Low Impedance Passivates for Electrical Connectors

K. L. Foster, J. B. Claypool, M. J. O'Keefe, W. G. Fahrenholtz

Missouri S&T

T. Nahlawi

Dipsol of America

S. P. Gaydos

Boeing

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WP18-F2-1439 Project Goals

- Develop trivalent chromium passivates (TCP) suitable for use on low hydrogen embrittlement (LHE) γ-ZnNi coatings used in DoD electrical connector assemblies
- Determine the mechanism that provides passivation behavior in Dipsol IZ-264 TCP coatings
- Develop and demonstrate a more reliable contact resistance test method to replace MIL-DTL-81706

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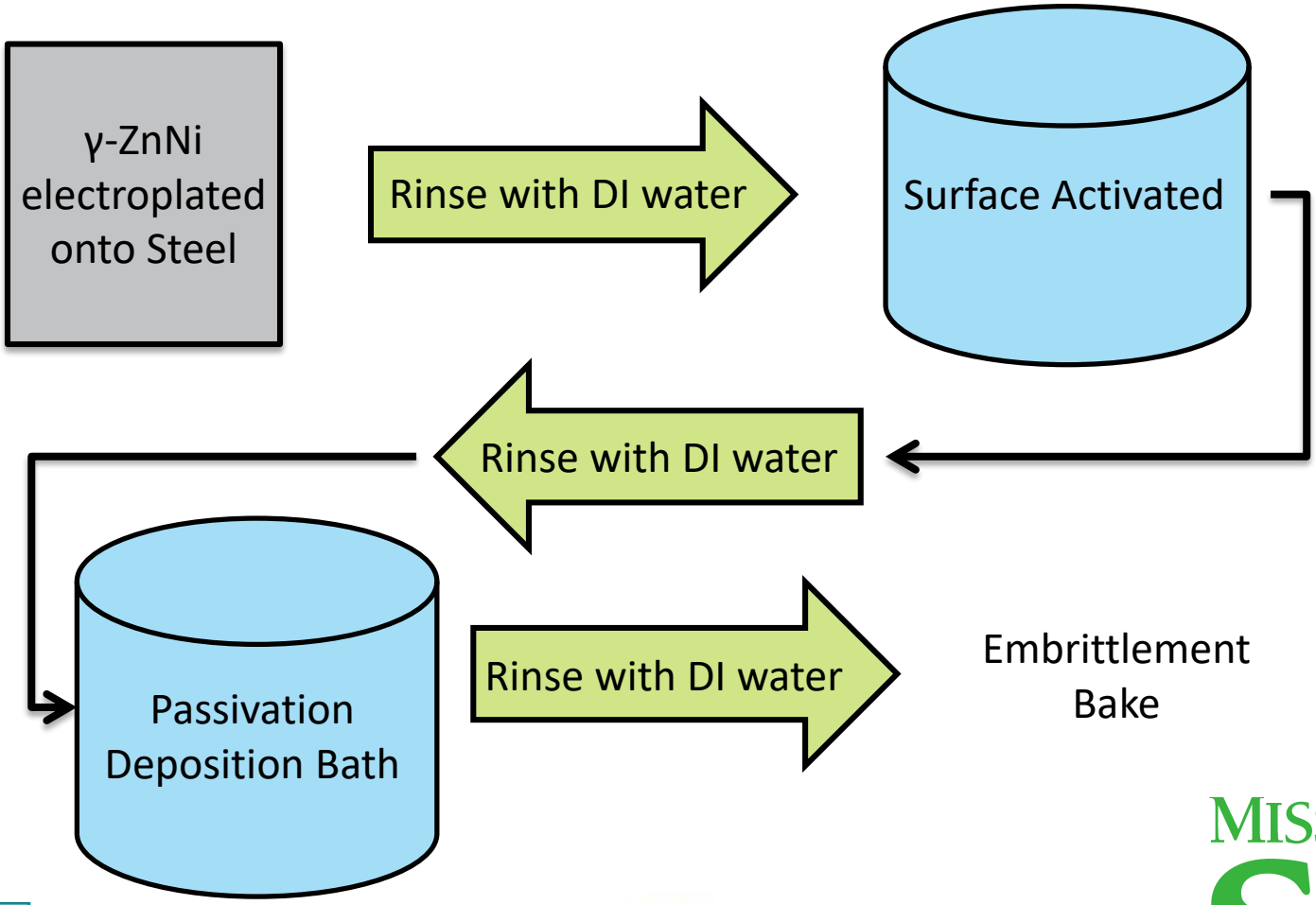
WP SEED-2527 Passivates

- Six different passivates were examined, four chromium based
  - Dipsol
    - IZ-264 trivalent chromium passivate (TCP)
    - Cobalt-free trivalent chromium passivate (Co-Free)
    - Modified cobalt-free trivalent chromium passivate (Co-Free Mod)
    - IZ-258 hexavalent chromate passivate (CrCC); used as control
- TCP and Co-Free Mod performed best and will be further developed and characterized under WP18-F2-1439

