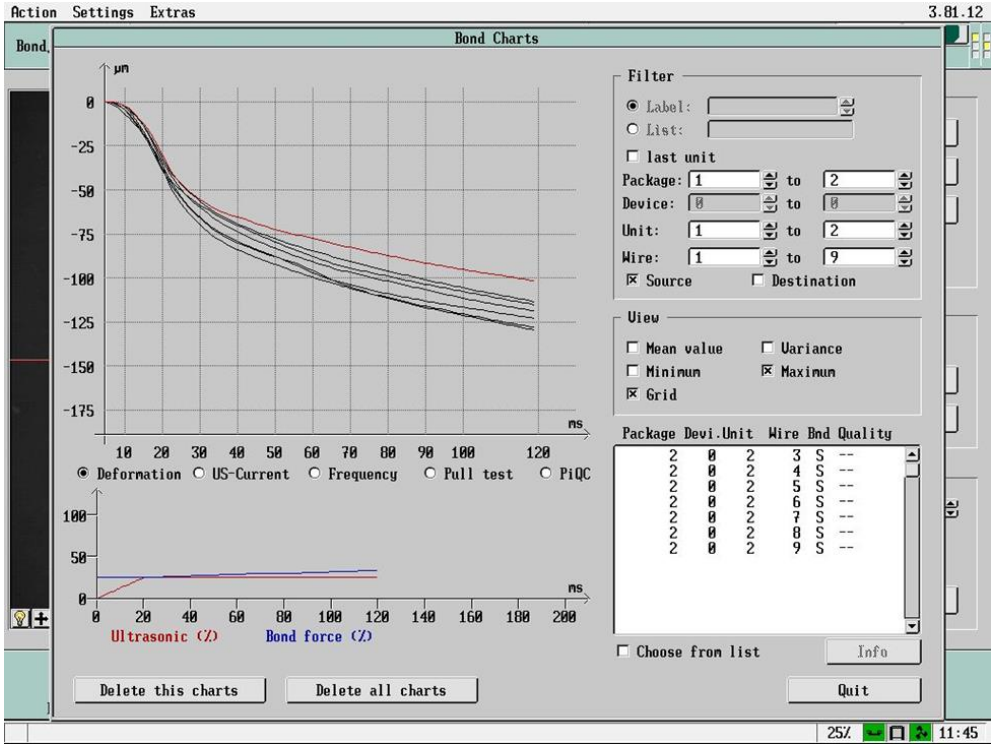
Top View of 20 mil Al wires on AlNb



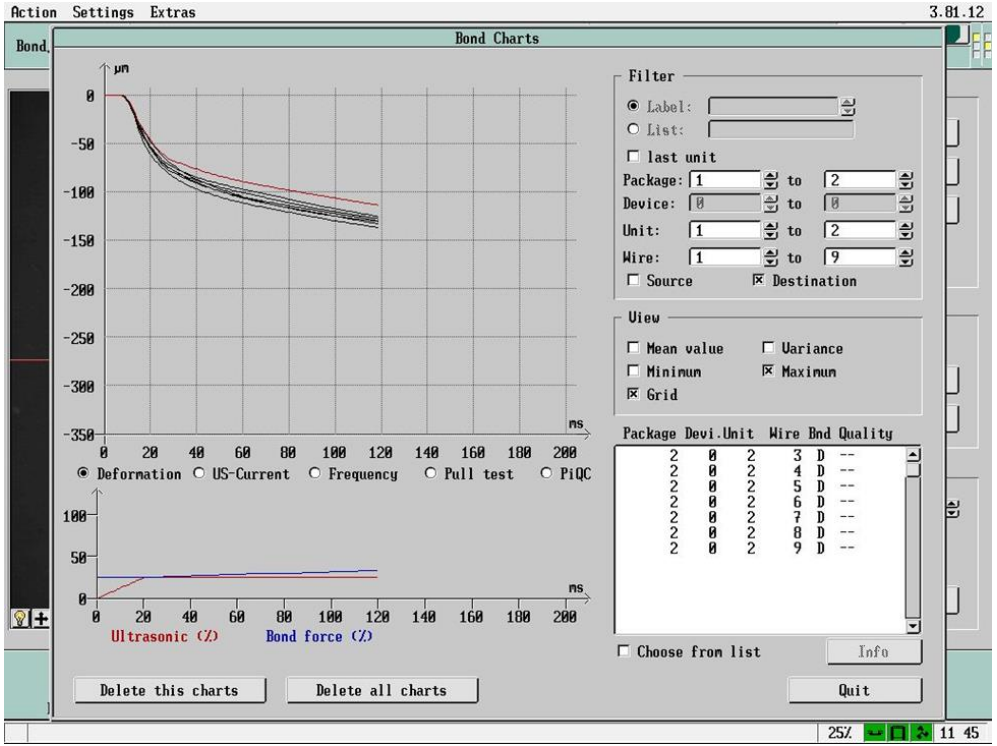
