



Nanostructured Metal Coatings for Electric Vehicles

Technology Introduction

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April 2021

Agenda

Company Profile

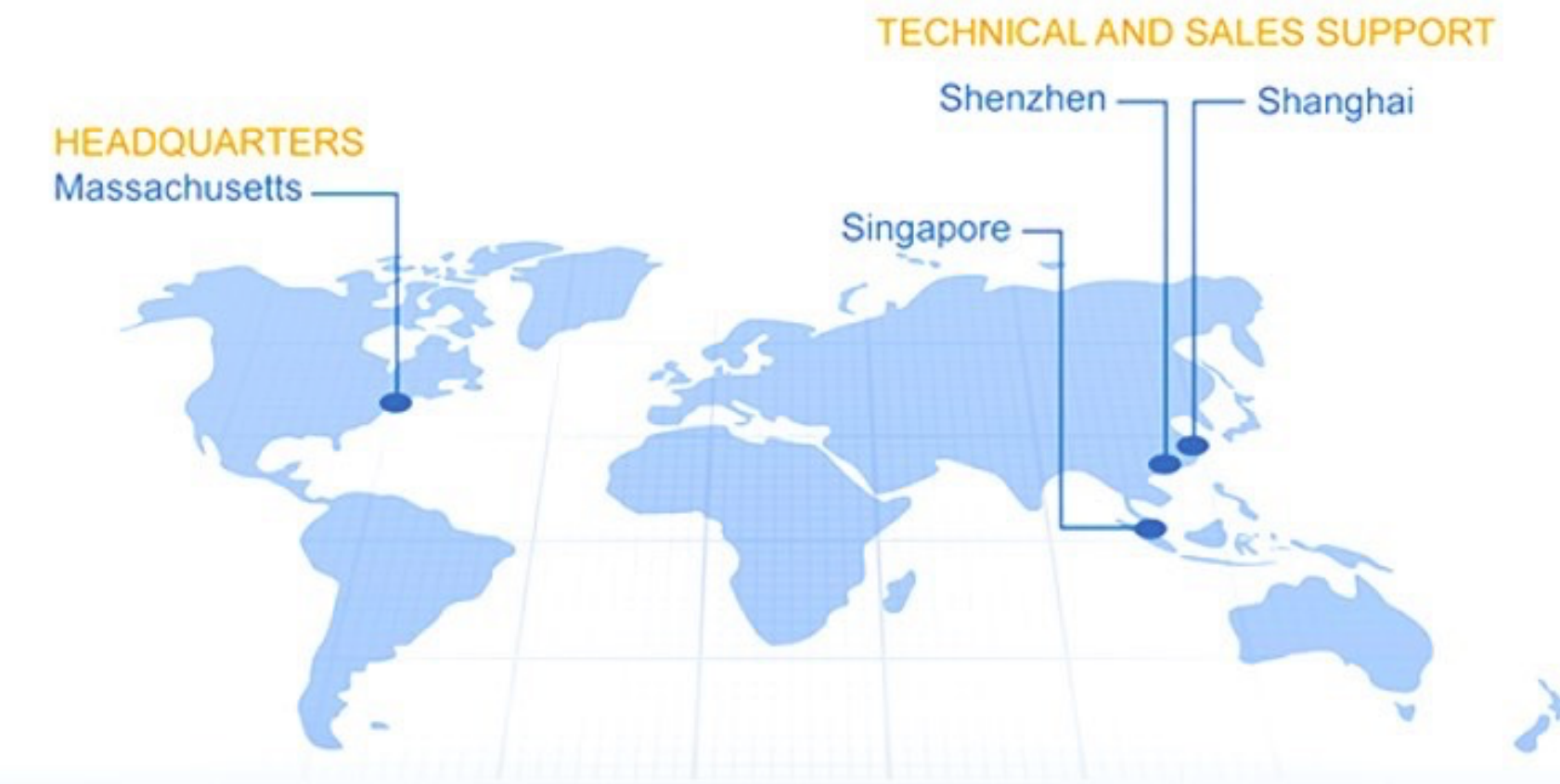
Xtallic technology

LUNA nanostructured silver alloys for EV connector applications

LUNA performance data

Identify customer technology needs for advanced coatings in electric vehicle

Proposal for collaboration



Xtalic Company Profile

Creating new alloys to address industry leader needs.

Enter mass production for fast charge waterproof smartphone connectors



2015

2019 - 2021

Testing begins on XTRONIC to increase wear life in smartphones charging connectors

2012

2010



XTRONIC coating is commercialized for high speed Datacomm backplane connectors



LUNA silver alloy coating demonstrates enhanced performance for EV automotive applications

XTRONIC is designed as an electroplated nanostructured nickel coating for high reliability connectors

2008

2006

Stable Nanocrystalline Ni-W alloys invented

2005

Founded at



Massachusetts Institute of Technology

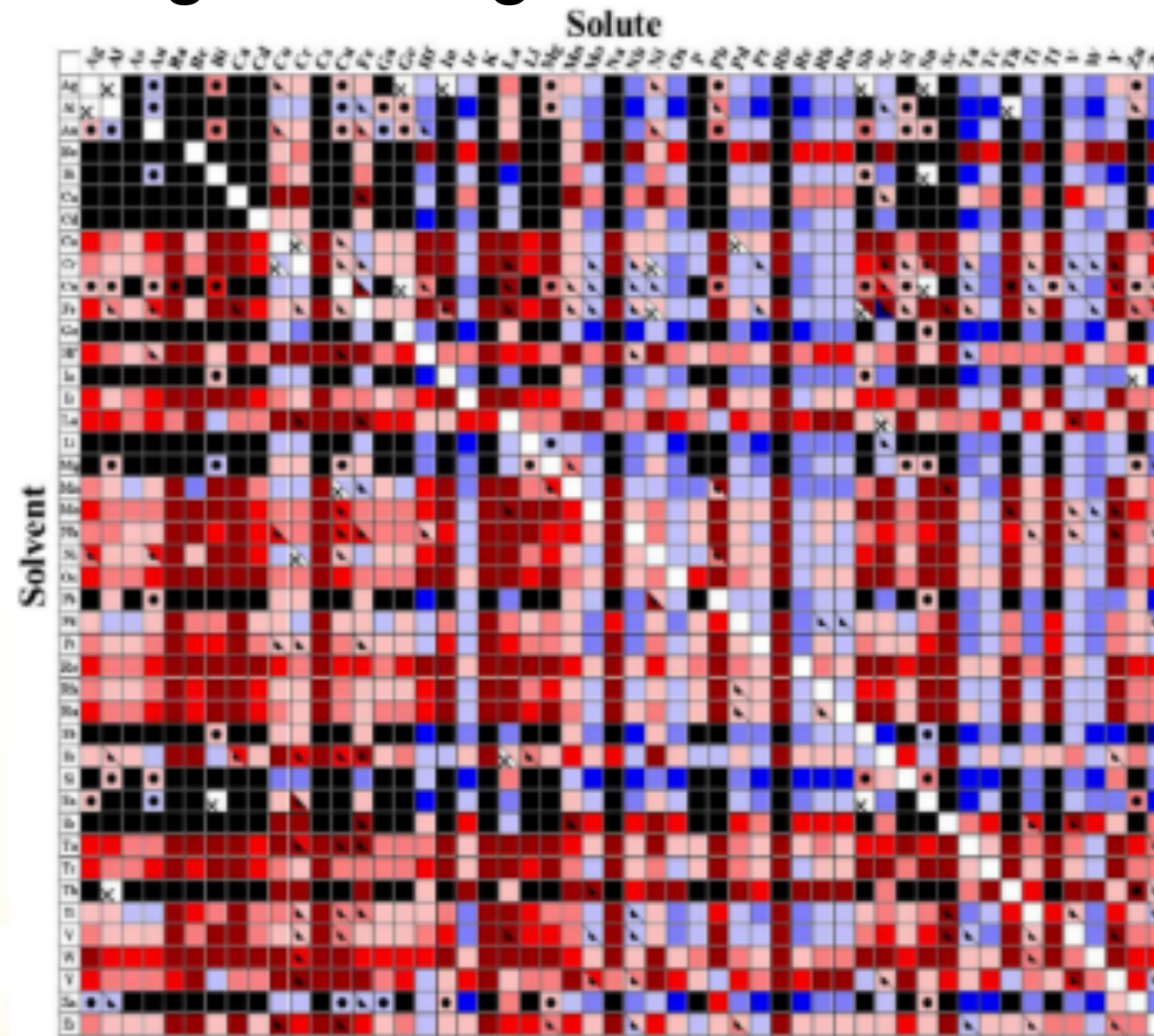
Xtalic Company Profile:
Headquarters: Marlborough, MA, USA
Sales & Tech Support: Singapore and China
~40 employees
>100 IP holdings
Privately held



Nanostructured Metal Coatings are Key for the Next Step in Automotive Interconnect Technology