Tri/Hexavalent Chromate Deposition Process



Sample Evaluation

- Electrochemical analysis
  - Cyclic Potentiodynamic Scan
  - Electrochemical Impedance Spectroscopy (EIS)
    - Electrolyte: 0.6 M $(NH_4)_2SO_4$ and 0.6 M NaCl
    - Saturated calomel reference
- Corrosion performance
  - ASTM B117
    - Evaluated at 100 hr. intervals for 1000 hrs.
- FIB/SEM/EDS analysis
- X-Ray Diffraction analysis
- Contact resistance: MIL-STD-81706B
  - 5 measurements on each panel
  - Measured 0 hrs., 100 hrs., and 1000 hrs. ASTM B117

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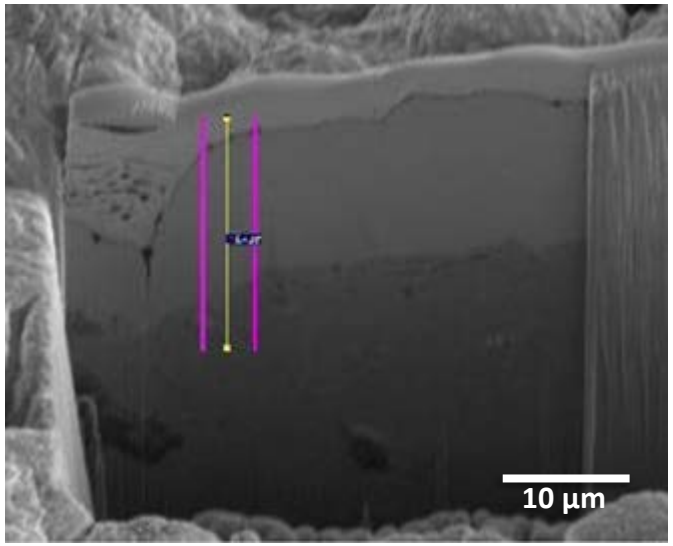
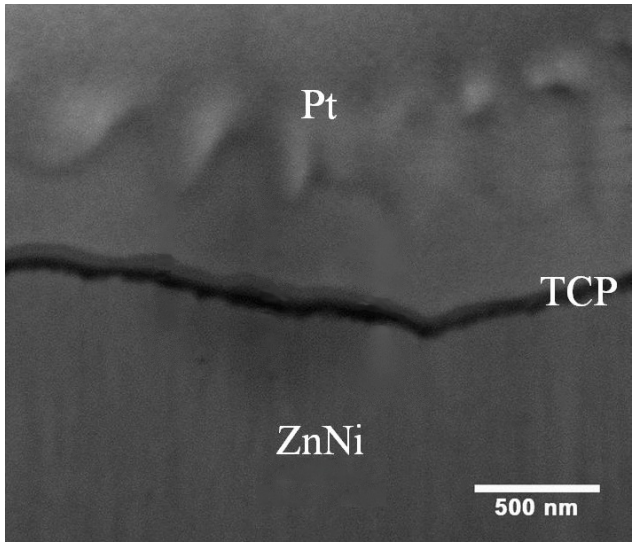
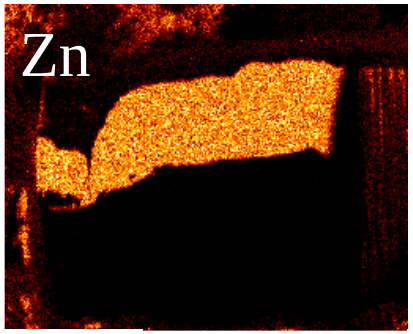
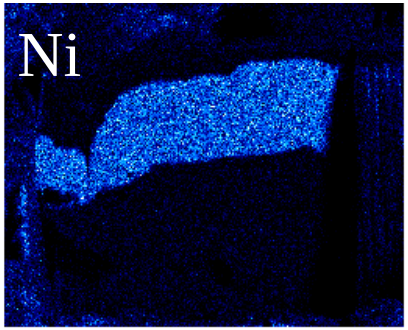
Focused Ion Beam Cross-Sections

