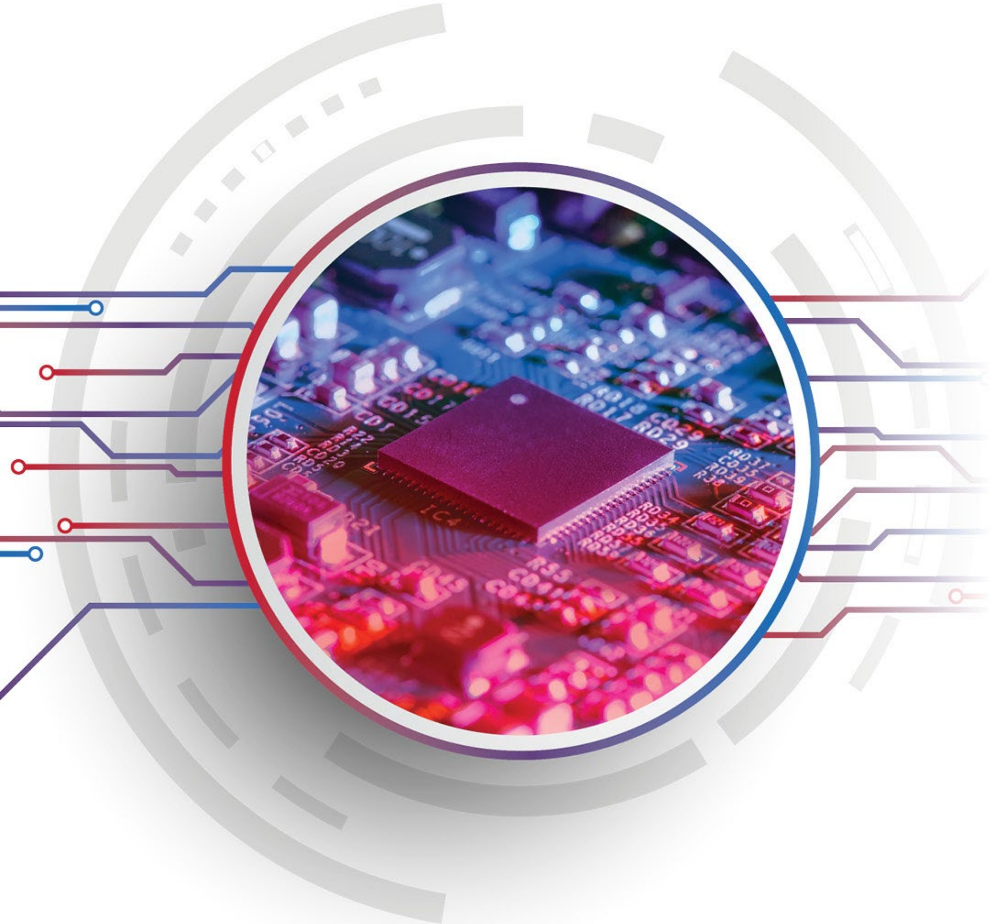

Innovative MID Plating Solutions

High Reliability Wire Bond Technique for MIDs

Jordan Kologe
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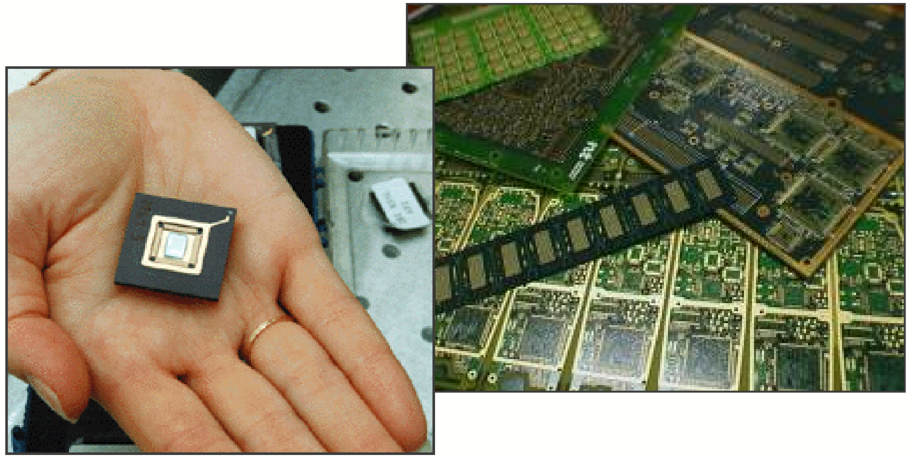
MacDermid Alpha Electronics Solutions

MacDermid Enthone

- Over 2000 Worldwide Employees in 23 Countries
- Over 3500 Customers Served Worldwide by Direct Sales/Service Organizations

Industrial Solutions

Electronics Solutions

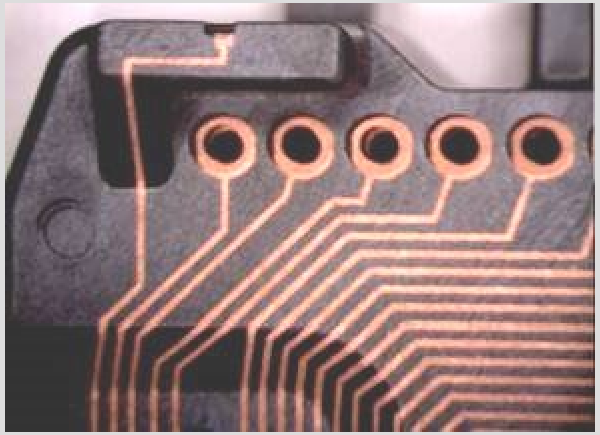


MID Metallization

- A “Merger” of Surface Finishing Innovations

Plating on Plastics Used for Decorative and Functional coatings

Electroless Copper for Electronics



A combined expertise in POP and electronics plating applications remain crucial in the development and optimization of MID plating processes.

MID Technology

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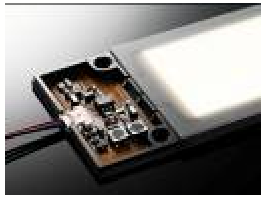
- Molded Interconnect Device (MID)
  - Defined as an injection molded thermoplastic substrate which incorporates a conductive circuit pattern
    - integrating mechanical and electrical functions
- Today's Market
  - Growth in MID is a result of advances in plastic materials and the development of Laser Direct Structuring (LDS)
    - Majority of production volume still remains in antennas for mobile communication devices including mobile phones, laptops, tablets, etc.
- Growth opportunities in additional markets
    - Automotive, medical, and lighting
    - Opens up capabilities in design and function
    - New options for miniaturization for form and fit