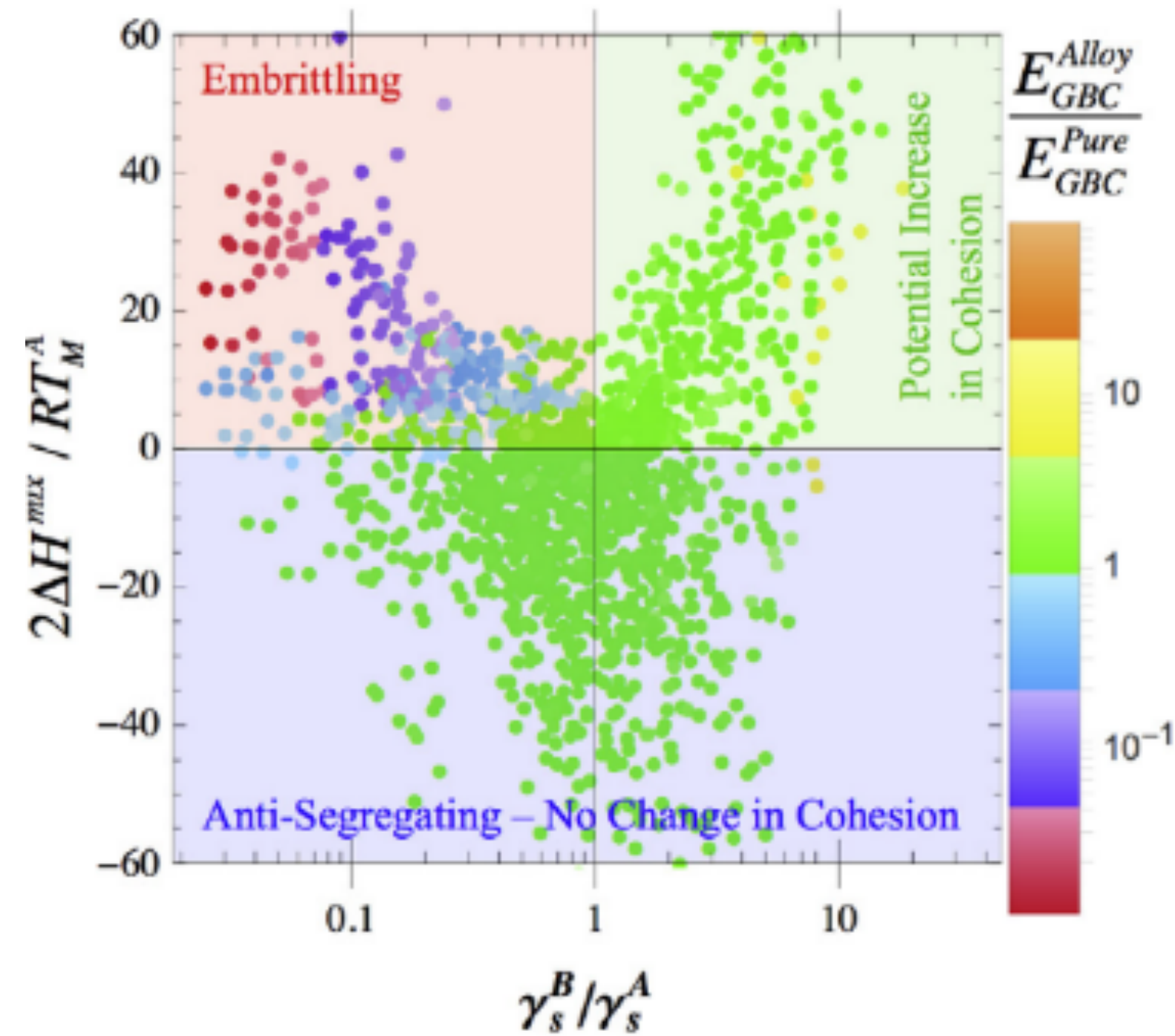
Controlling the grain size enables control over properties

Original Design Tool



Map of binary alloy options

Updated Alloy Design Tool



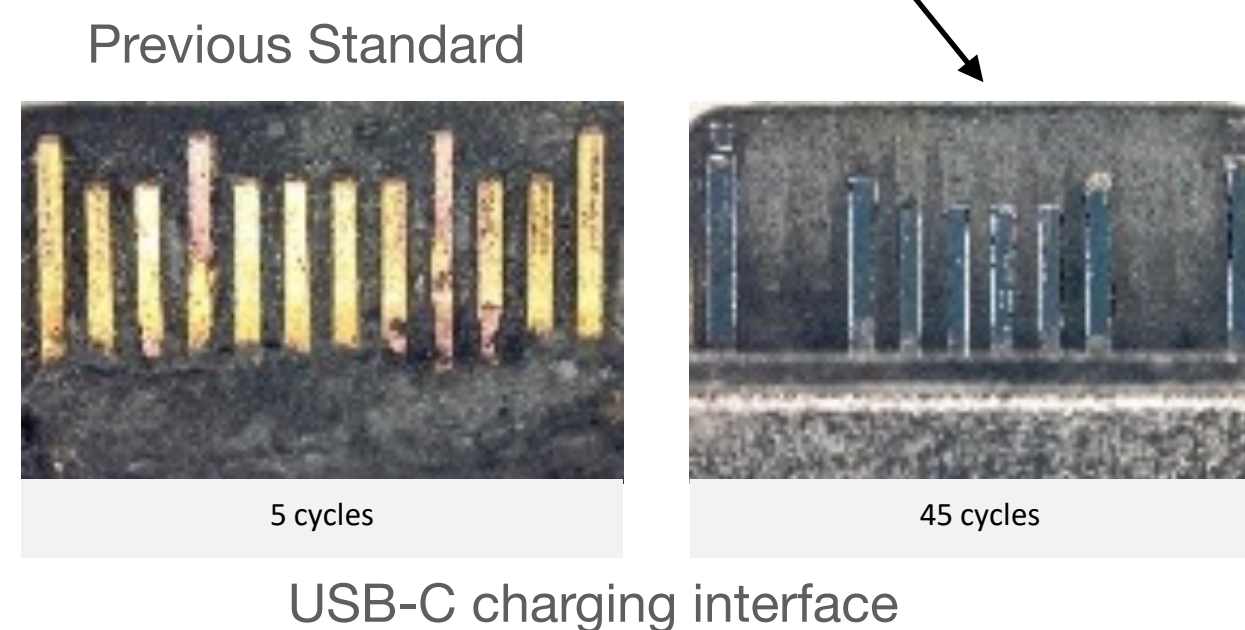
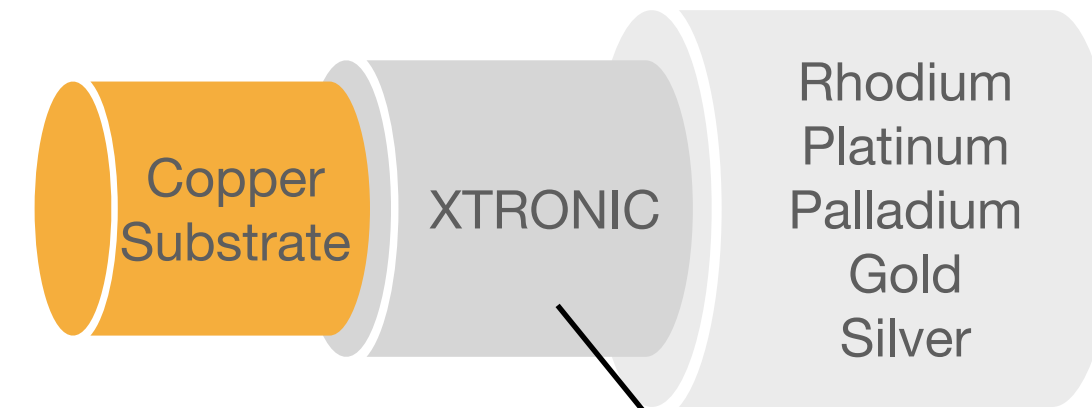
Nanostructured alloys with preferred properties.

Ternary and higher order alloy simulation in collaboration with MIT.

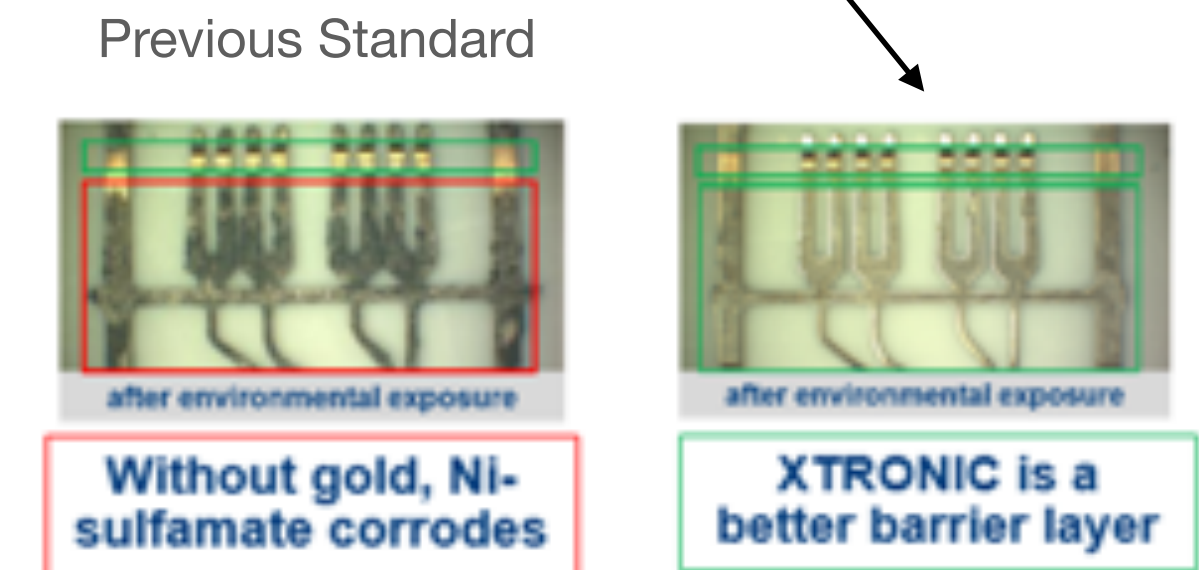
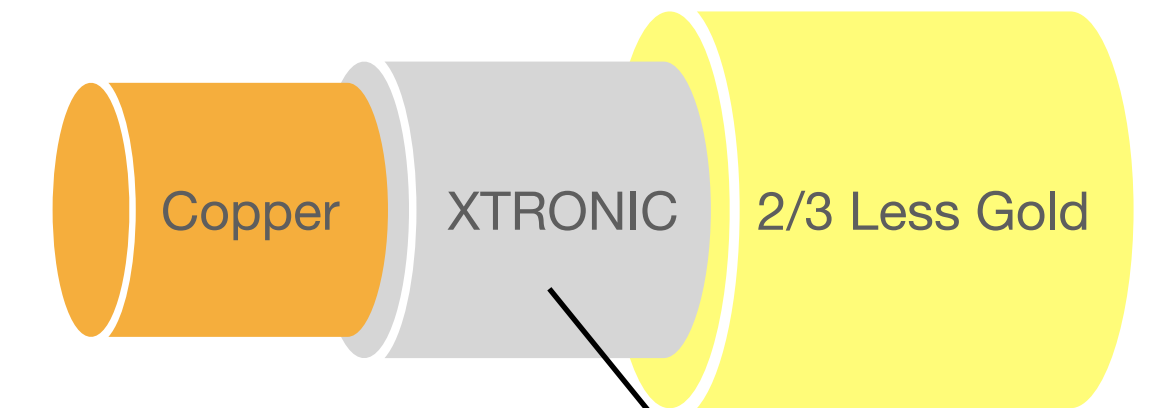
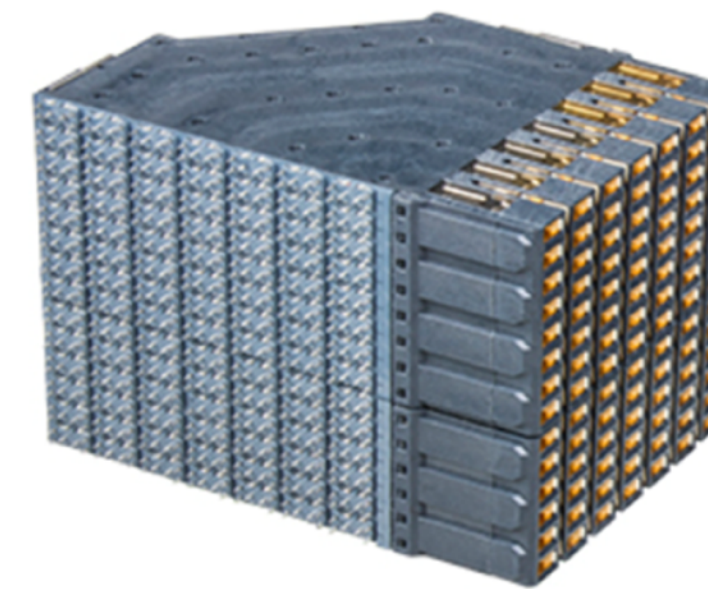
Xtalic Protects 25+ Billion Critical Contacts