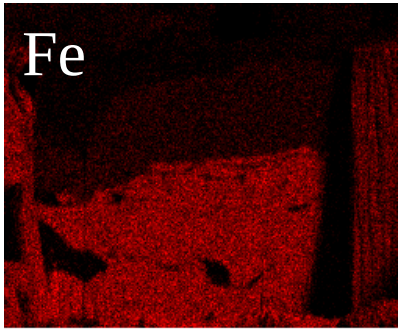




TCP Thickness ~ 100 nm







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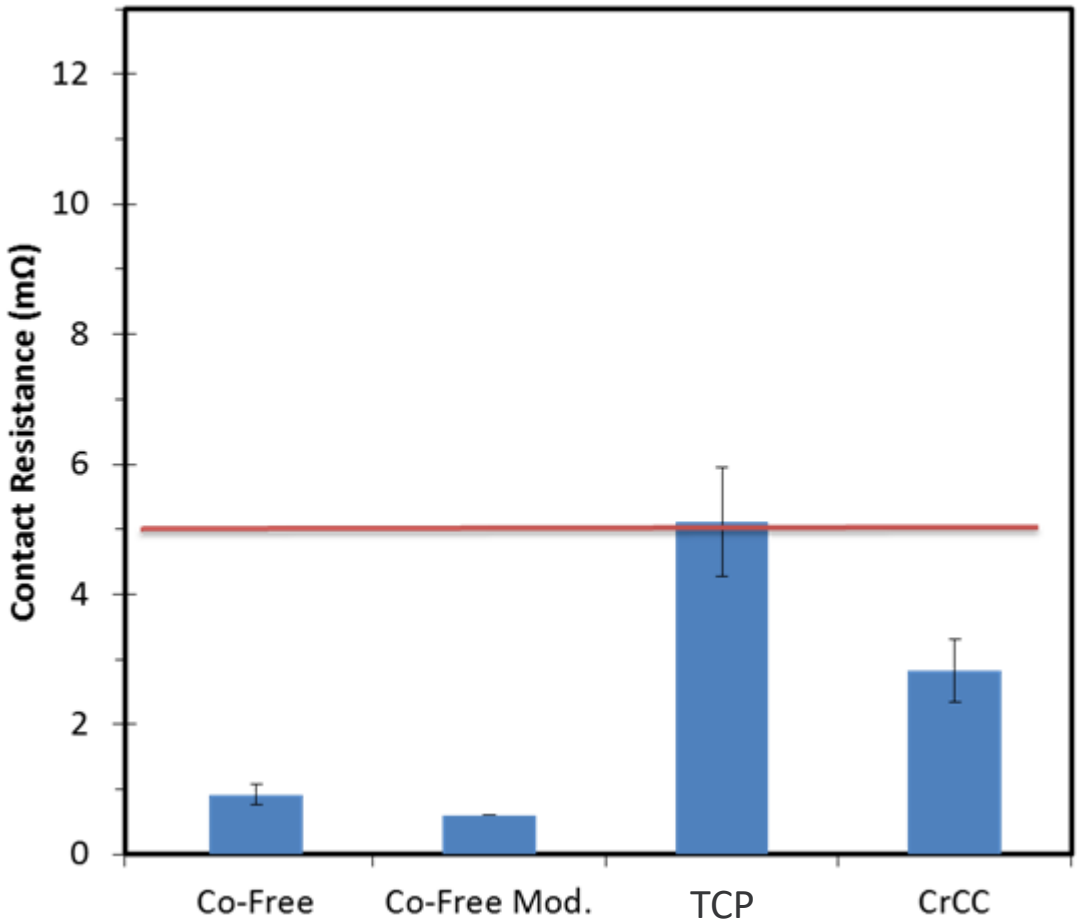
As-Deposited Contact Resistance