Top View Photo of Al wires on Au-Nb



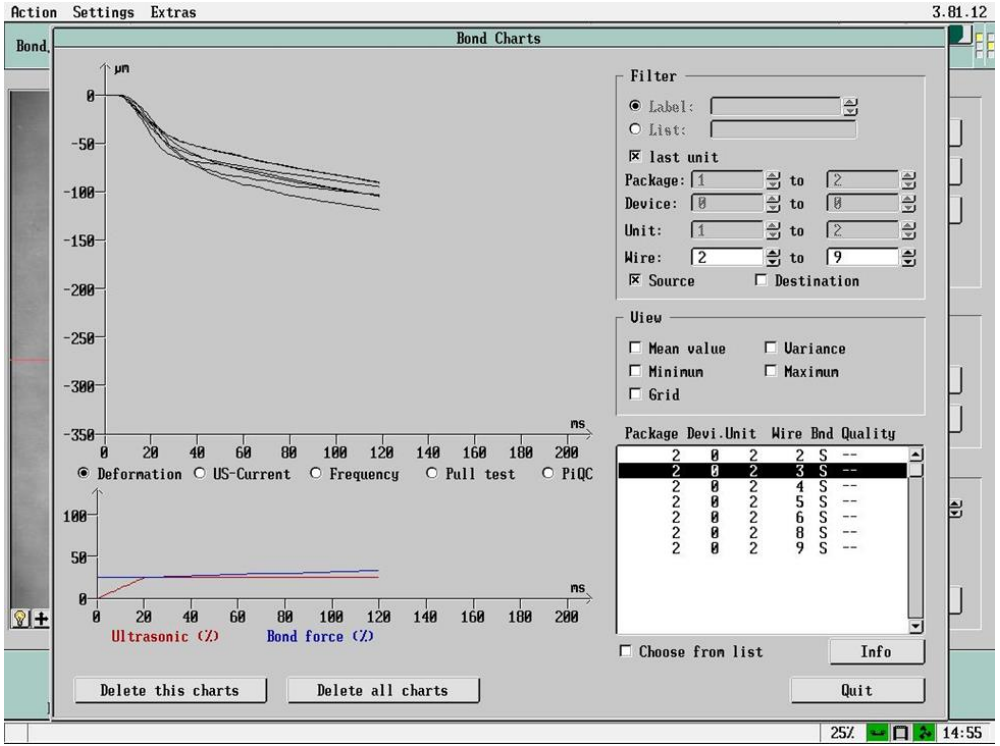
Bond Deformation Trace on Au-Nb on 1st bond