Utilized by 5 top 10 smartphone OEMs and 30 top electronics OEMs

Protecting more than 1 billion smartphone connectors.

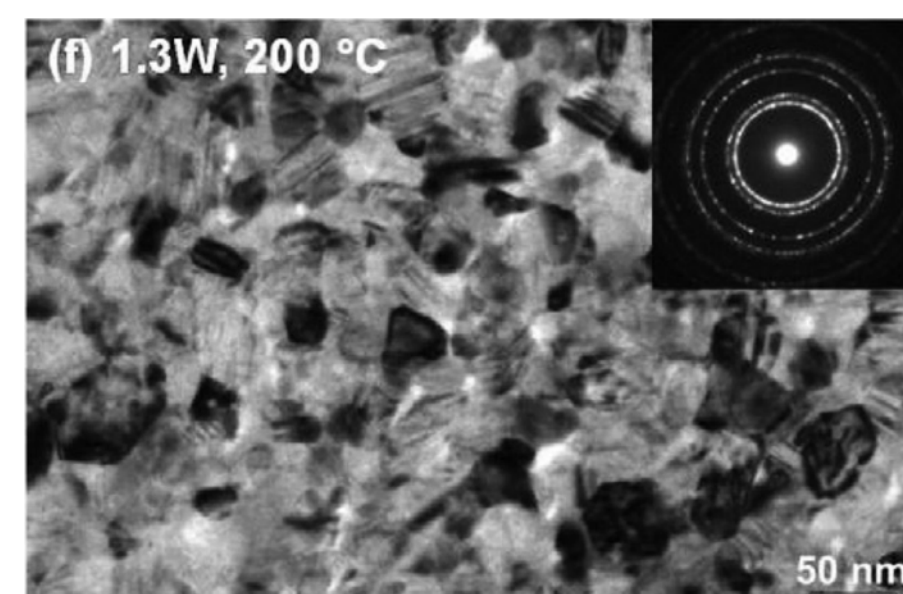
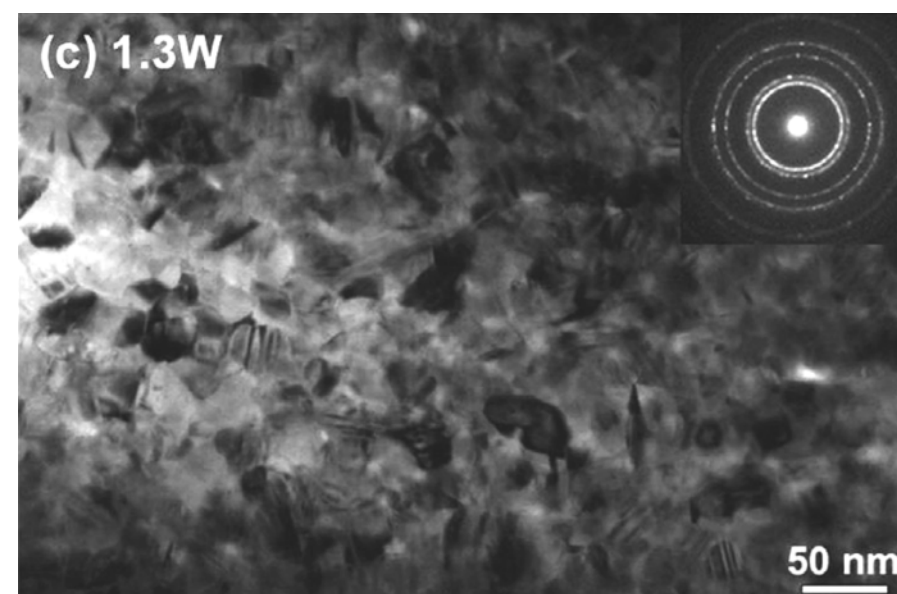


Over \$100m in gold saved across enterprise servers.



LUNA[®] Nanostructured Silver Coating

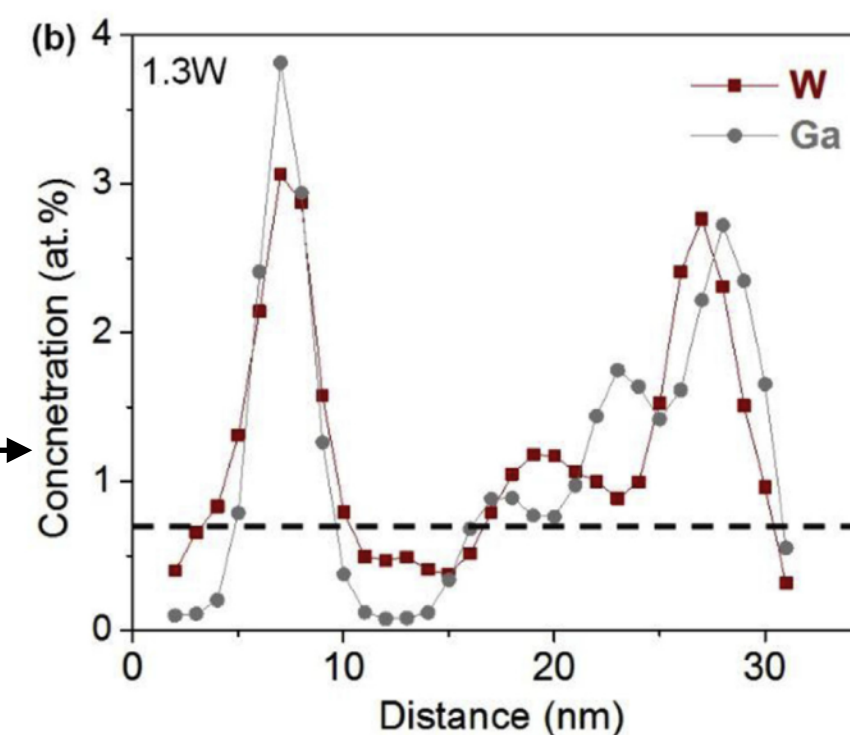
Manufactured through electrodeposition



TEM analysis of LUNA at 1.3%W with SAD inset:
 (Left) as plated and (right) after 24 hours at 200 C.
 Resulting structure is thermodynamically stable.

Atom probe analysis across grain boundaries showing W rich regions due to W segregation.