Smart phones

Laptops

Medical

Lighting



Automotive

MID Industry Drivers and Trends

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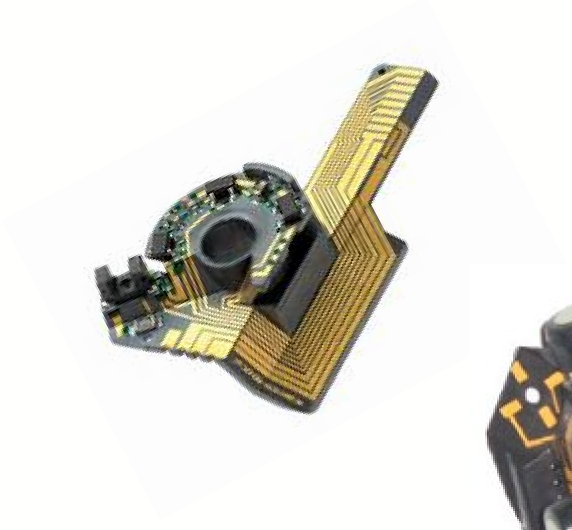
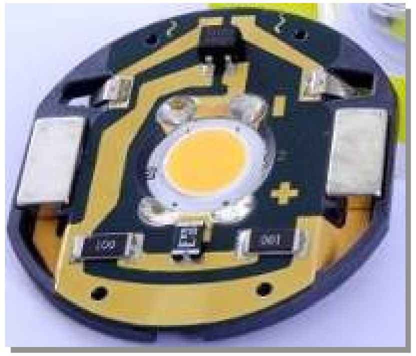
- Fine Pitch Technology
  - Opens design capabilities
  - Miniaturization
- SMT Capability
  - Reflow resistant plastics
  - Solderable surface finishes
- Wire bond capability
  - Proper choice of plastics, plating thickness, surface roughness and final finish
- Lighter design
  - Integrating circuitry with existing part to reduce number of components
- Power and Style
  - Integrating circuitry to provide opportunities for future designs





Wire Bonding to MID

Issues, Considerations, Current Capabilites

MacDermid Alpha
ELECTRONICS SOLUTIONS

Wire Bonding

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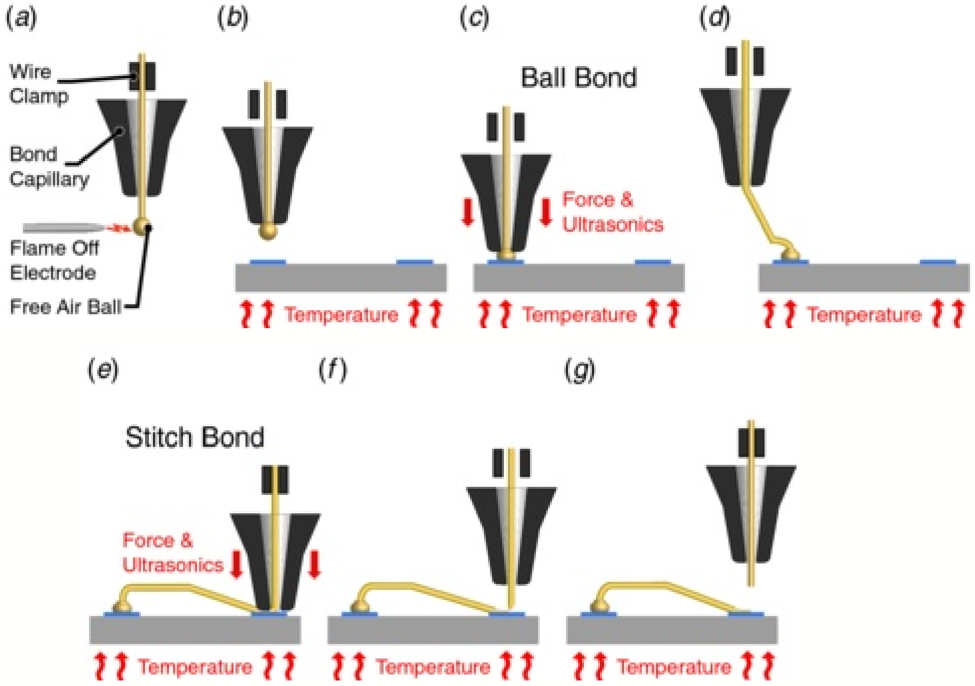

- Wire bonding is currently the most widely used IC to leadframe interconnection process.
- Microscopic gold wire (18-30 micron) is thermosonically welded from connections on IC to connections on frame for interaction with PCB.

Problems with MID wire bonding

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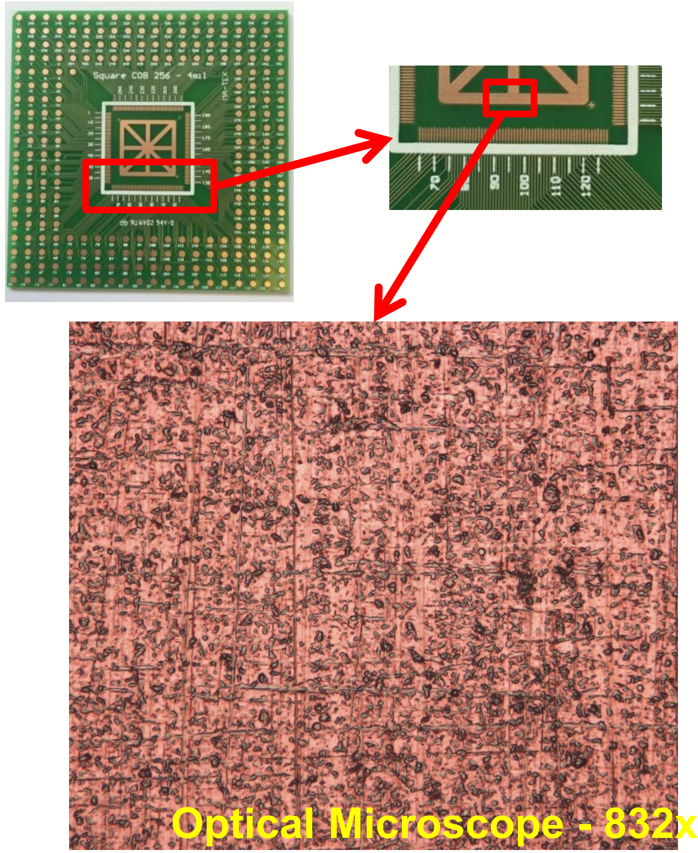

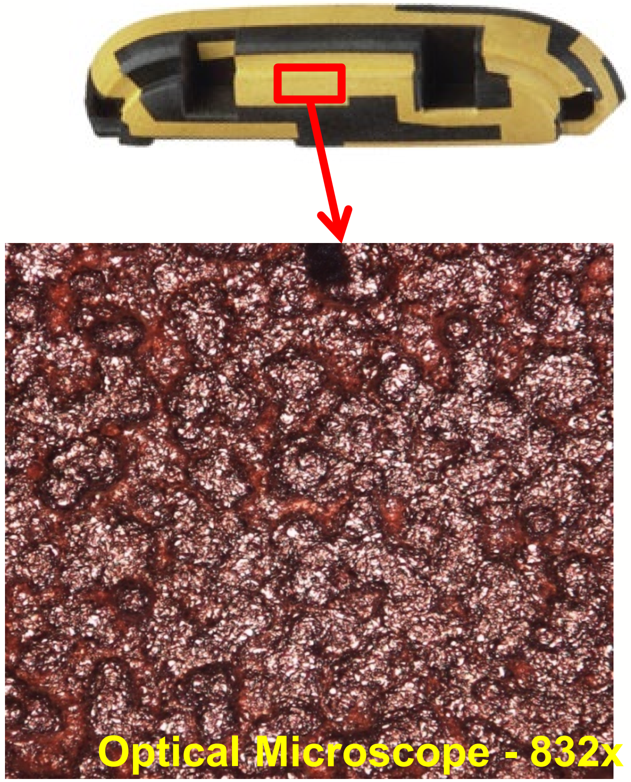

- IC substrates based off of conventional materials are very smooth after plating.
- The final roughness of MIDs finished for wire bonding is too rough for consistent wire bonding.