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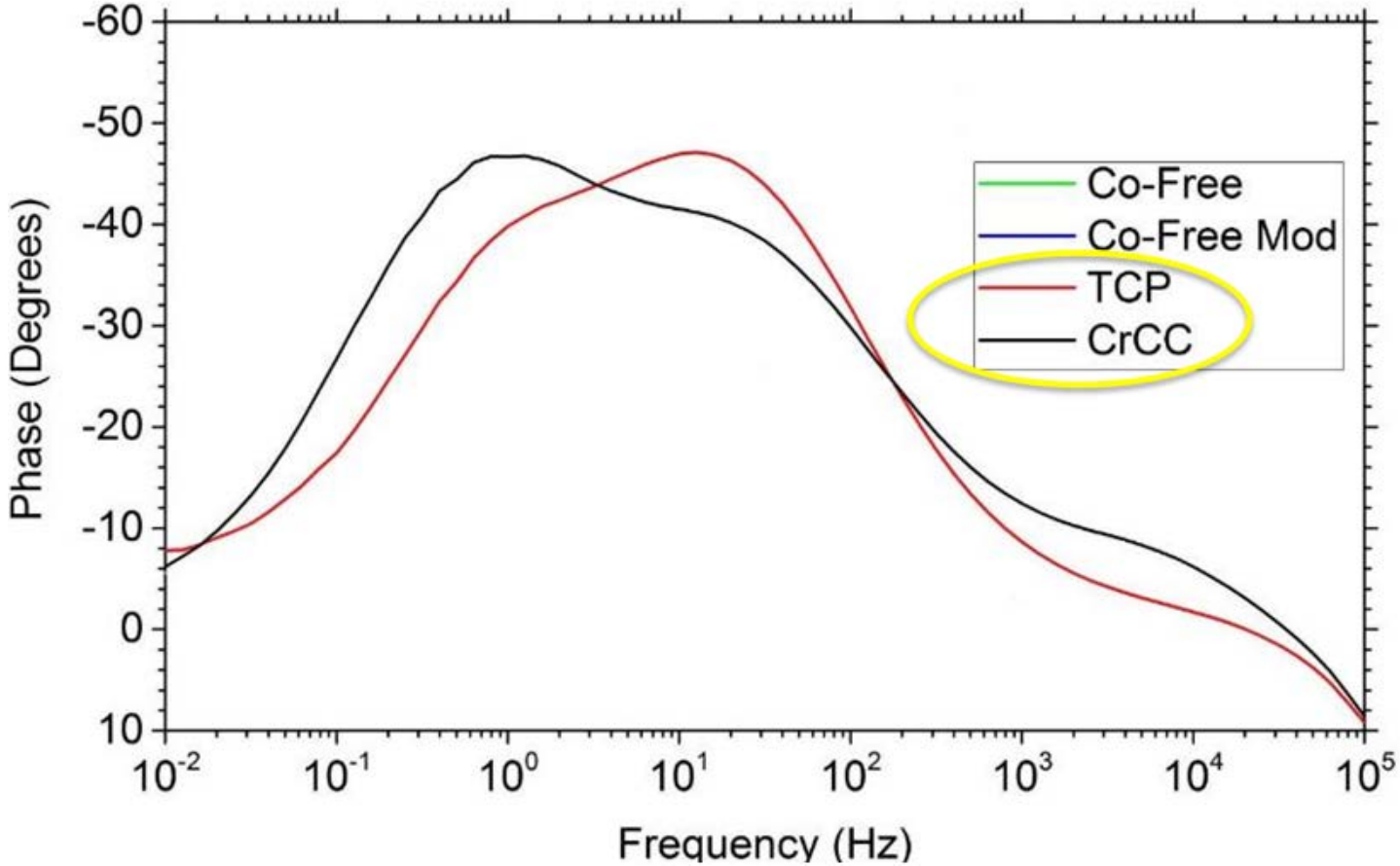