From Schuh <https://doi.org/10.1016/j.actamat.2018.09.014>



Mechanical

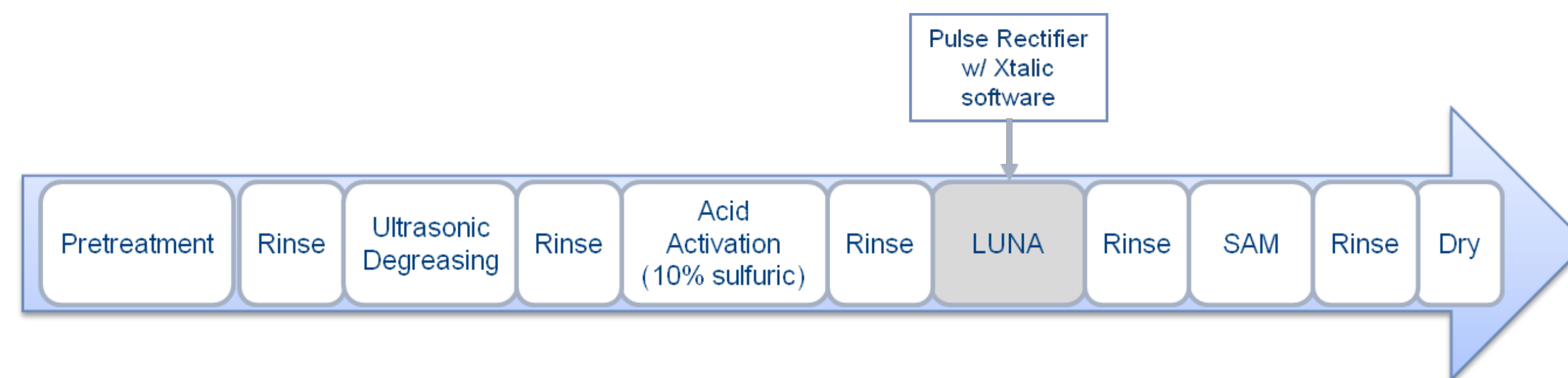
- Hardness ~2GPa (2-3x pure Ag)
- CoF $\mu = .7$ [.2 with lube]
- Thermal Stability > 225 C

Electrical

- Resistivity ~ 4 $\mu\Omega$ cm

Manufacturing

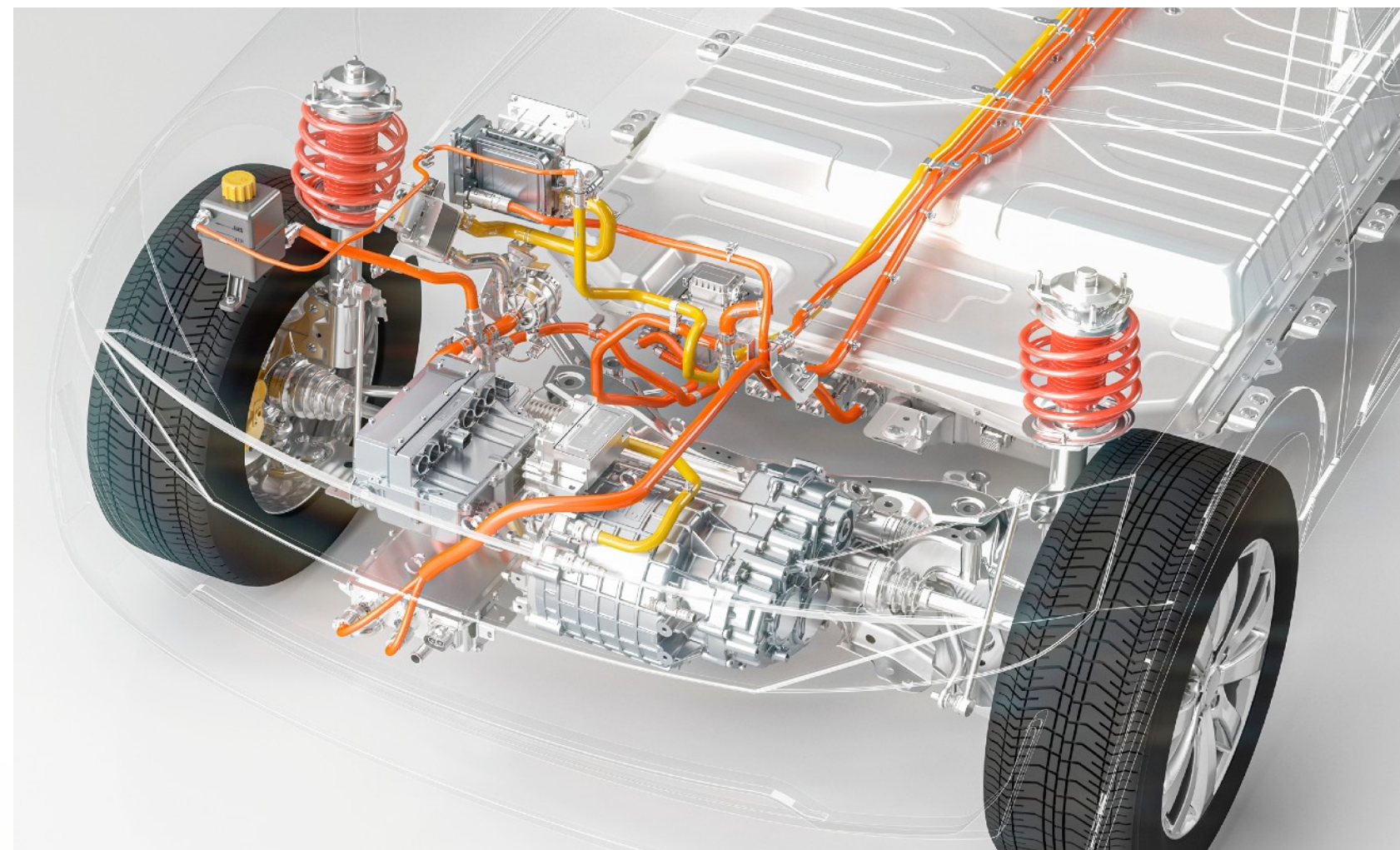
- Pulse reverse electrodeposition
- Barrel and Rack
- Cyanide Free



LUNA as part of the plating process

Performance Benefits for Electric Vehicles

LUNA[®] — Xtalic's stable nanostructured silver optimized for EV



High power interconnects

- Max operating temp = 220 C
- Low insertion force
- Crimp capable
- Cyanide free plating process