Types of Wire Bonding - Overview

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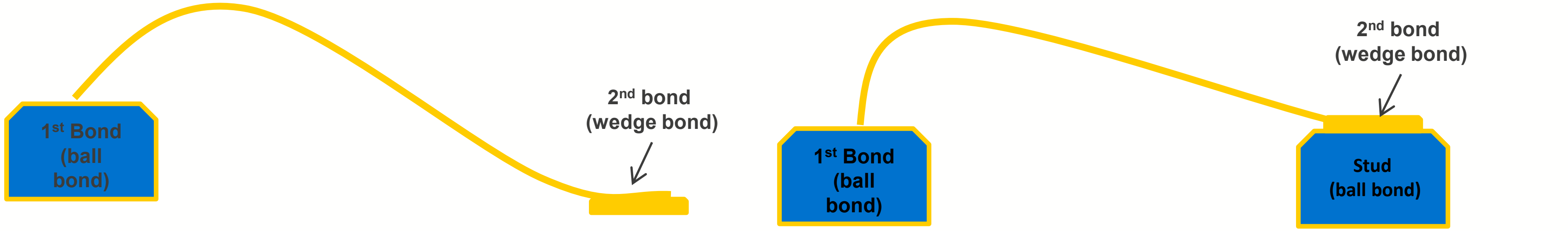
- Conventional Gold Ball-Stitch Bonding
  - Involves placing the first bond onto the IC (the ball bond) and the second bond onto the lead frame (the wedge bond).
- SSB (Stand-off Stitch Bonding)
  - A type of wire bonding method recently developed and put into practice at many wire bonding applications which involve unconventional surface types (composition / type / etc). With SSB bonding, a gold stud is first placed on the area where the wedge bond will finally be placed. The ball bond is placed on the IC pad. Finally, the wedge bond is placed on top of the gold stud. This gives the wedge bond the high strength of a ball bond, with the flexibility imparted by gold wire bonding.

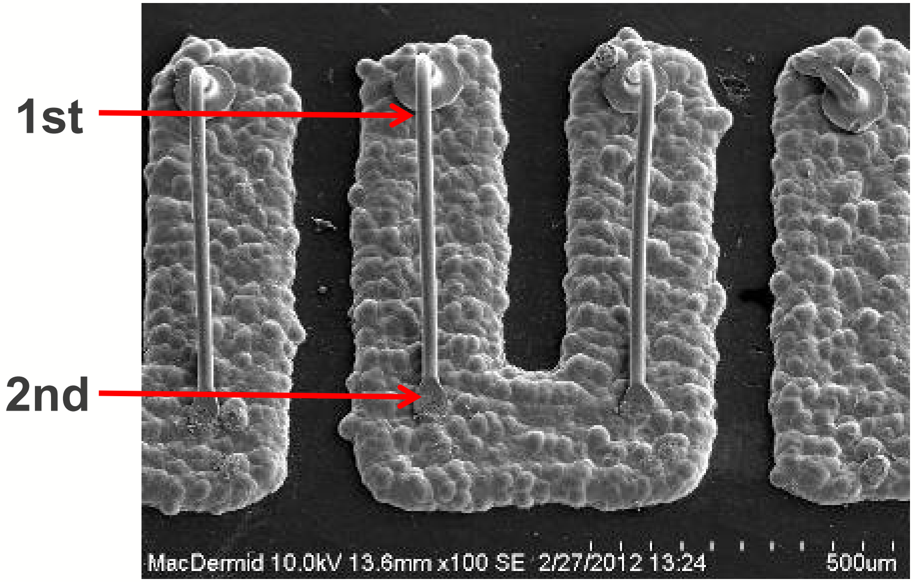


Conventional Gold Ball-Stitch Bonding **Stand-Off Stitch Bonding**

SSB Bonding - Overview

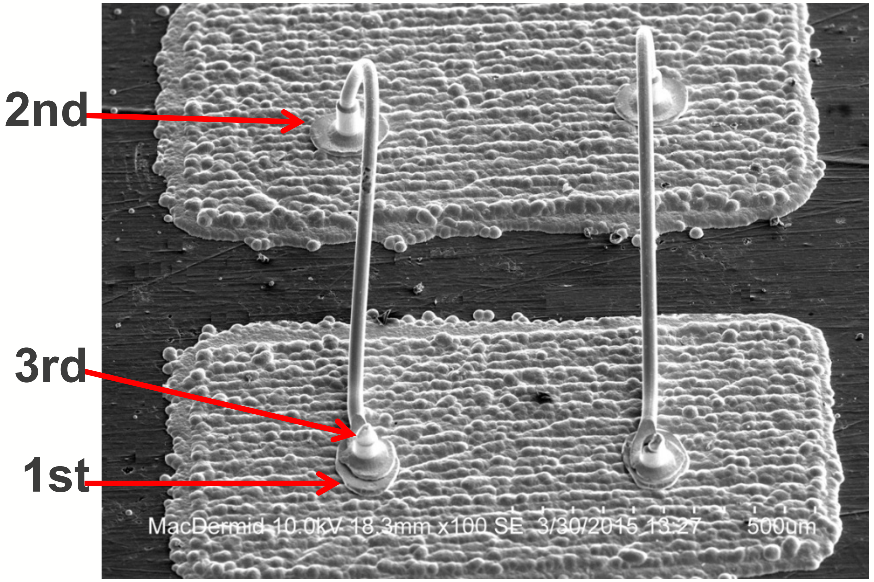
- A comparison of conventional gold wire bonding vs. stand-off stitch wire bonding on MID substrates.

Conventional Gold Ball-Stitch Bonding



- Step 2 – Place stitch

Stand-Off Stitch Bonding



- Step 1 – Place Stud
- Step 2 – Place 1st bond
- Step 3 – Place stitch onto stud

Experiment Design / Overview

- To determine the benefit of copper plating thickness on wire bond reliability
- Samples are plated with 6, 12, 18, 30 microns of electroless copper and then finished with our ENEPIG
  - Test responses:
  - % Successful bond formation
  - % Proper stitch bond formation
  - Wire bonding destructive pull testing
  - SEM micrograph of stand-off stitch bonds
  - Cu metallization thickness by X-ray fluorescence
  - Topography by 3d microscope
  - Roughness by ZYGO interferometry
- Conclusions

Experimental Results Overview

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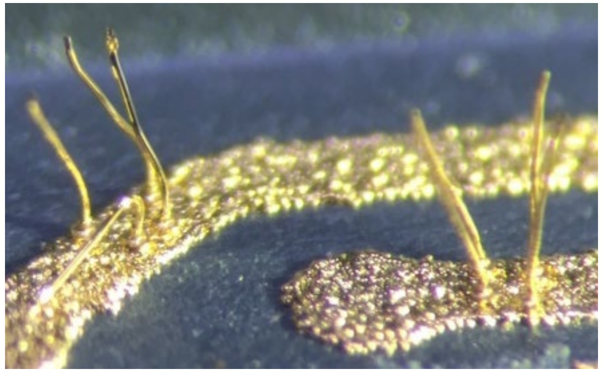
Sample	Bonding Type	% NSOL	%Poor Wedge Formation	Wire Bond Average	Wire Bond Min	Wire Bond Max	Standard Deviation
6.0 um	Conventional	98.0%	100.0%	n/a	n/a	n/a	n/a
	SSB	0.0%	0.0%	9.336	7.291	11.985	1.205
12.0 um	Conventional	14.0%	74.4%	9.916	1.137	12.378	2.477
	SSB	0.0%	0.0%	9.710	7.700	12.258	0.963
18.0 um	Conventional	2.0%	32.7%	9.958	7.813	11.648	0.924
	SSB	0.0%	0.0%	10.011	6.173	11.264	1.135
30.0 um	Conventional	0.0%	14.0%	10.208	6.234	11.463	1.313
	SSB	0.0%	0.0%	10.252	9.031	11.583	0.730