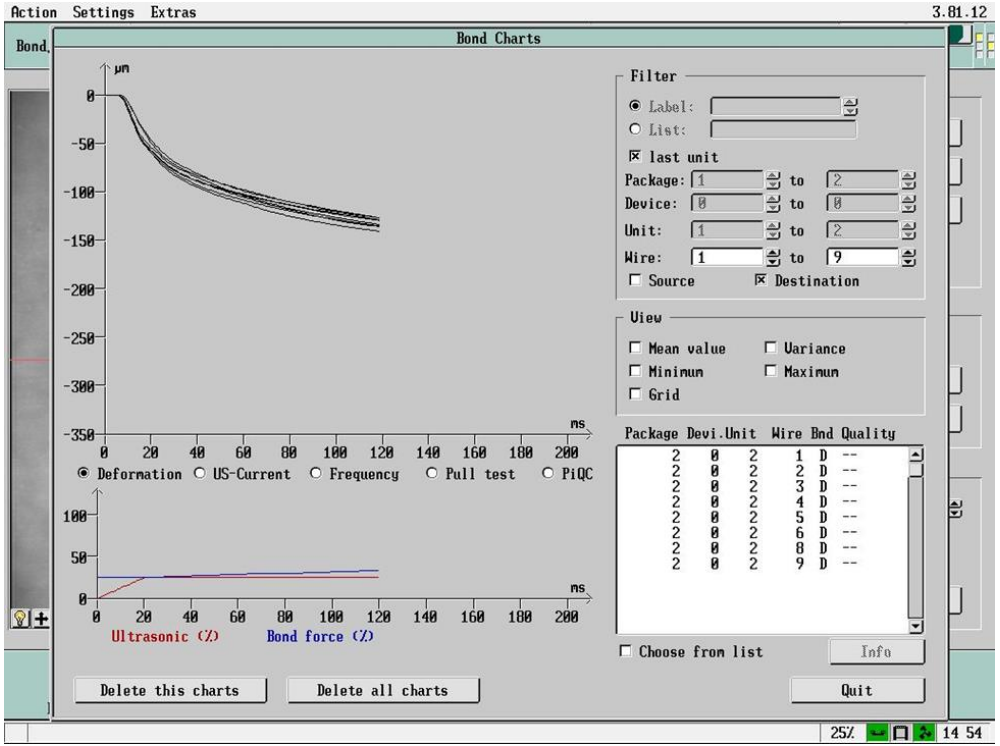
Bond Deformation Trace for Au-Nb on 2nd bond