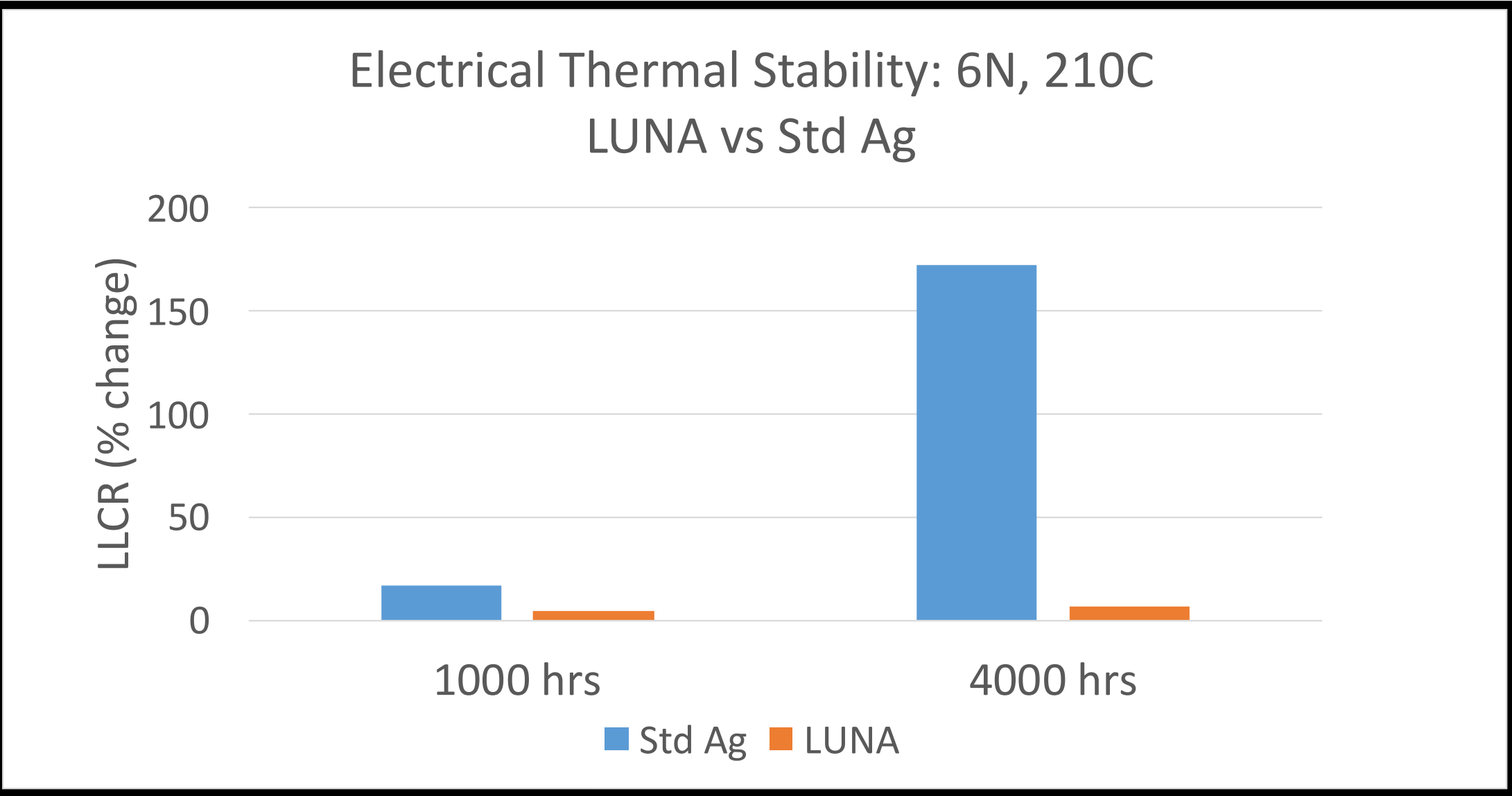
EV charger contacts

- Improved wear at 25% thickness
- Improved corrosion resistance

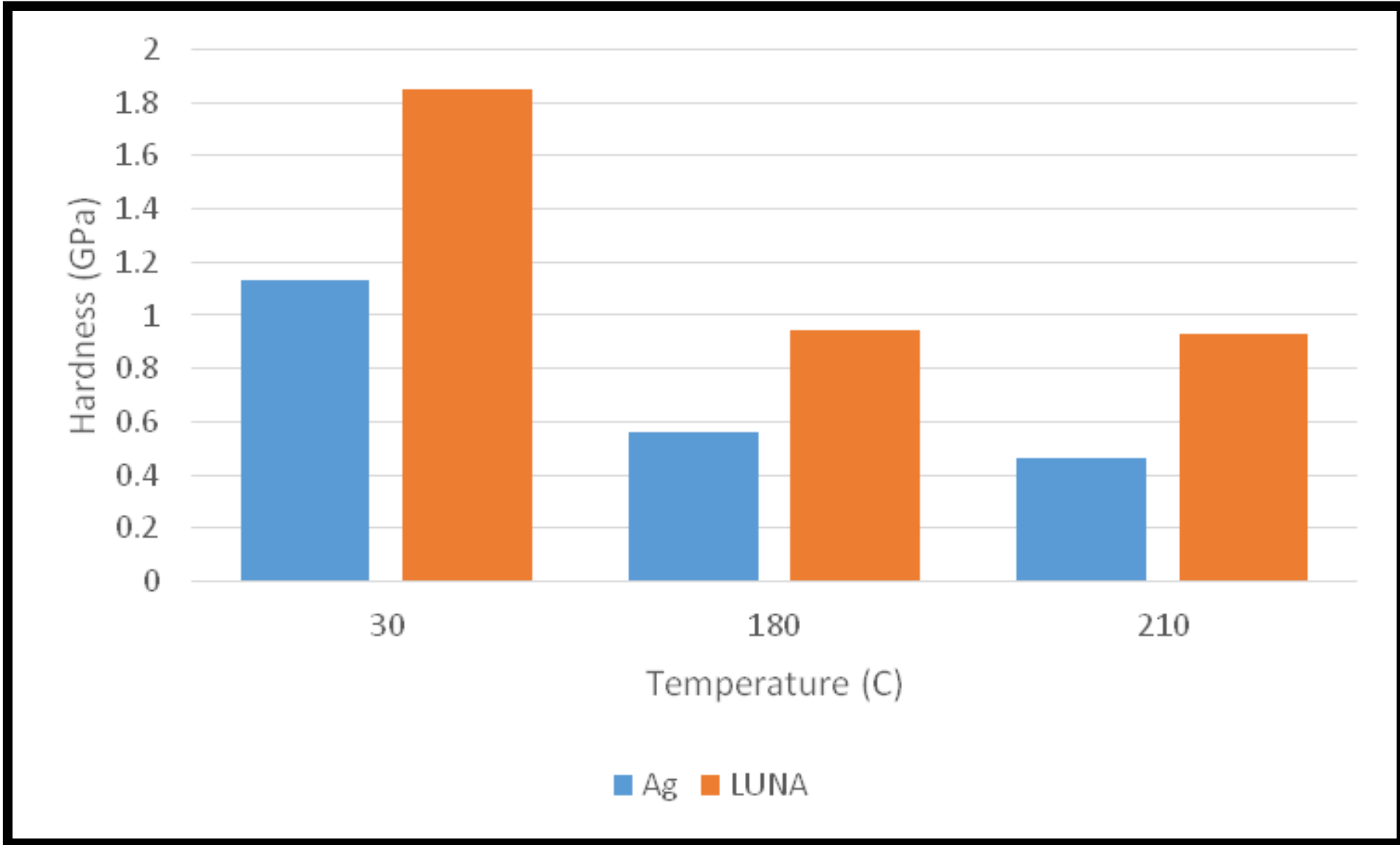
LUNA Extends Thermal Stability Performance

Contact physics beyond 170 C

LUNA provides low and stable contact resistance after 210 C heat age for 4000 hours



LUNA is about 2 times harder across the temperature spectrum

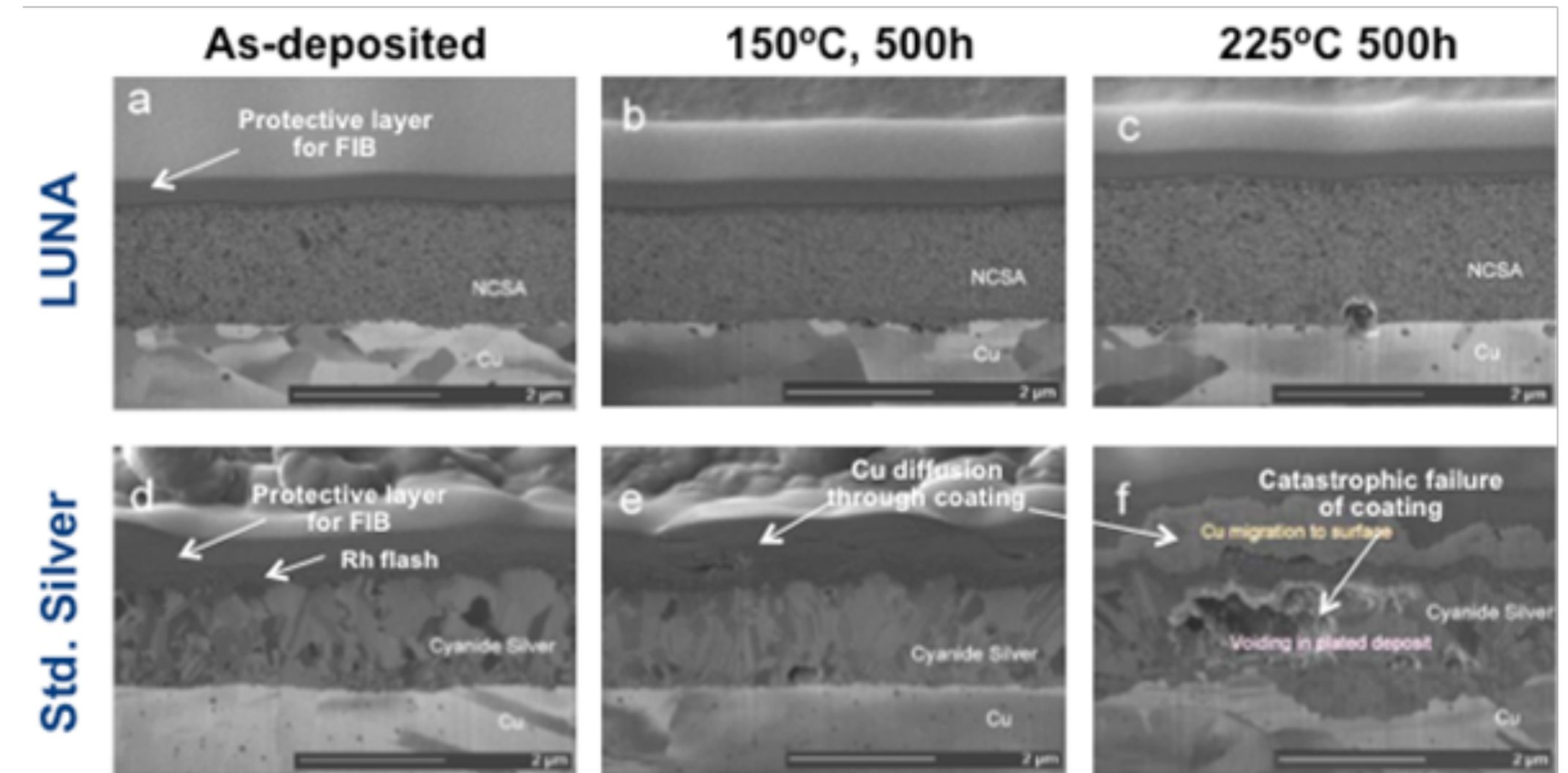
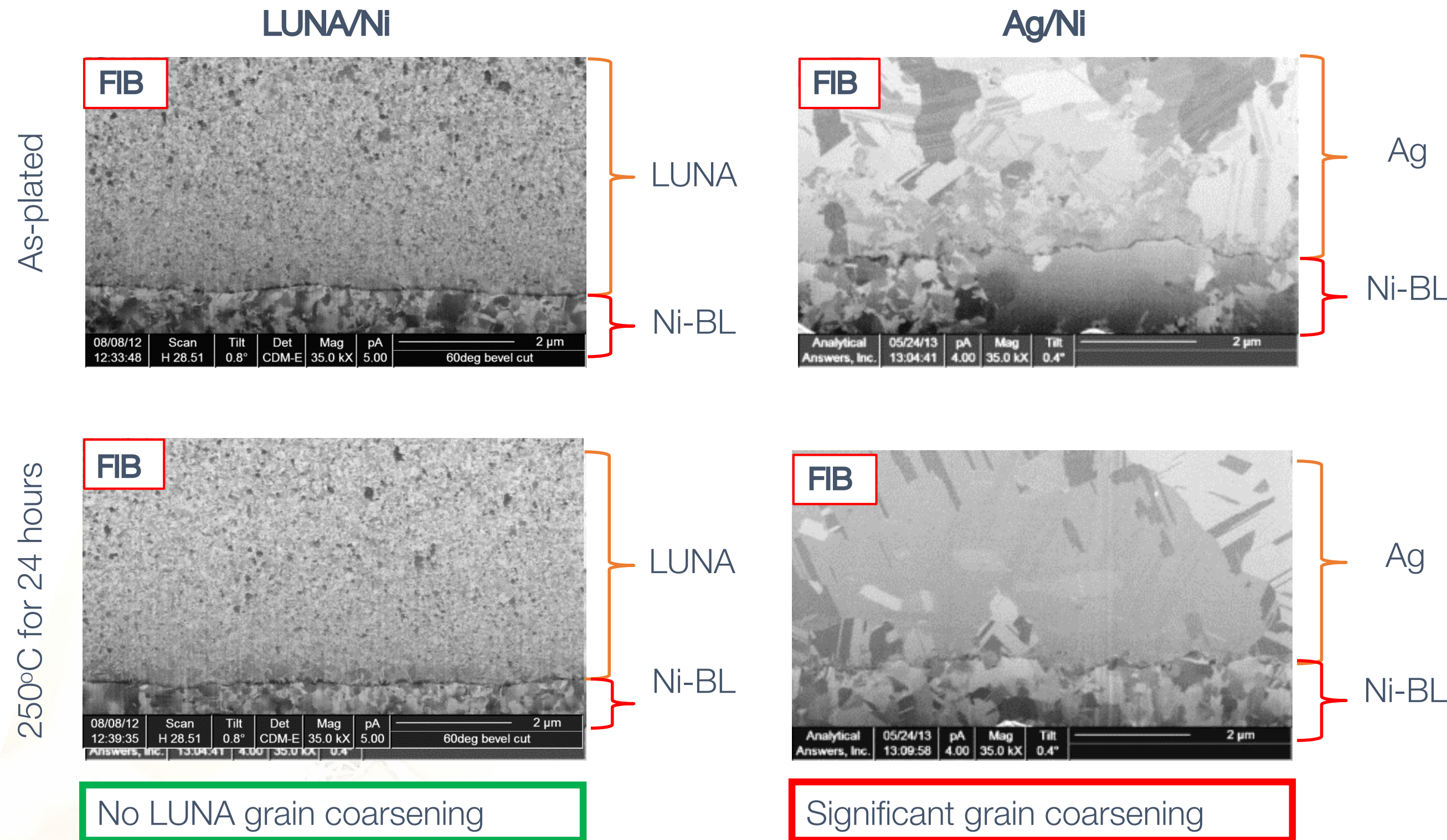