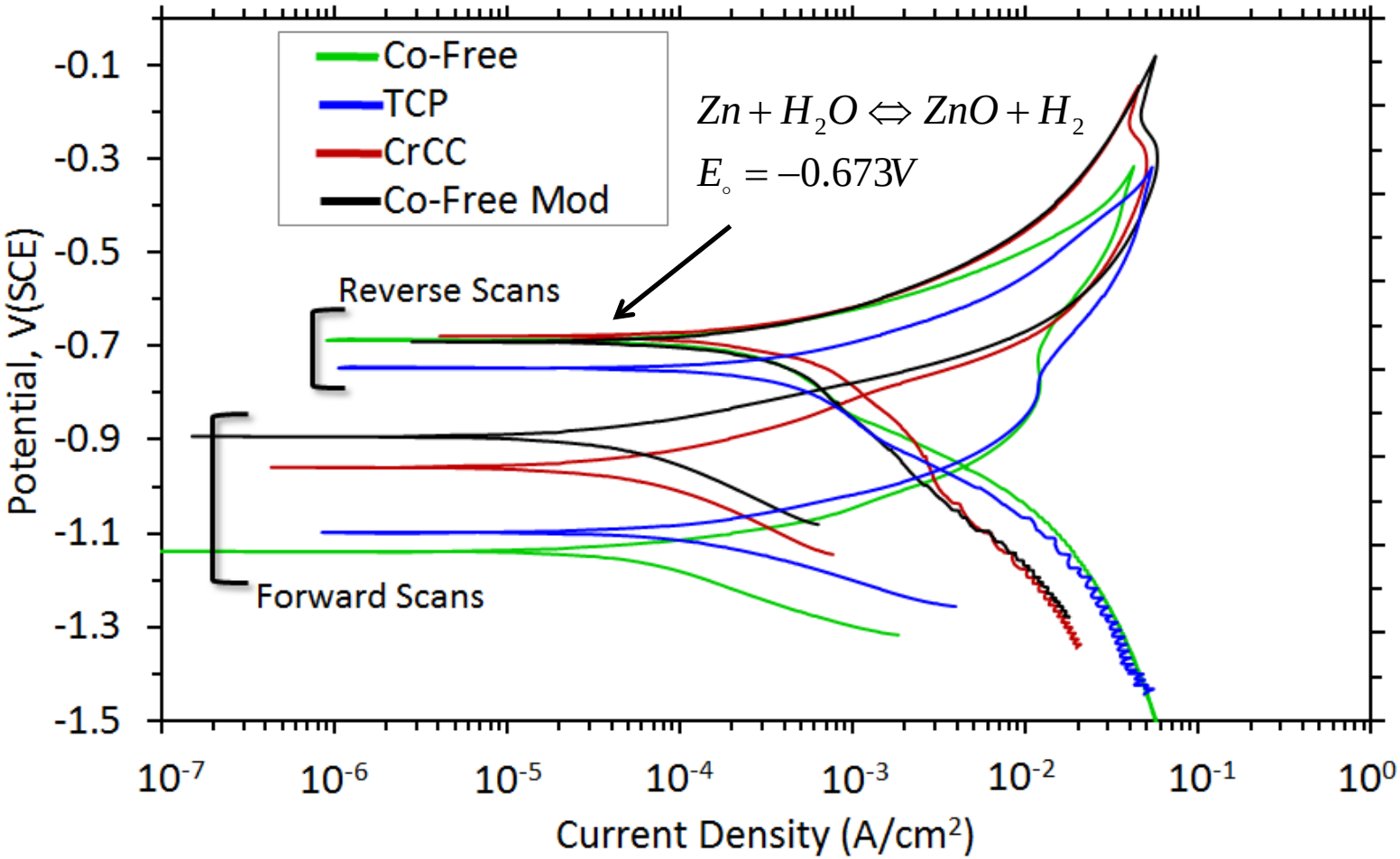
As-Deposited Bode Phase Angle Plots