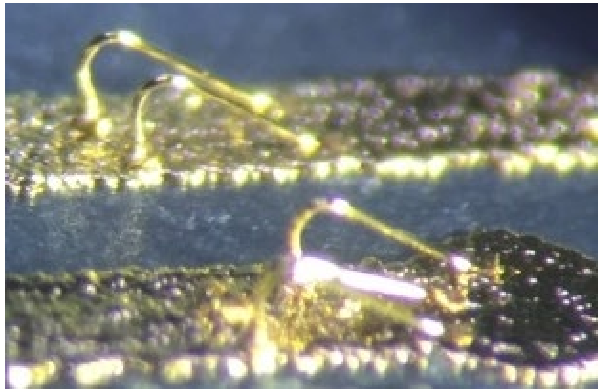
- 50 bonds tested for each sample.
- 1 mil gold wire, 99.99% Au, 3-5% elongation, 8gm breaking load.

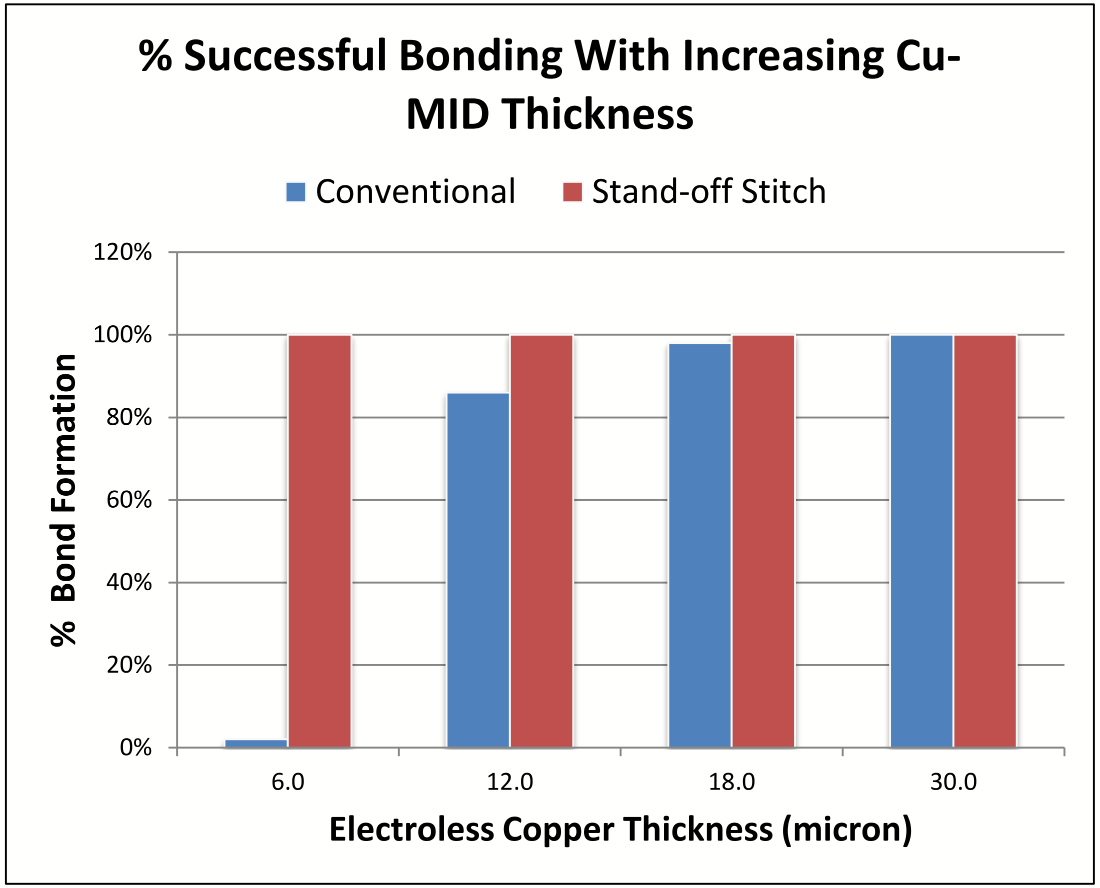
Experiment Results – Bond Formation

Non Stick Lead Appearance



Successful Bonding Appearance





- NSOL – Non Stick On Lead. NSOL will stop wire bonding automatic process.

Experiment Results – Poor Bond Appearance

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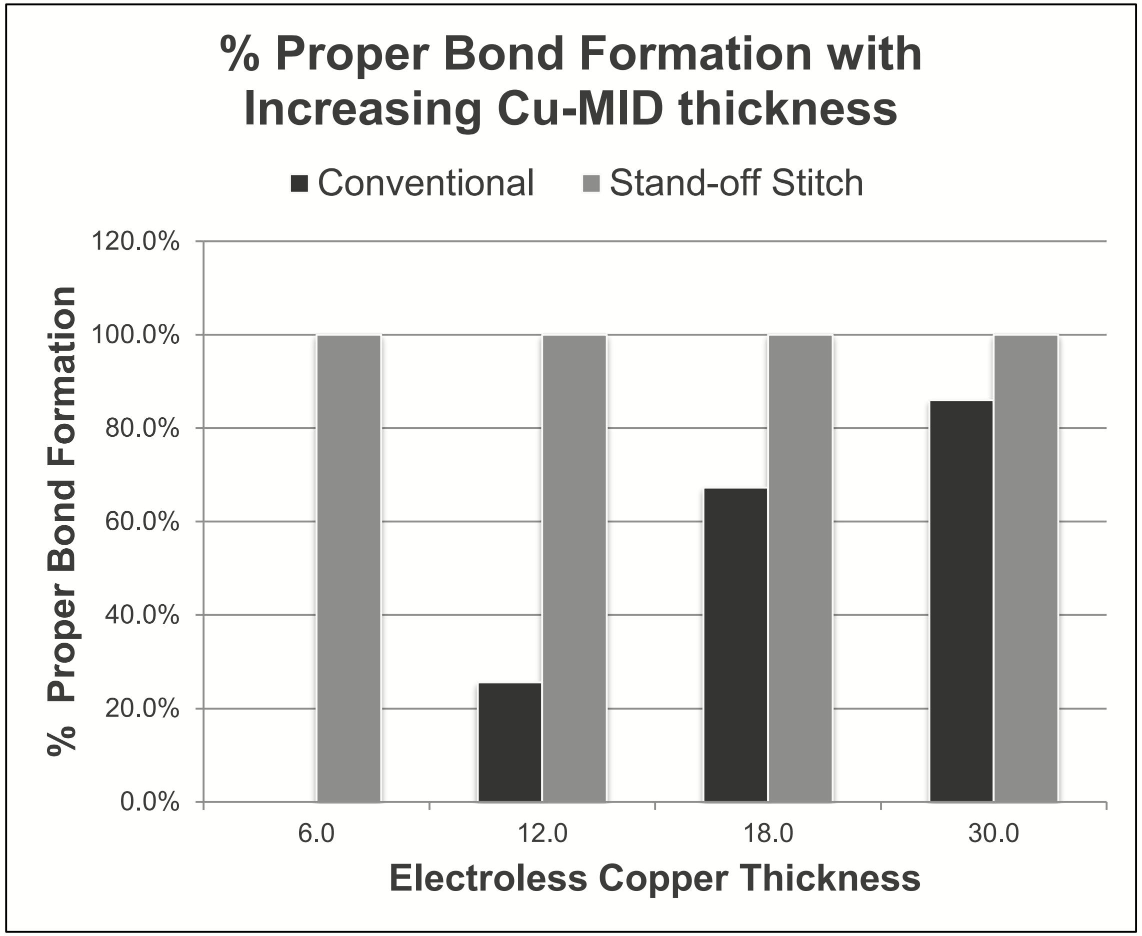
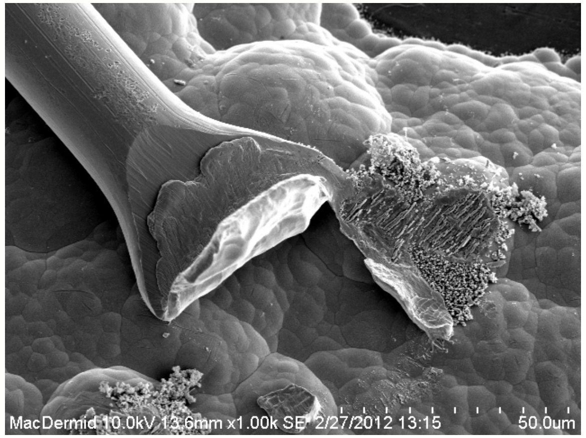
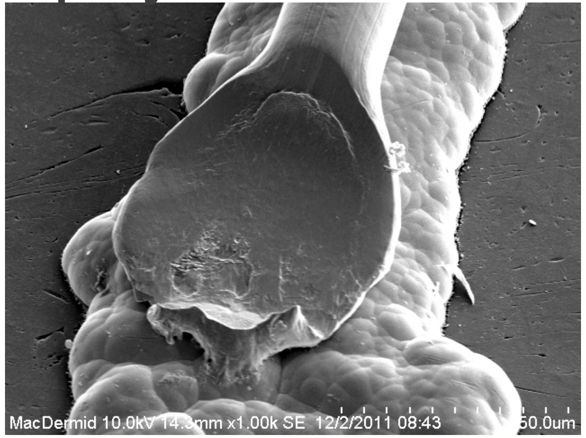