Bond Deformation on AlNb – 1st bond

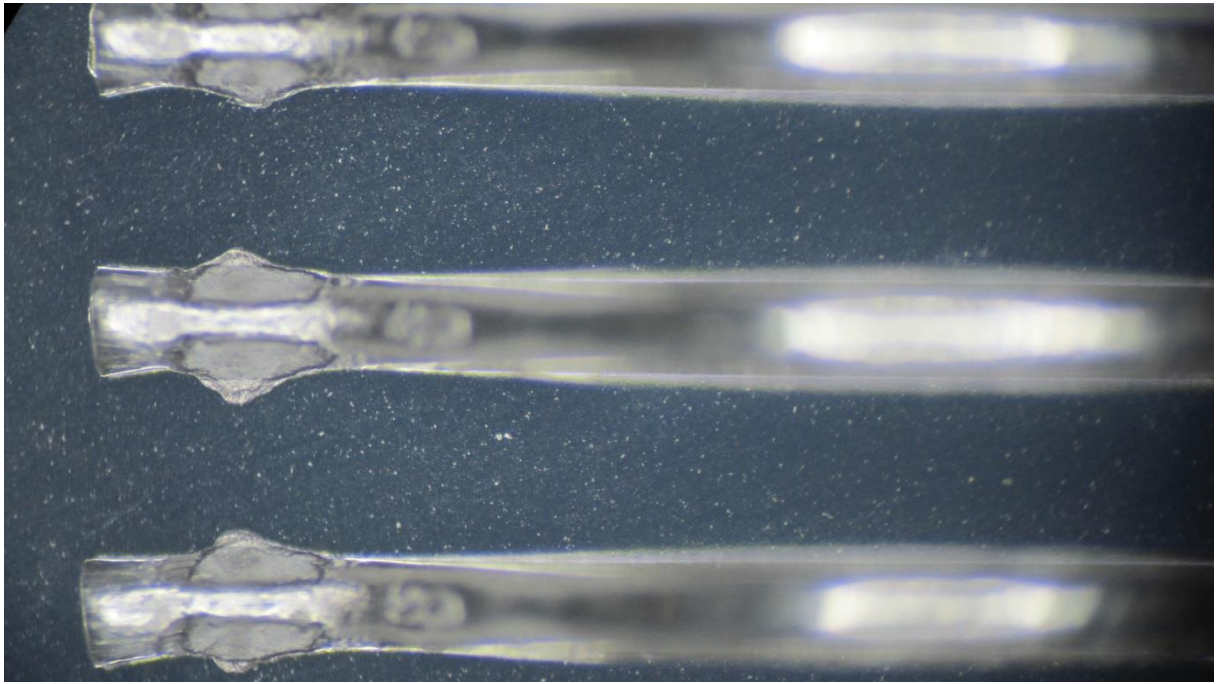


Bond Deformation Trace on AlNb – 2nd bond

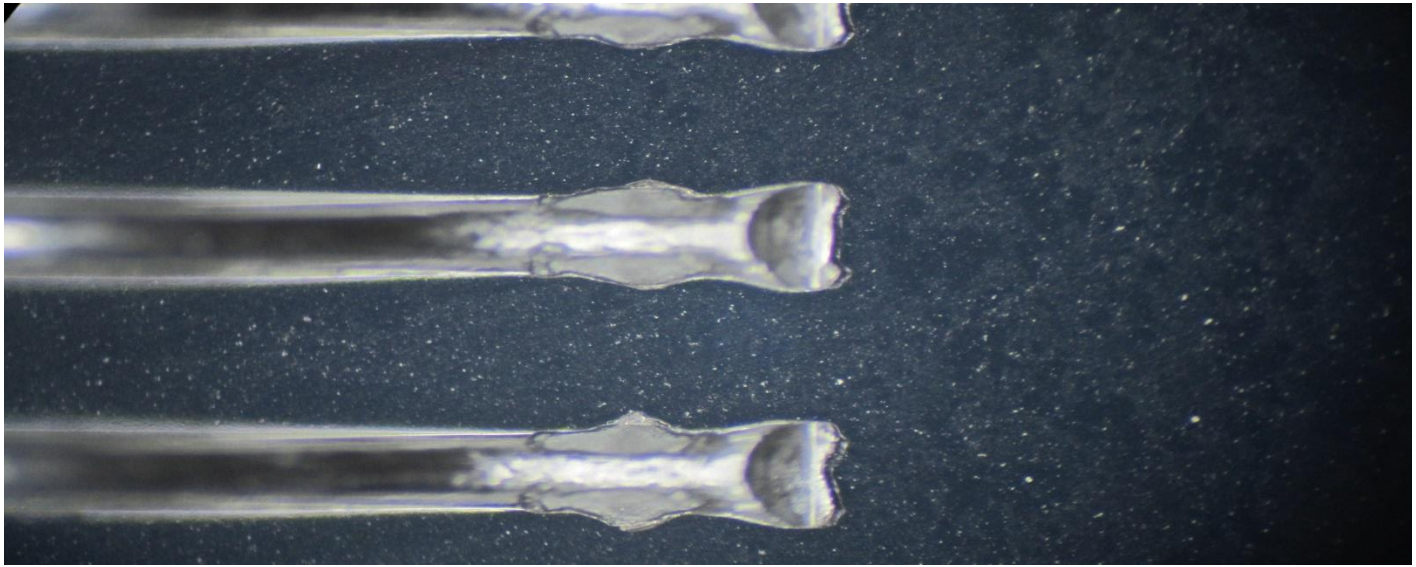


Al wire on AlNb

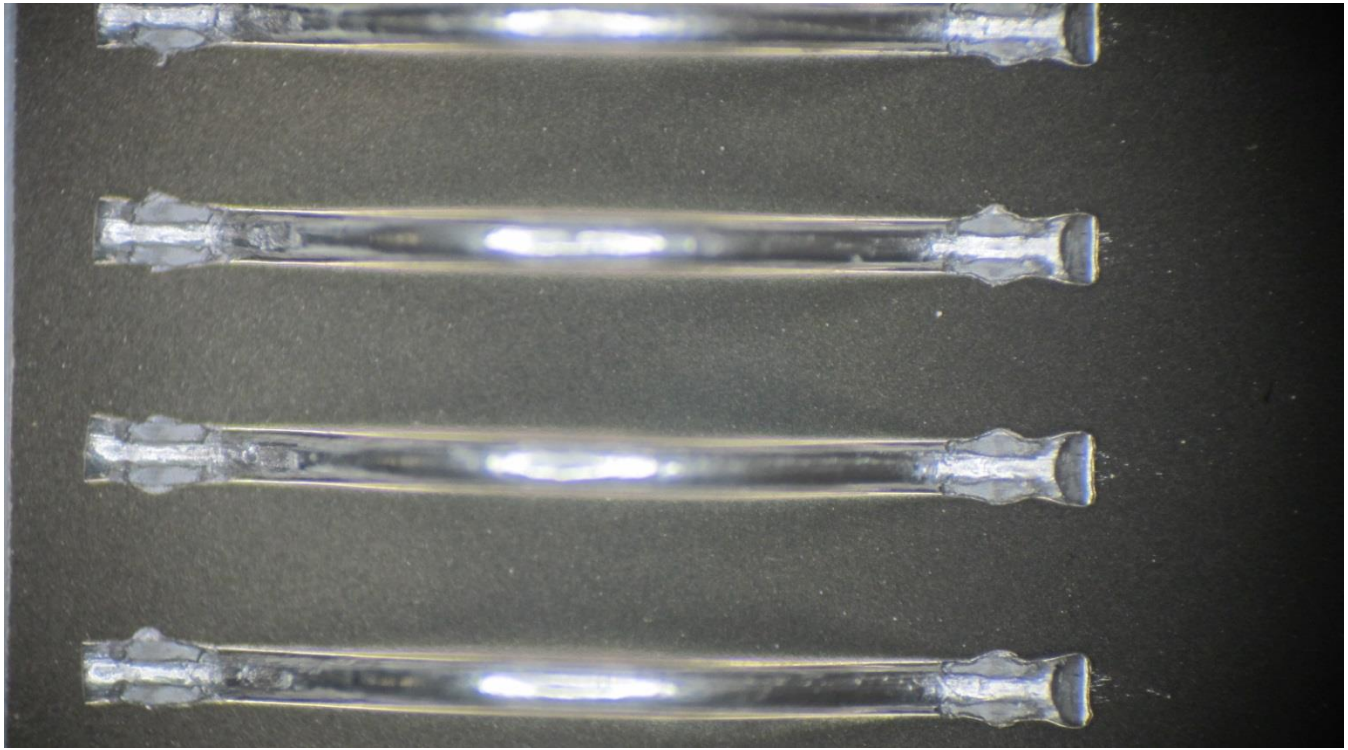
Close up of 1st bonds on AlNb



Close-up 2nd bonds of Al wire on AlNb



Close up of Al wires on AuNb



Bonding onto Nb

- Many instances of non-sticks.
- Need to investigate as to why the high number of non-sticks.
- No instances of contamination.
- Frequency?
- Grain structure?
- Do cross-sectional analysis of parts.