As-Deposited Polarization Curves



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Before and After 1000 Hours of Salt Spray Testing (SST)

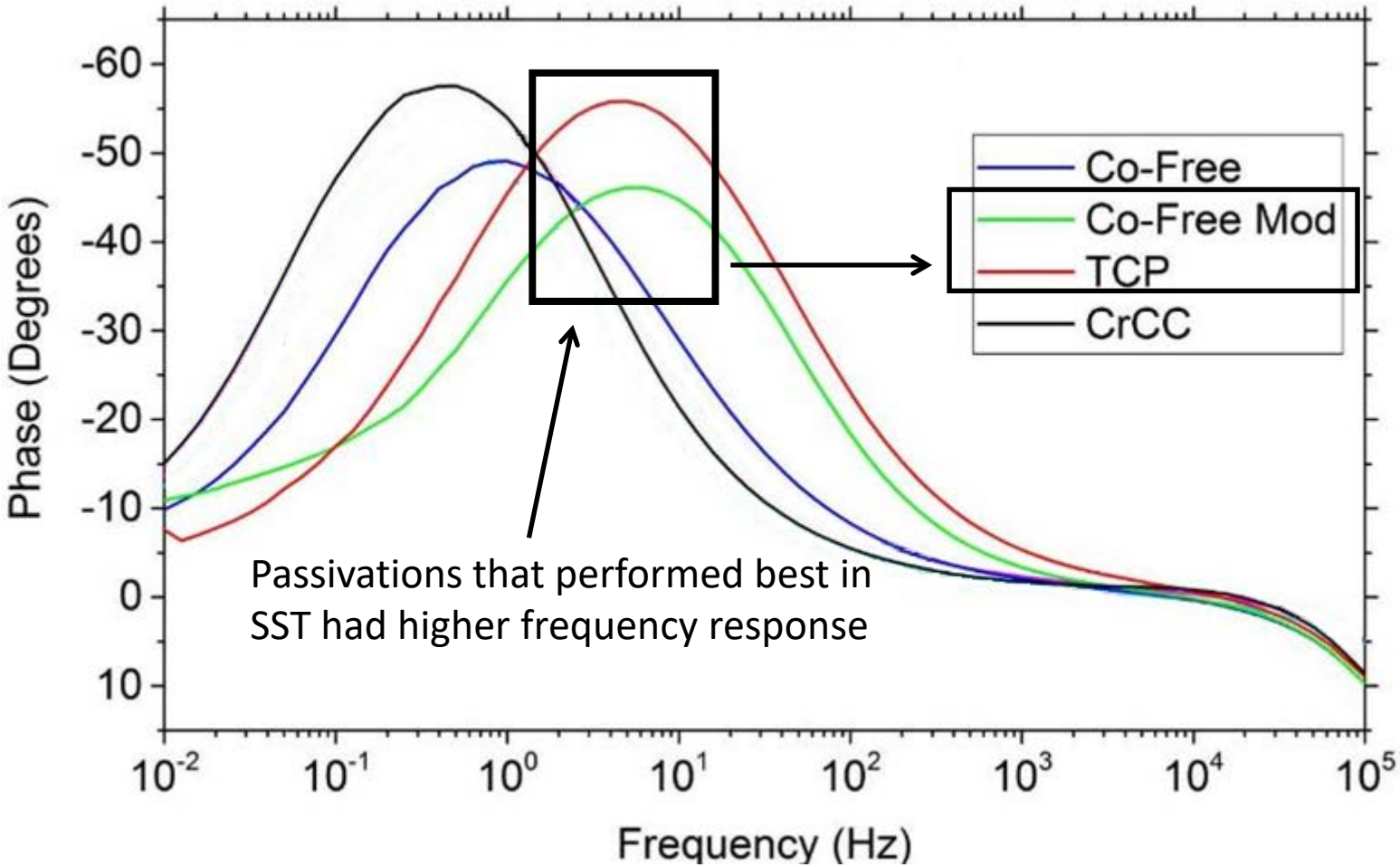
Co-Free

Co-Free Mod

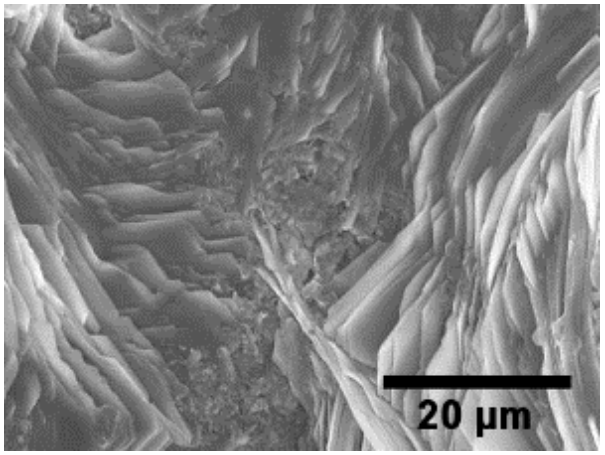
CrCC

TCP

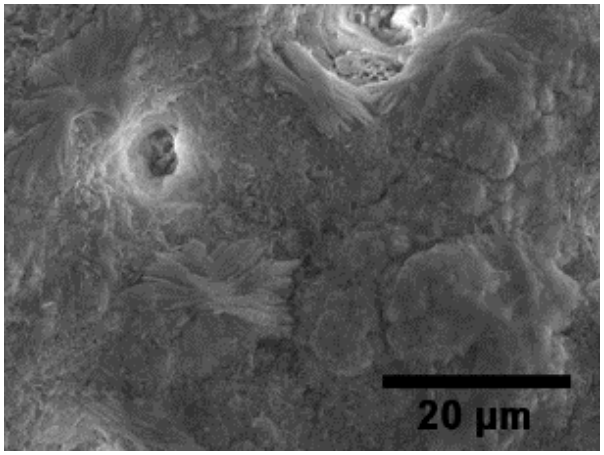
Bode Phase Angle Plots after 1000 Hours SST



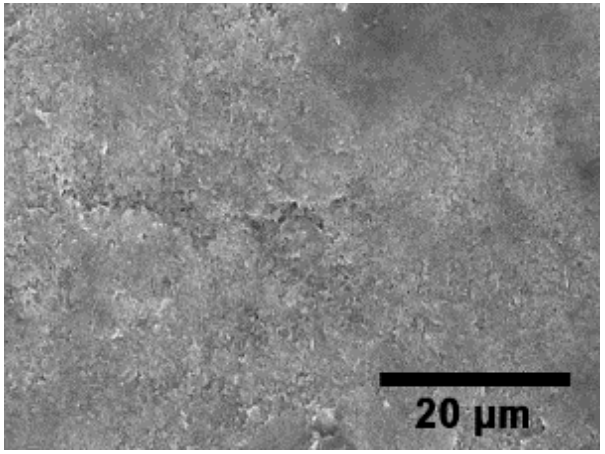
Corrosion Product Morphology After 1000 Hours SST