Poorly formed stitch bond



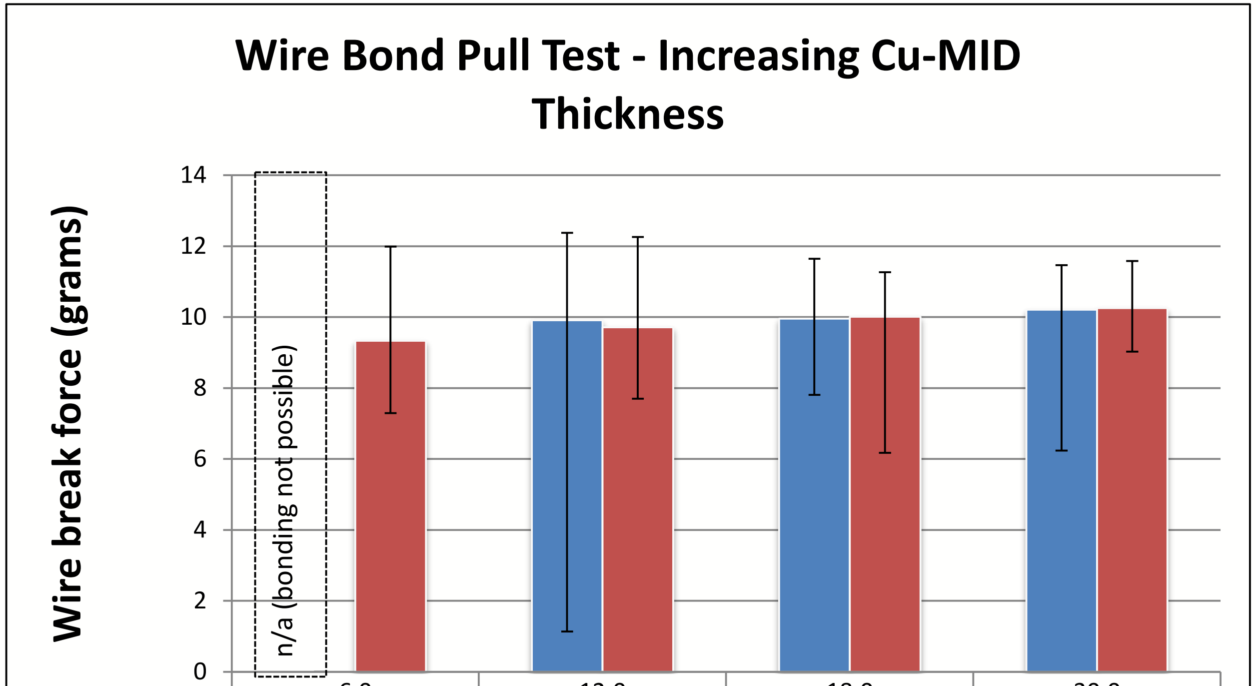
Properly formed stitch bond



- Conventional wire bonding on rough MID will have occurrence of poorly formed stitch bonds.
- Stitch bonds are always flat with stand-off stitch bonding on MID.

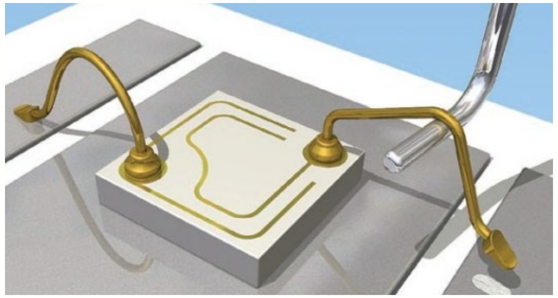
Experiment Results – Destructive Pull Test

MacDermid Enthone



	6.0	12.0	18.0	30.0
Conventional	0	9.916	9.958	10.208
Stand-off Stitch	9.336	9.710	10.011	10.252

XYZTEC Condor Pull Testing Apparatus



Pull Testing Diagram

- Statistics – 50 bonds
- Bonding wire – 1mil, 99.99% Au, 8 gm min. BL, 3-5% elongation
- Failure – 5 grams or lower

Actual Part Design – Wire Bonded with SSB

- **Stand-off Stitch Bond tests on MID – Chip Substrate for Electronic Device**
- **Plated with Our Cu-ENEPIG**

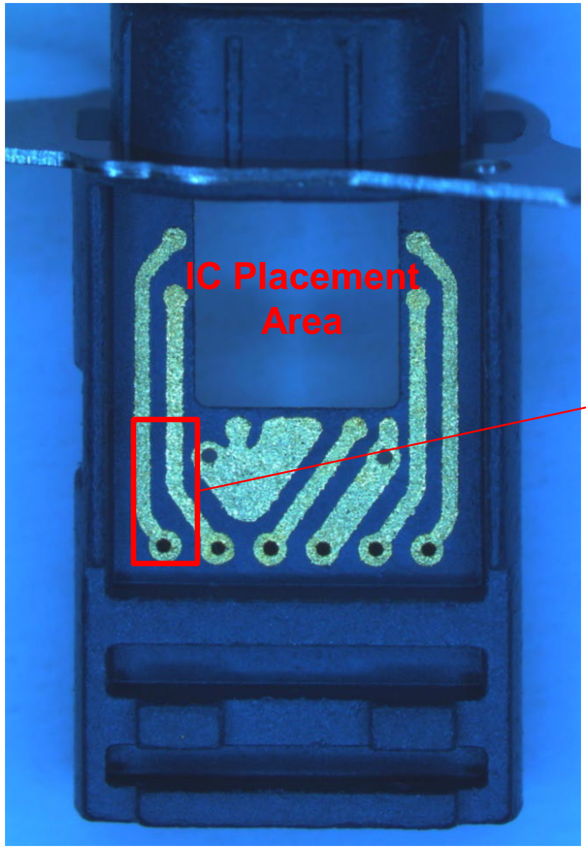


Image permission from *Emerson* and *Molex*.