Problem – Non-stick of Al wire on Nb

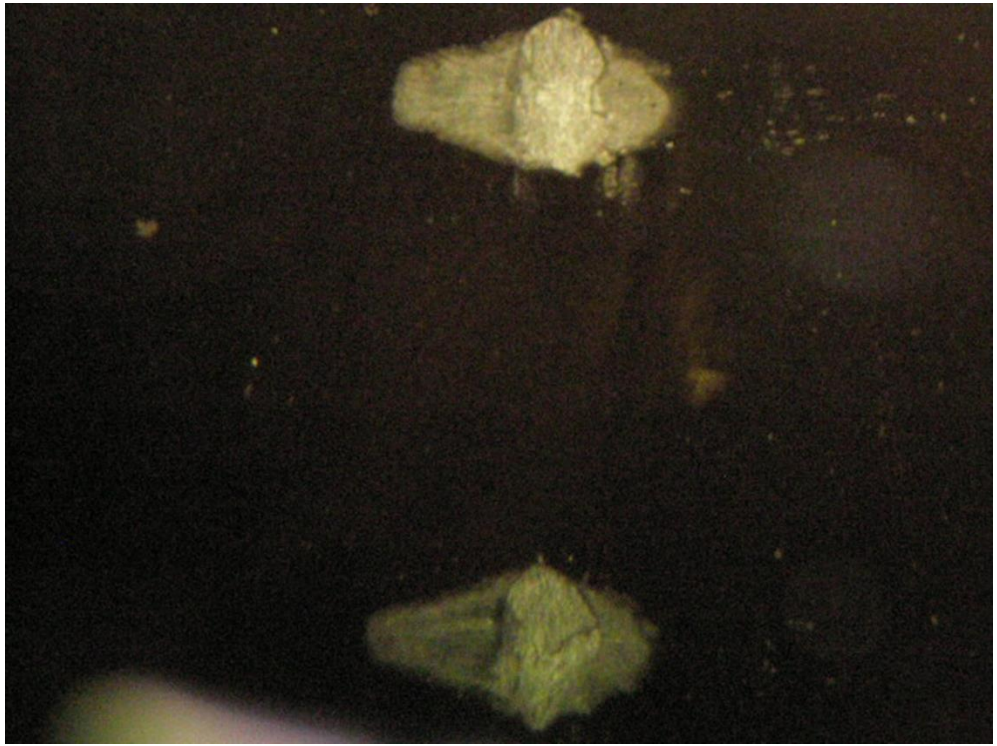
Wire Pull Test Data - AlNb

- 20 mil Al wire
- Breaking load of wire was 500 to 800 grams tensile.
- Minimum pull strength is half the tensile - 250 grams.
- Mean: 1.2183 kg
- Standard Deviation: 70.284 g

Shear Test Results for AuNb

- Average Shear was 1,566 grams with standard deviation of 161.
- Minimum expected shear is 500 grams.
- Decent nuggets post-shear.

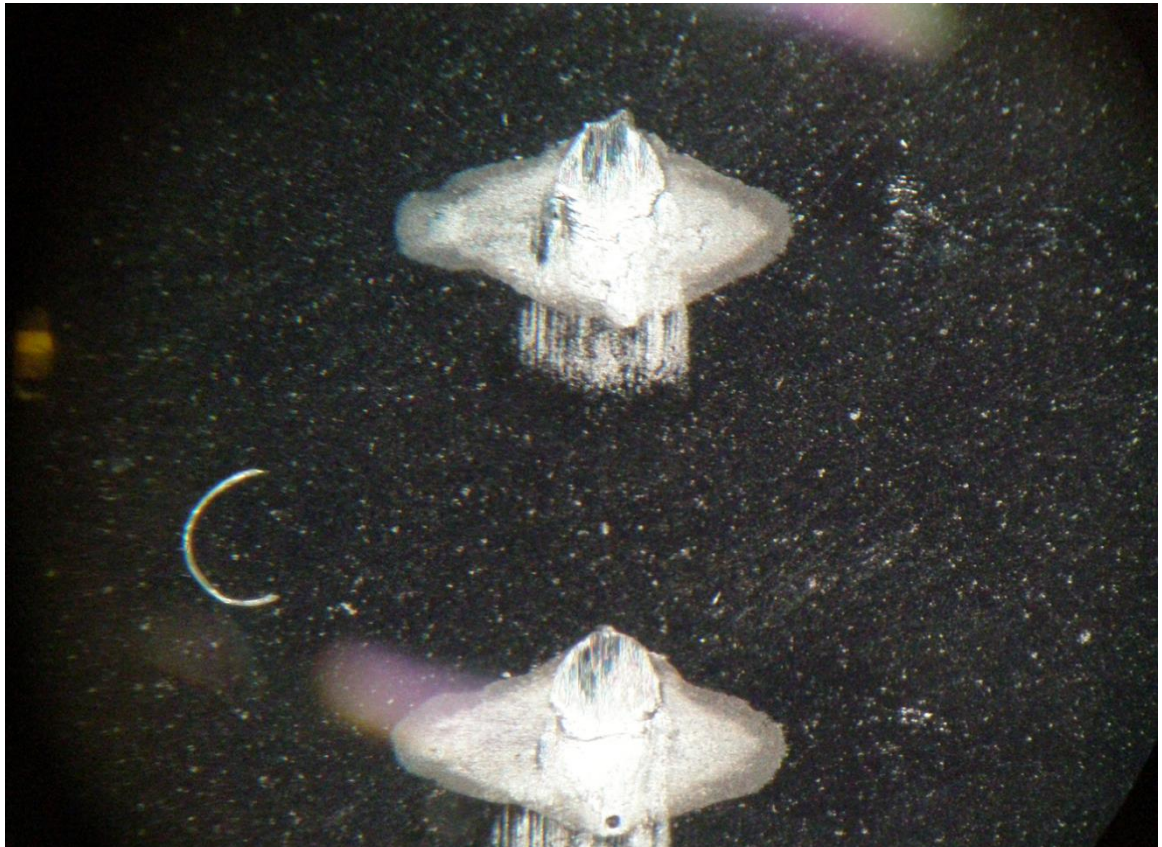
Shear Results - AuNb



Shear Results for AlNb

- Average shear was 1,746 grams with a standard deviation of 88.
- Minimum shear value is 500 grams.
- Acceptable nugget post-shear.