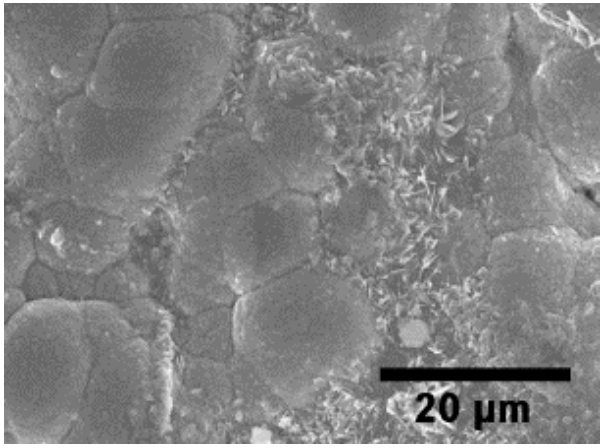
Co-Free



Co-Free Mod



CrCC



TCP

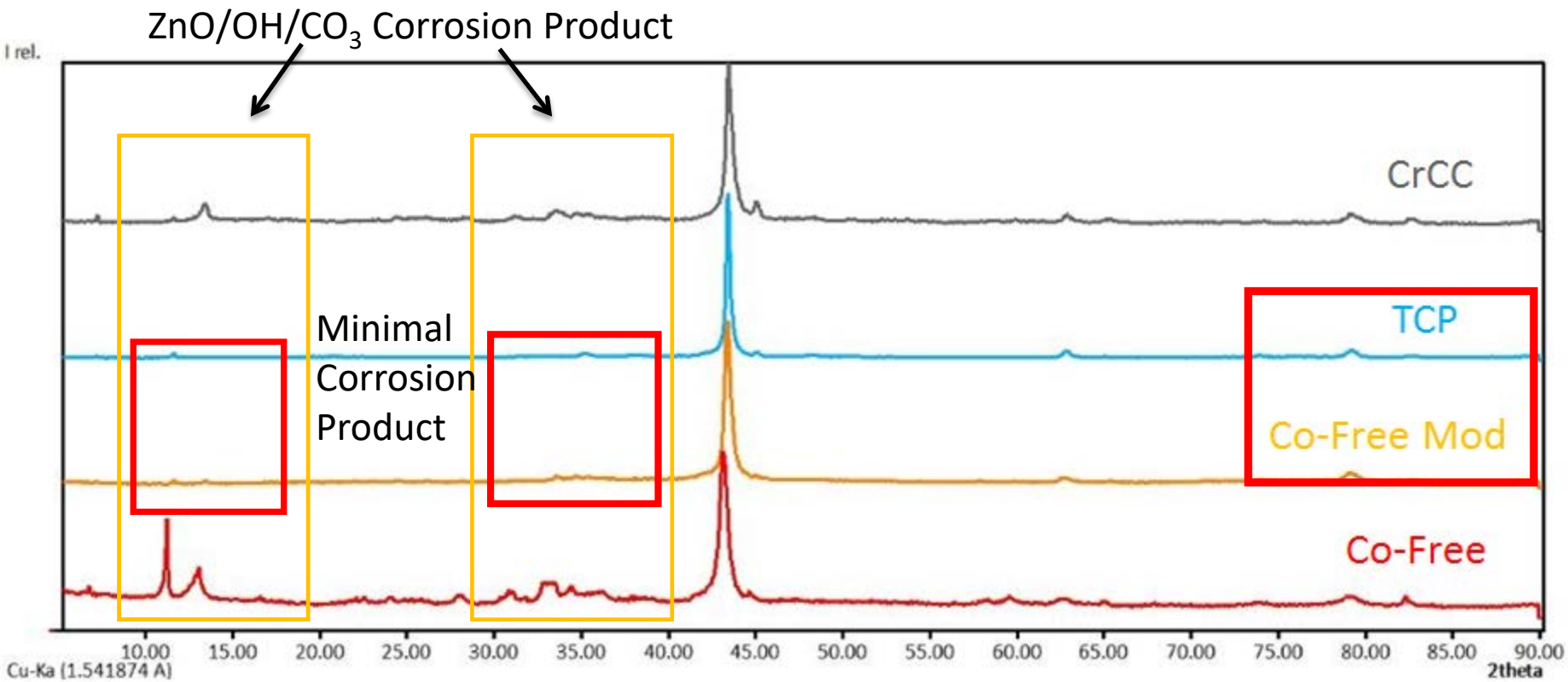
Corrosion Product Composition

Atomic % (EDS)					
	Co-Free	Co-Free Mod	TCP	CrCC	ZnNi (XRF)
Ni	1	7	11	1	14
Zn	39	23	63	52	86
O	46	65	22	44	0

> Co-Free Mod and TCP surface had little/no corrosion product

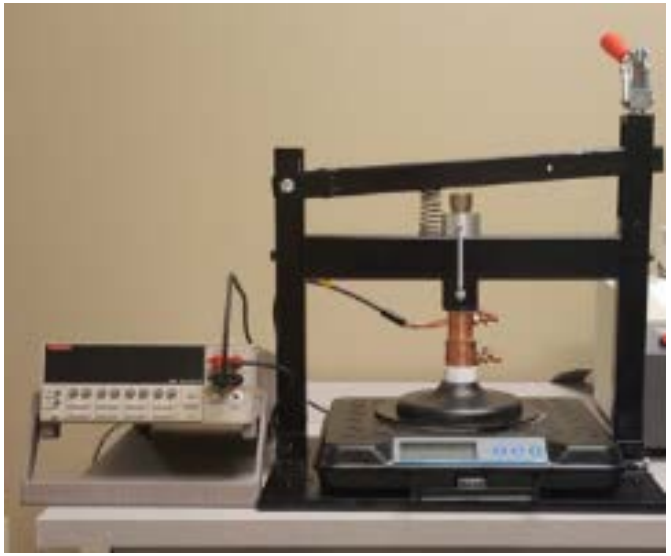
- EDS detected higher Ni signal where no corrosion visible