SSB Wire Bond – SEM Micrographs

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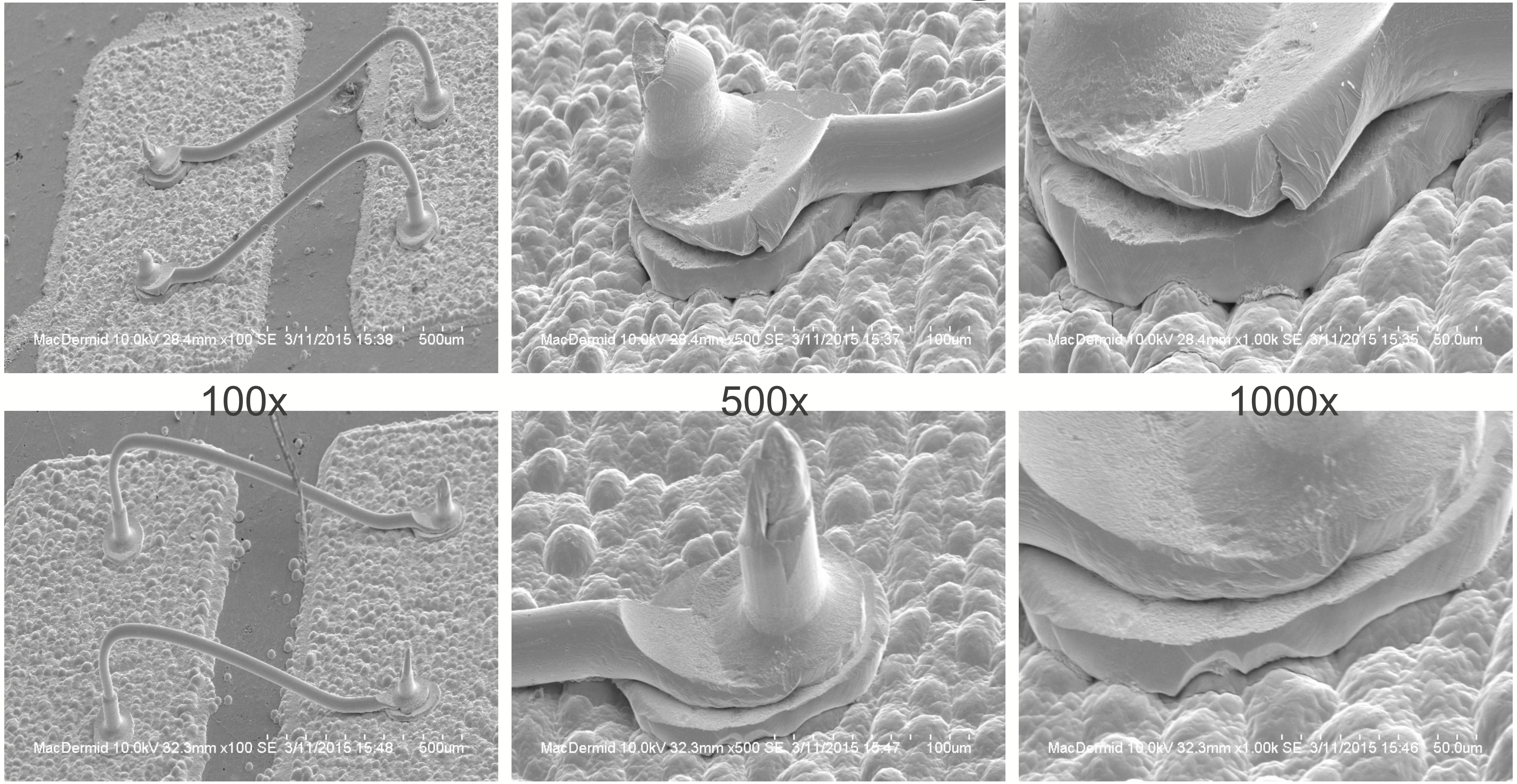
6 micron Cu

12 micron Cu



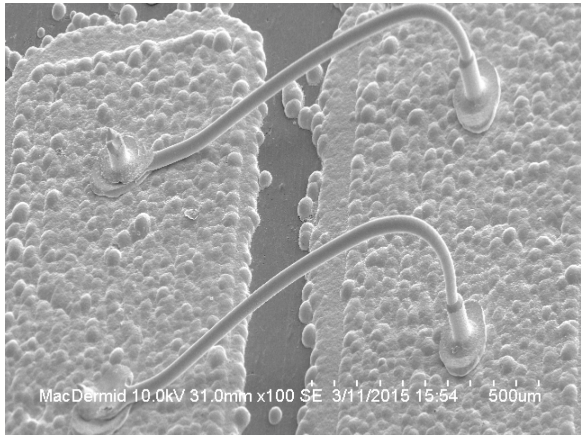
100x 500x 1000x

100x 500x 1000x

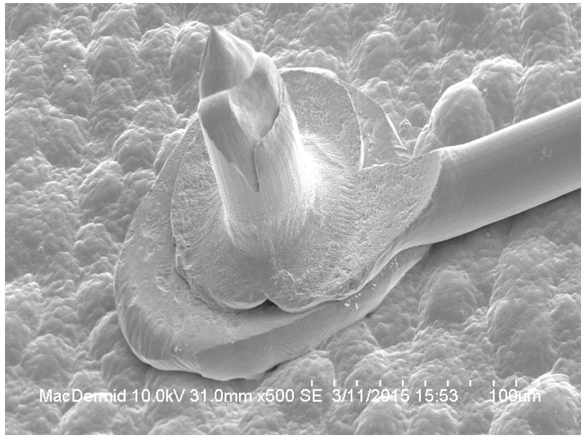
- Note the high roughness of substrate on the 5.7 micron Cu sample.
- Sample gets smoother at higher thickness Cu.