Shear Results – AlNb Nuggets



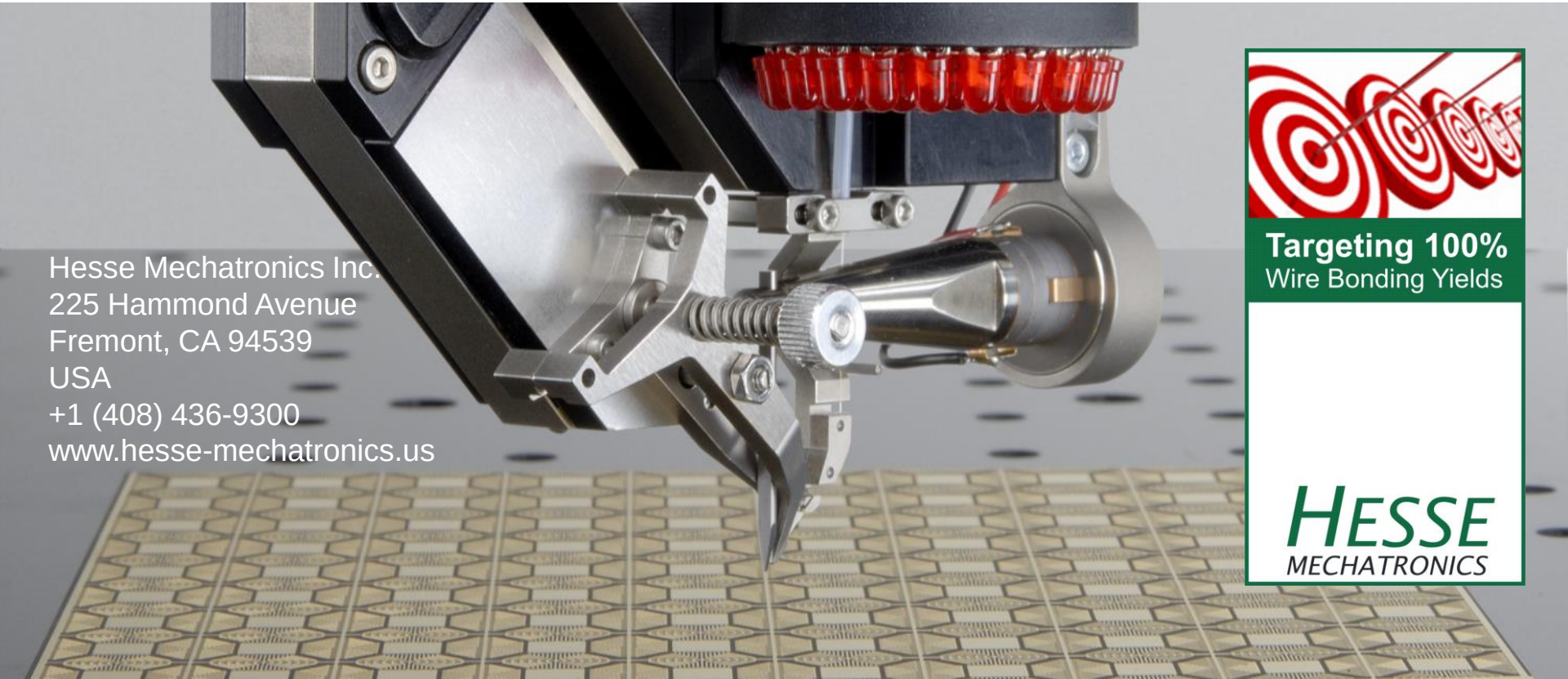
Conclusions

- Bonding onto AlNb had the best bondability and test results.
- Bonding onto AuNb was 2nd best.
- Bonding onto Nb was not good. Investigating reasons why and will setup a DOE to determine bond parameters.

Future Work

- Auburn University, Hesse Mechatronics & Fermilab have just started a new experiment with wire bonding fine Al wire onto: Nb; AlNb; AuNb.
- NIST in Colorado has been working with Hesse on wire bonding to Nb for quantum computing.
- Applications include microwave amplifiers for the South Pole and Particle Physics (“God-particle”).
- Additional testing of heavy Al wire and ribbon will be used in actual parts.

Thank you for your kind attention!



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