Nanoindentation hardness study at temperature using thick silver plating

Design Tools Ensure Stable Nanostructure

Thermal performance provides additional reliability, safety, and performance

Diffusion Performance



LUNA microstructure virtually eliminates fast grain boundary diffusion, preventing copper migration at temperature. Standard silver shows significant inter-diffusion and Kirkendall voiding at 225 C.

LUNA is thermally stable through 250 C while traditional silver shows significant grain coarsening and softening

Enhance Wear Performance with LUNA

5um of LUNA outperforms 20um of standard silver

Part types

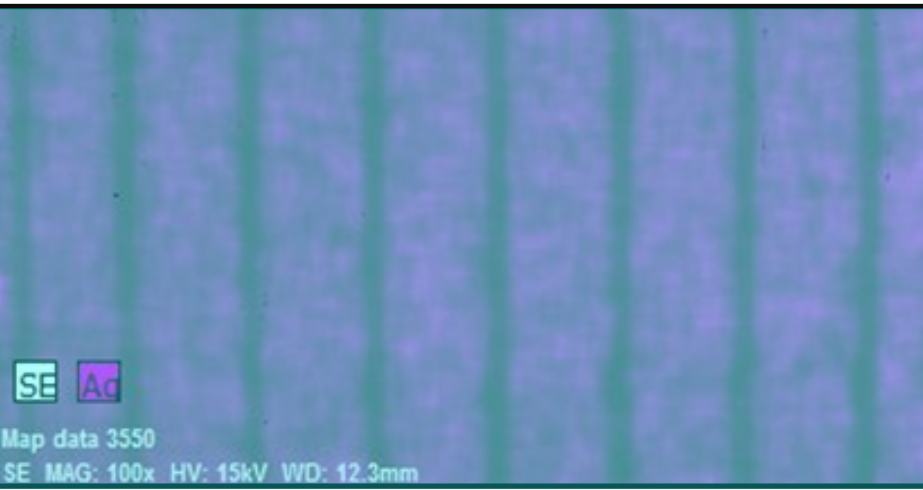
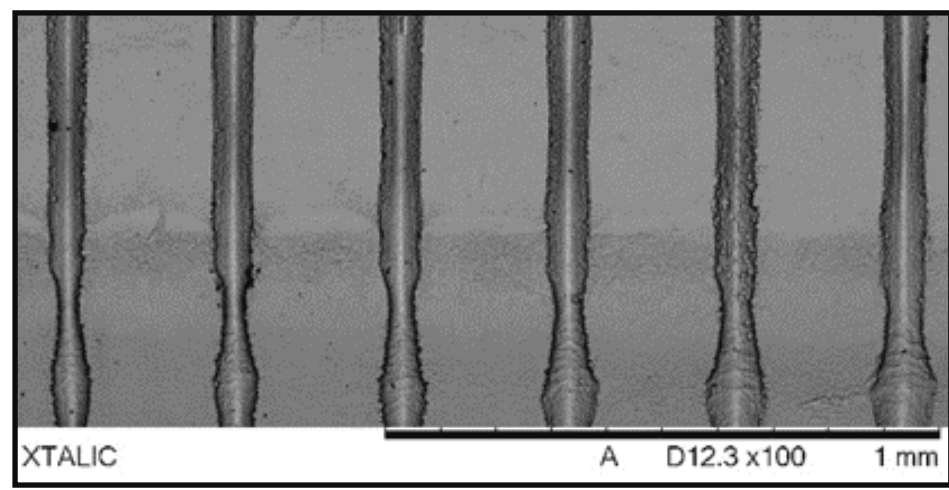
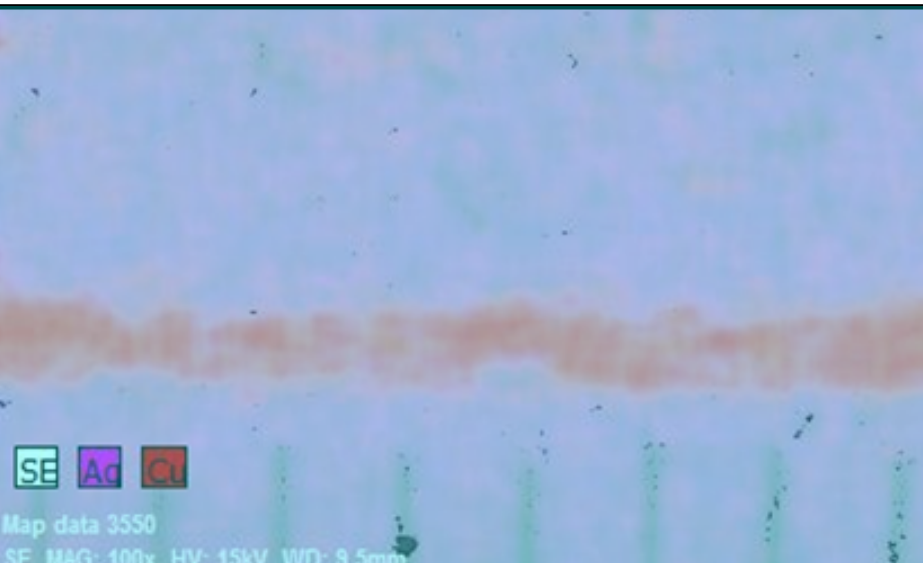
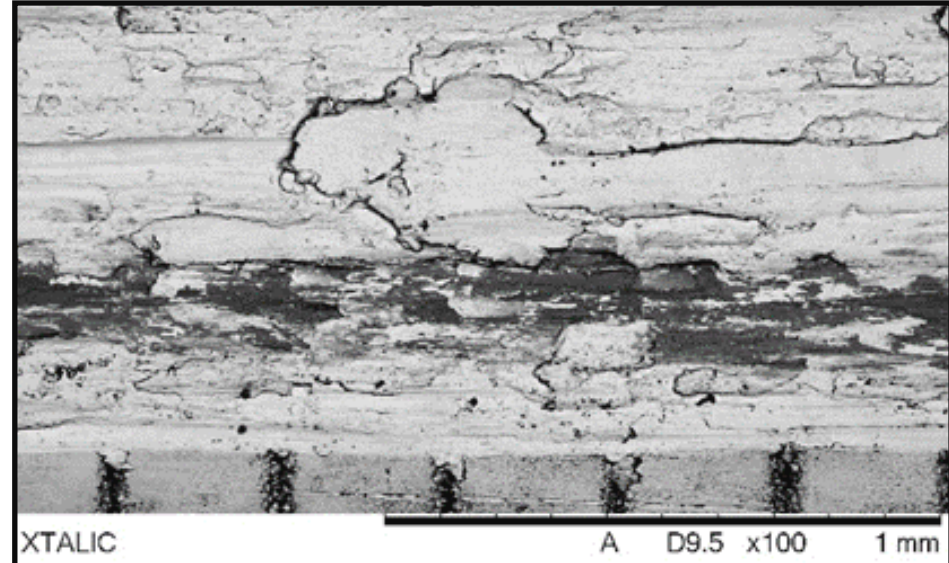


SEM micrograph

EDS map of surface

Cyanide Ag Coating, 20um

LUNA nano crystalline silver 5um



After 5000 wear cycles on a circular EV pin with 5N mating force:

← Exposed Cu and galling wear of Ag surface

← LUNA shows no evidence of significant wear or exposure of Cu

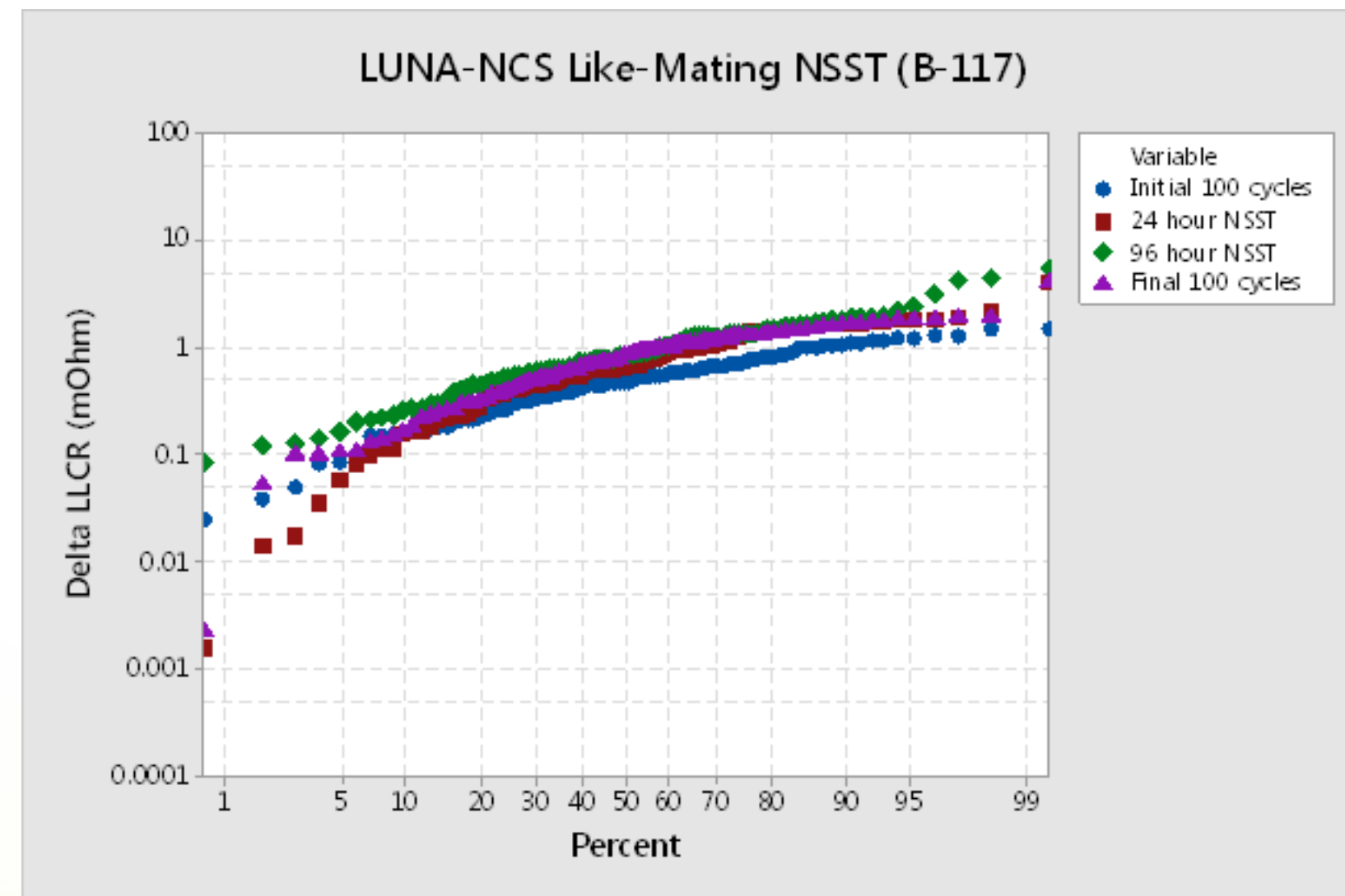
SAM corrosion inhibitor applied to all parts, without lubricant.

Increase Corrosion Protection with LUNA

Industry standard connector reliability tests

Neutral salt spray test (ASTM B-117)

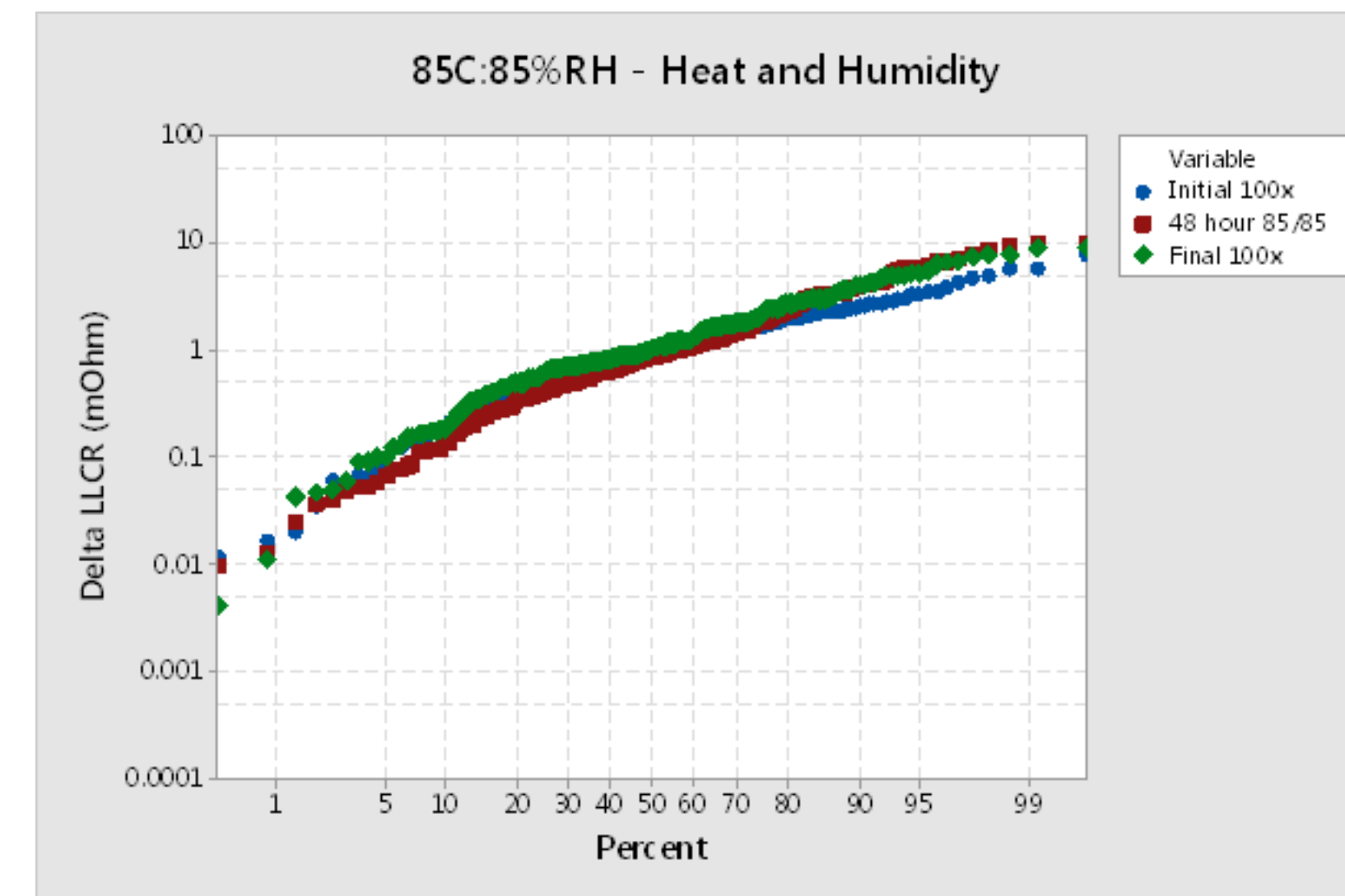
No observed issues up to 96 hours of exposure with 100x initial and final durability cycles



	Initial 100x	24 hour	96 hour	Final 100x
Maximum	1.52	4.14	7.37	6.03
Minimum	0.02	0.00	0.69	1.27
Mean	0.55	0.83	3.01	2.82
Median	0.48	0.65	2.85	2.87
Std.Dev.	0.35	0.67	0.93	0.70
>5 mOhm	0%	0%	4%	1%

85 C/85% - Heat and Humidity

No observed issues up to 48 hours of exposure with 100x initial and final durability cycles

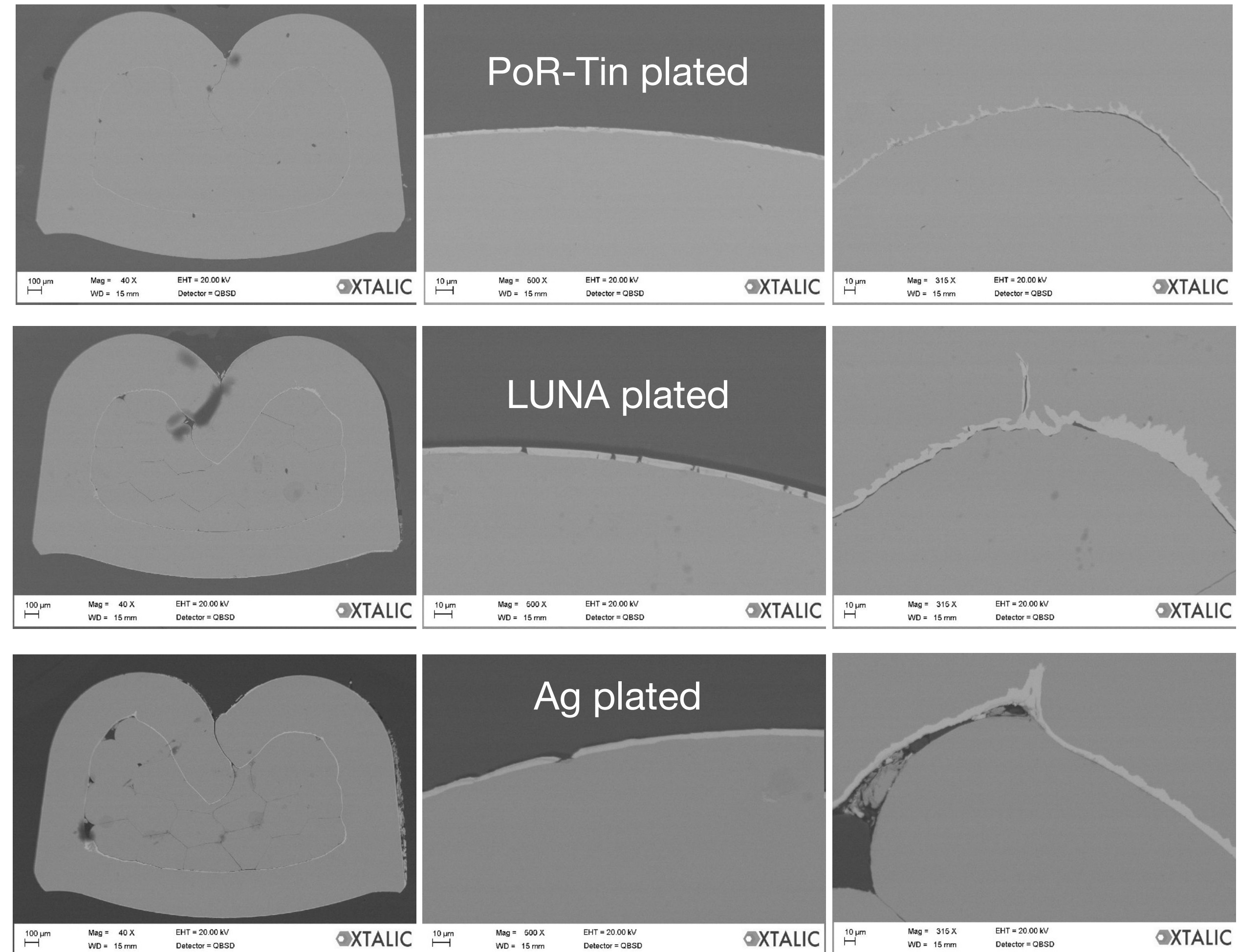


	Initial 100x	48 hour 85/85	Final 100x
Maximum	7.77	9.92	8.99
Minimum	0.01	0.01	0.00
Mean	1.23	1.55	1.68
Median	0.94	0.87	1.05
St.Dev.	1.14	1.90	1.74
> 5 mOhm	2%	7%	6%