Wire Bond – SEM Micrographs

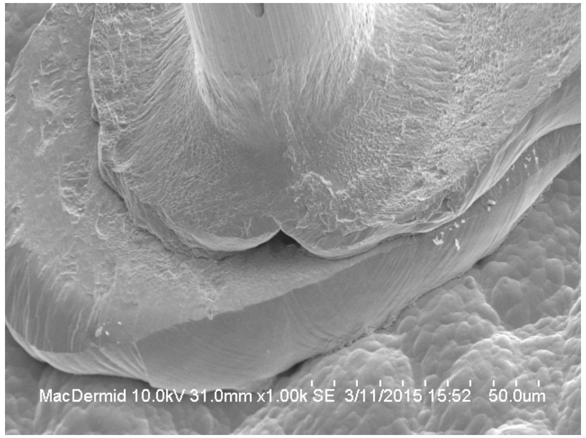
18 micron Cu



100x

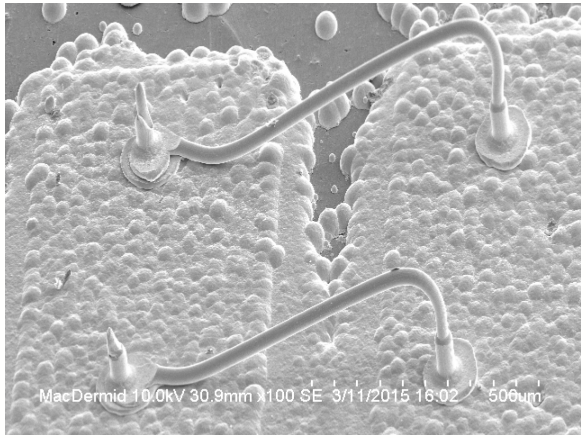


500x

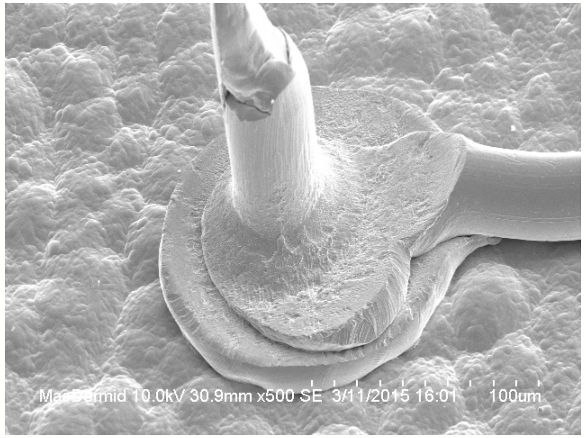


1000x

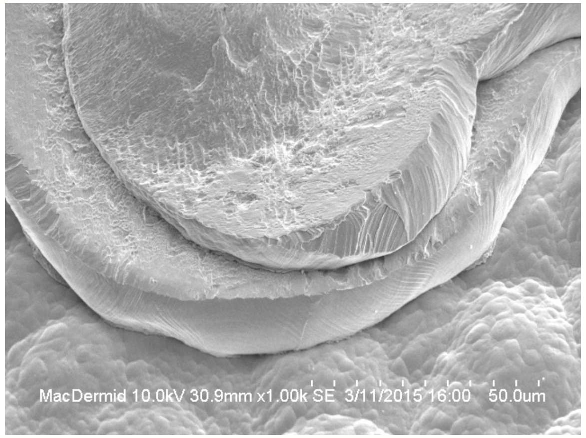
30 micron Cu



100x



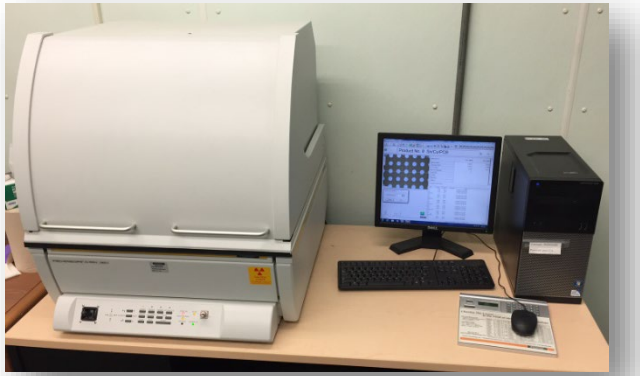
500x



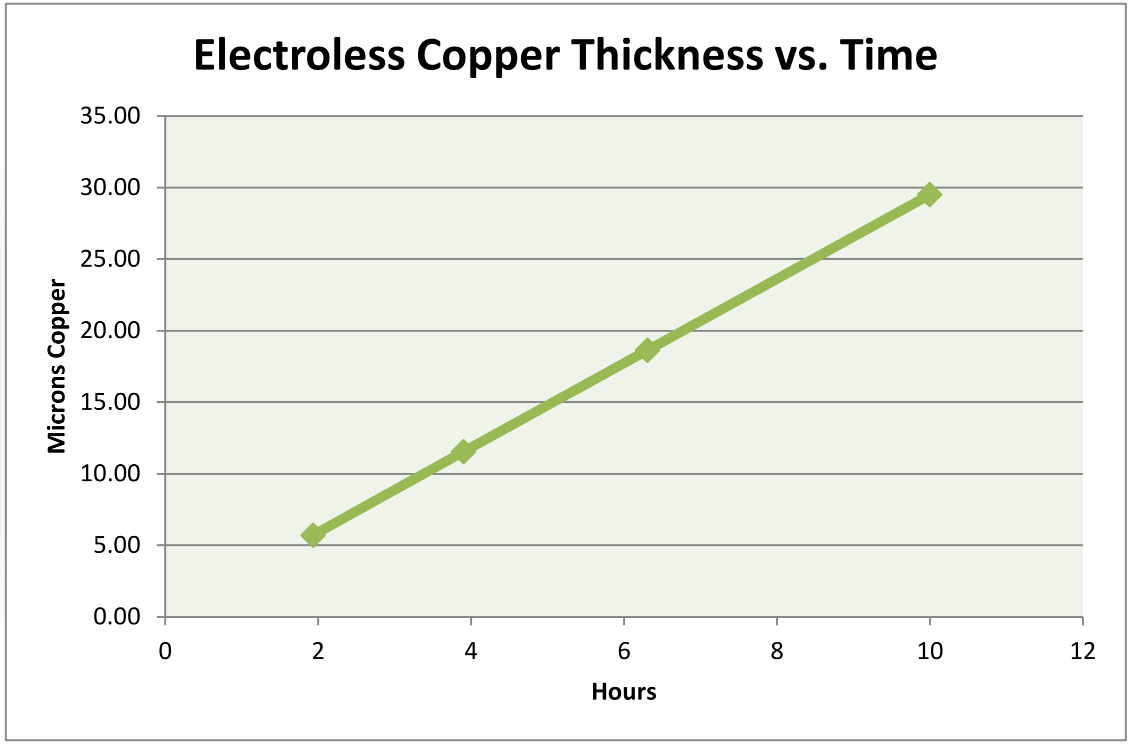
1000x

- Note the smoother surface given by building the Cu metallization to higher thicknesses.
- The higher the thickness, the greater chance for extraneous plating.

Thickness by X-Ray Fluorescense

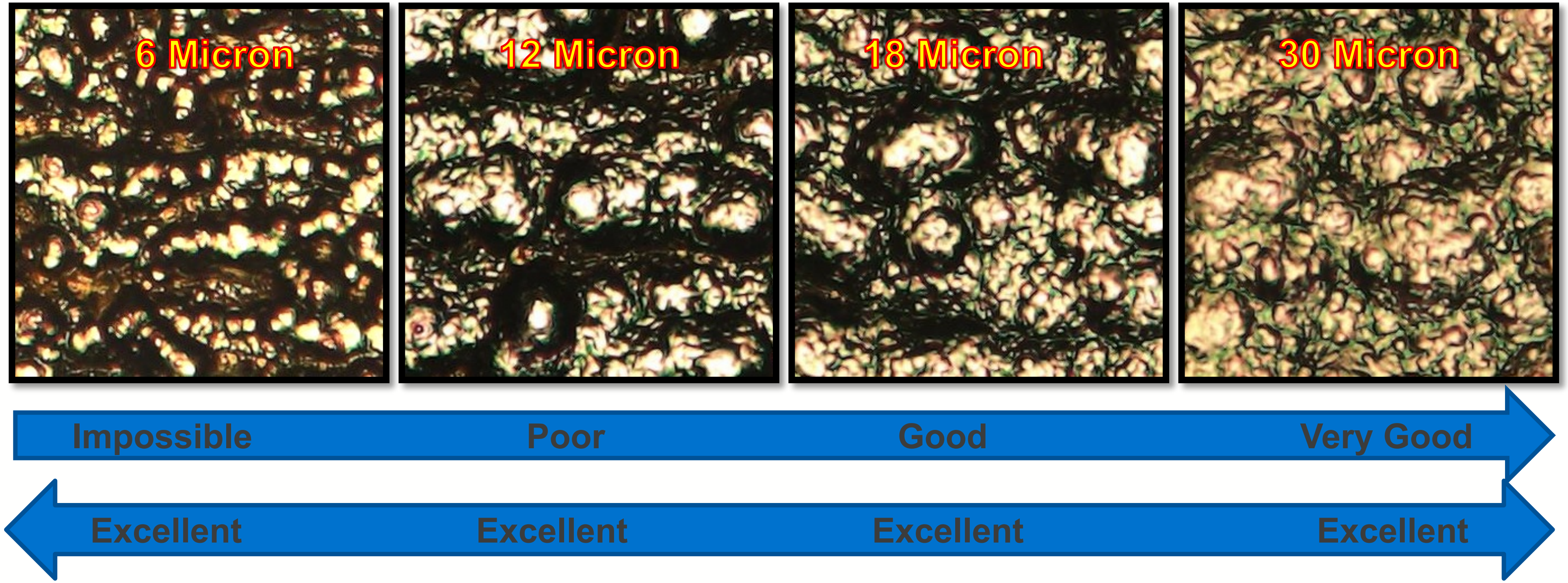


Fischer X-Ray Fluorescence Spectrometer



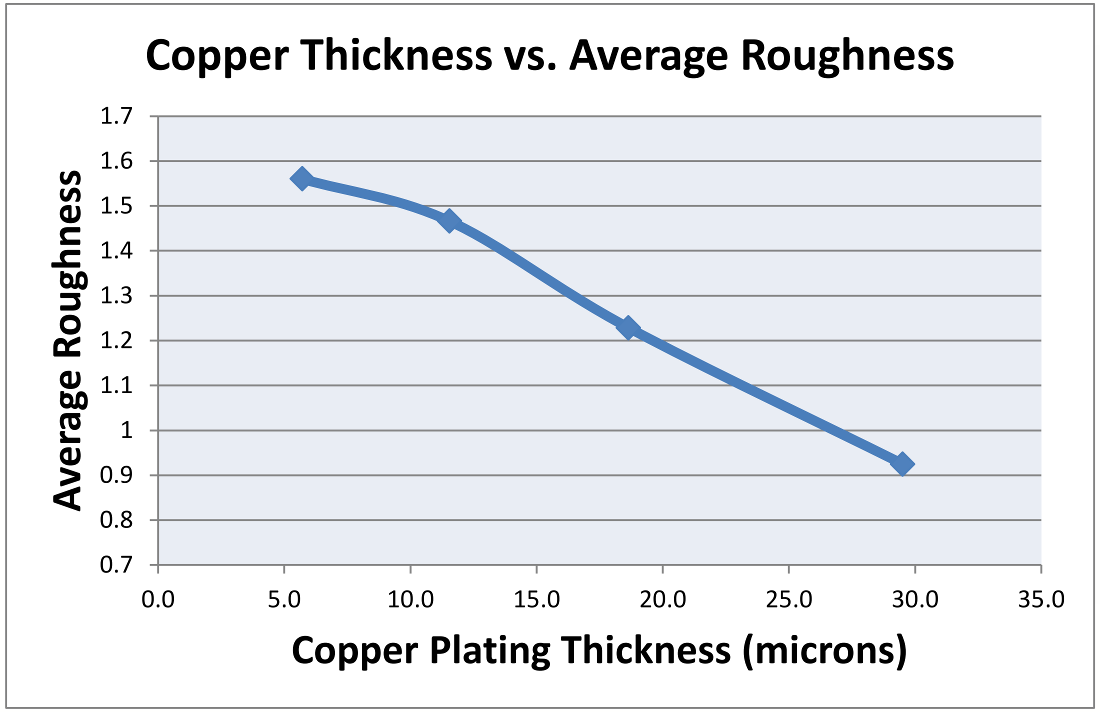
- Thickness measured by X-ray fluorescence. 10 measurement average.
- Electroless copper can be built to virtually any thickness.
- Long plating times required for leveling effect.

Surface Roughness - Bondability



- Optical microscope shows the surface gets visibly smoother as Cu thickness increases.
- Conventional wire bonding improves with thickness.
- Stand-off stitch bonding can be successfully applied for all thicknesses.

Experiment Results – ZYGO Interferometry

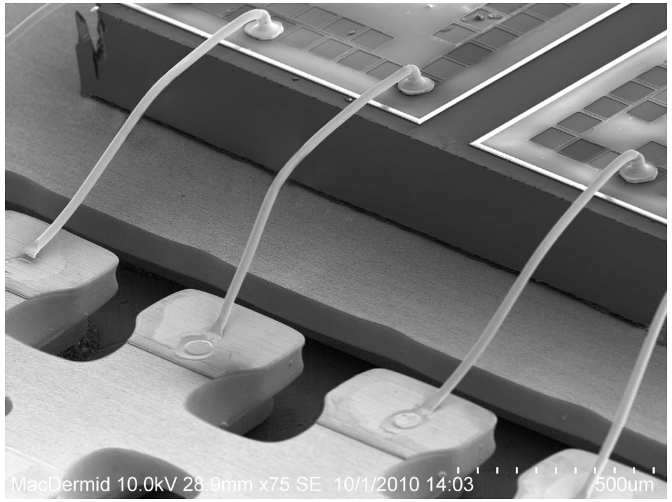


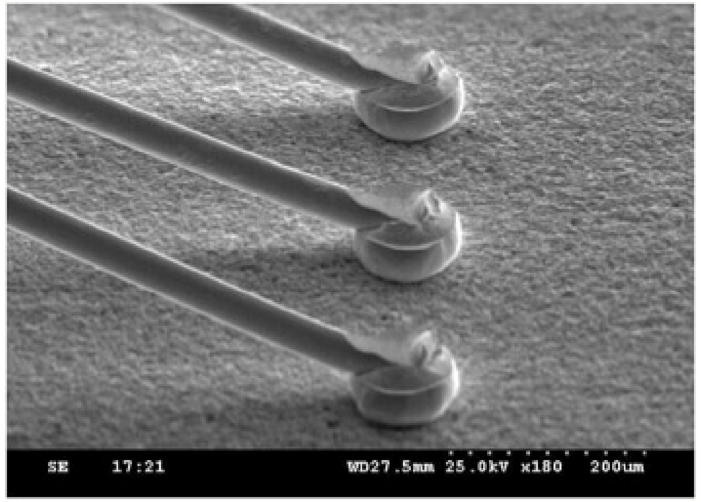
ZYGO NewView 7100 Interferometer

- Zygo interferometer measures surface roughness attributes using light microscopy.
- Roughness decreases as plating thickness increases.

Conclusions

- The ability to wire bond to MIDs finished with Cu-ENEPIG opens electronics engineering possibilities.
- Stand-off Stitch bonding (SSB) broadens electroless plating process window saving time and money.
- High statistical reliability can be achieved wire bonding to MIDs using stand-off stitch bonding.





There Are No Limits to MID