LUNA Crimp Study

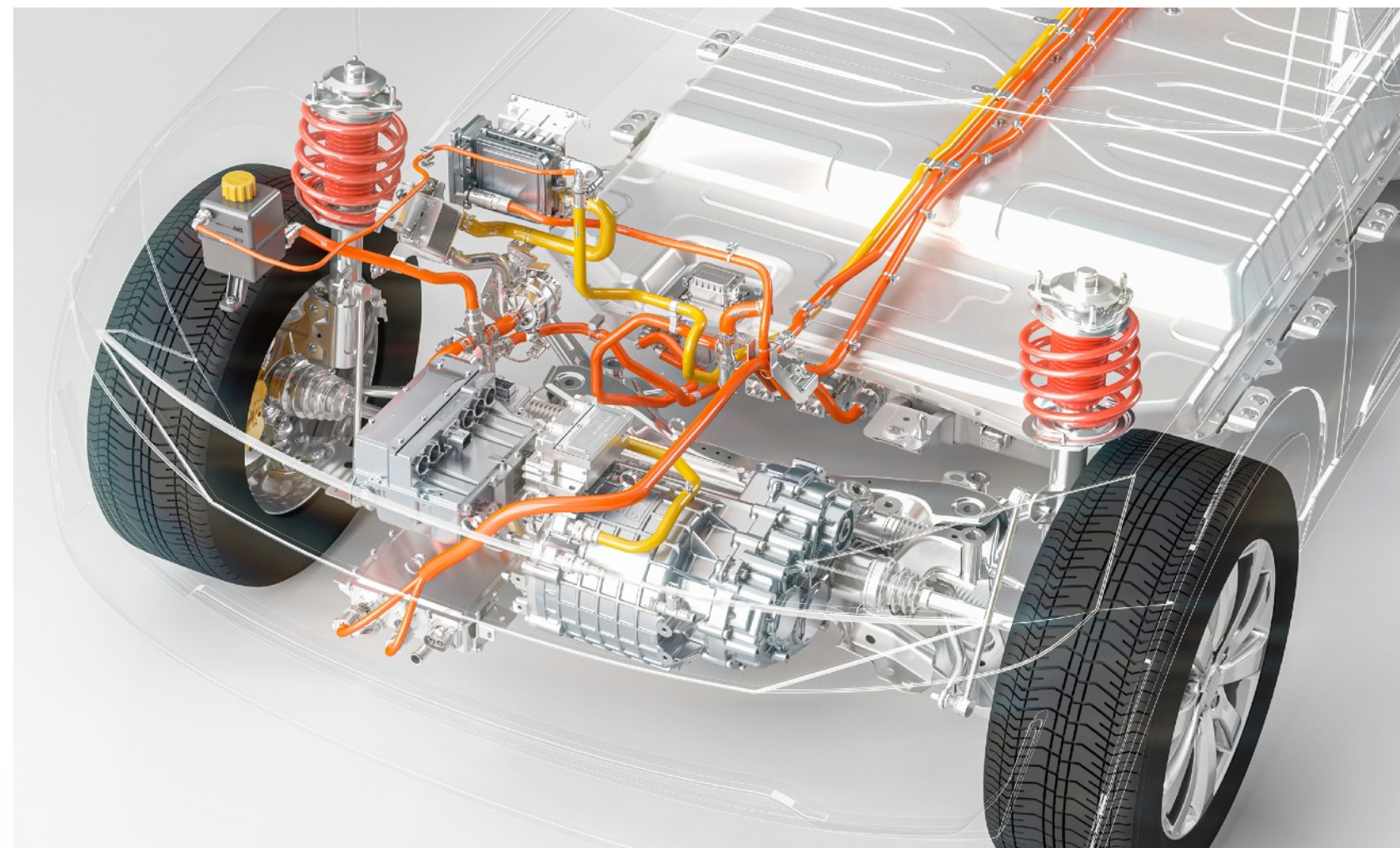
- TE 2.5mm, medium current contact
- F-crimp
- Materials:
 - Tin plated PoR
 - Compare to LUNA plated
- Crimp to copper wire
 - Recommended TE hand crimp tool
 - Target crimp height $1.85 \pm 0.03 \text{mm}$

Analyze crimp cross-sections for reliability



Performance Benefits for Electric Vehicles

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High power interconnects

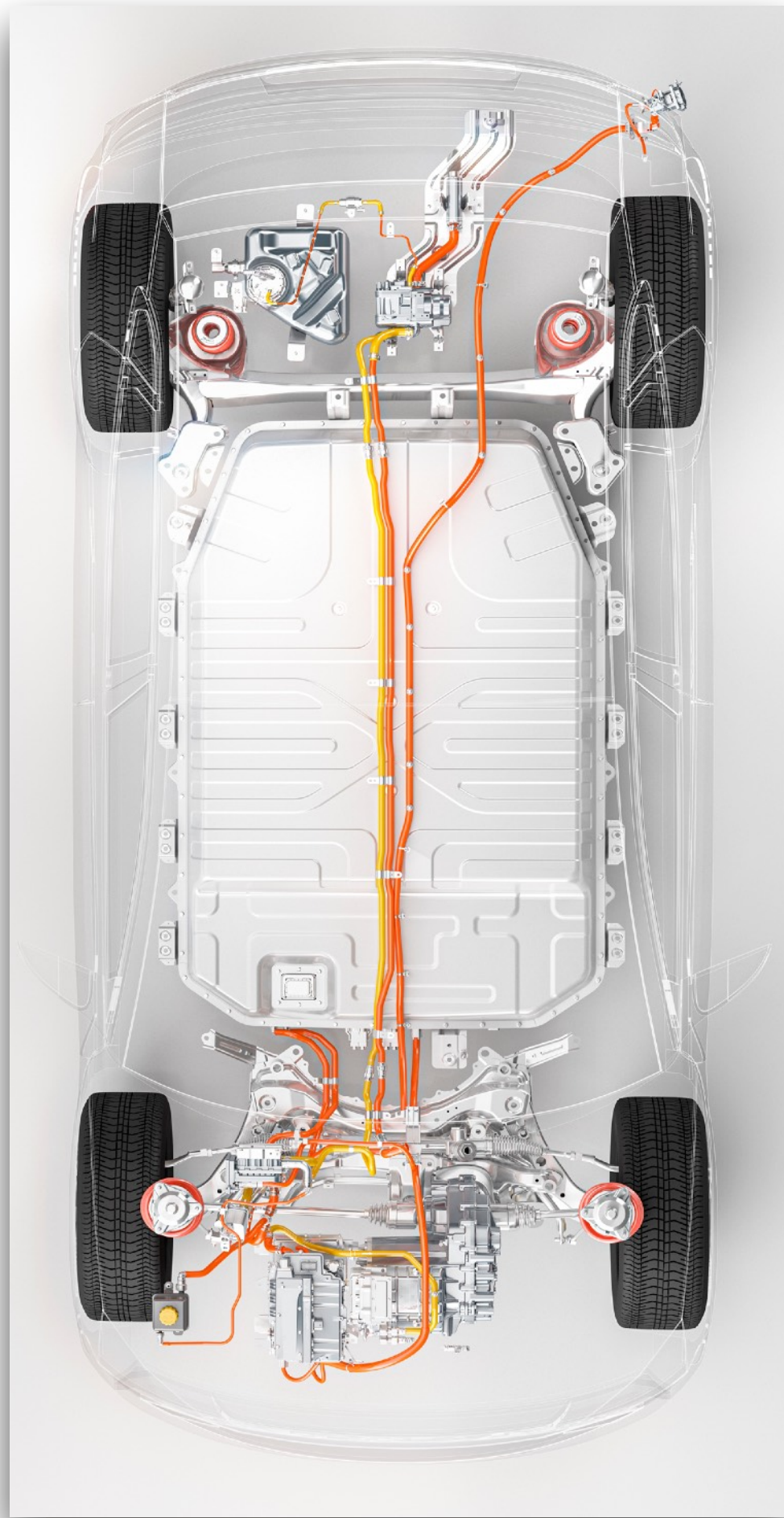
- Max operating temp = 220 C
- Low insertion force
- Crimp capable
- Cyanide free plating process



EV charger contacts

- Improved wear at 25% thickness
- Improved corrosion resistance

Xtalic Coatings Enable Emerging Product Requirements



Proposal for collaboration:

1. Identify specific part types and proposed value proposition
 - Extended charging port life with LUNA
 - Increased temperature range with LUNA
2. How do we collaborate for a new coating technology?
3. Select a project leader for technology evaluation and sampling

Aligning with your needs and process to adopt technology



Thank You!