X-Ray Diffraction after 1000 Hours SST

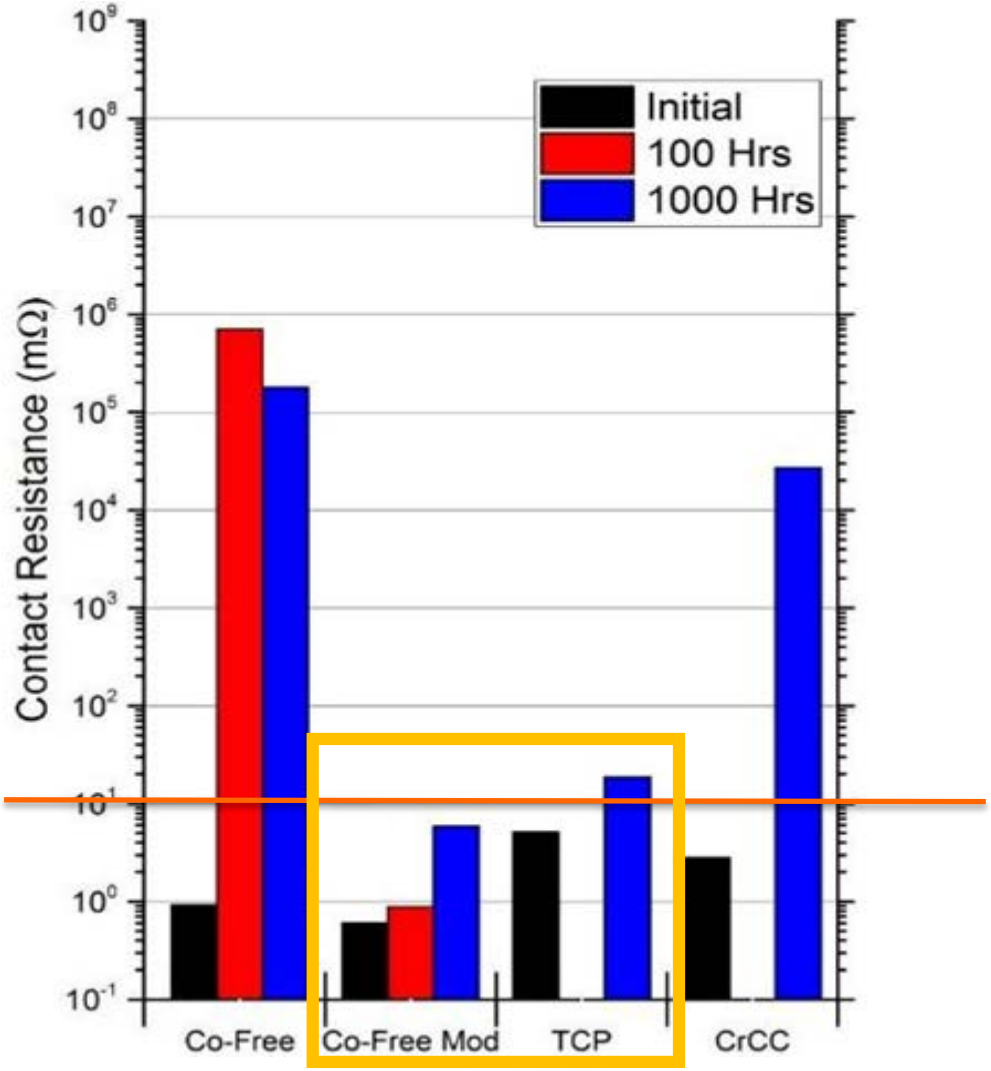


Electrical Contact Resistance Setup

- MIL-STD-81706B
  - 200 ψ 2 psi pressure on sample
  - Cu or Ag-plated Cu Electrodes
  - 120 grit or finer electrode roughness
  - Top electrode 1 in^2, bottom larger
- Less than 5 mΩ initial contact resistance
- Less than 10 mΩ contact resistance after SST



Electrical Contact Resistance



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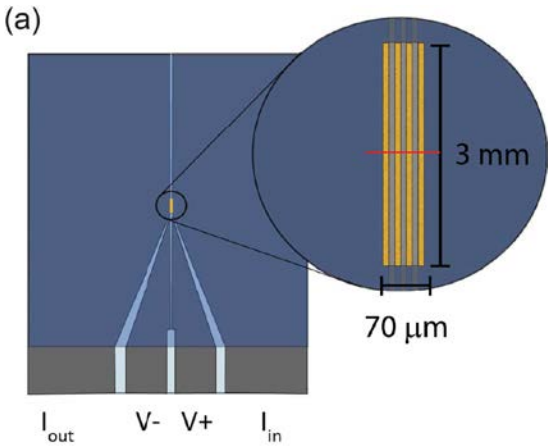
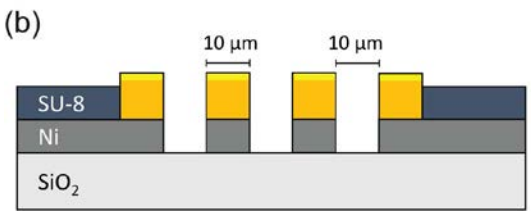
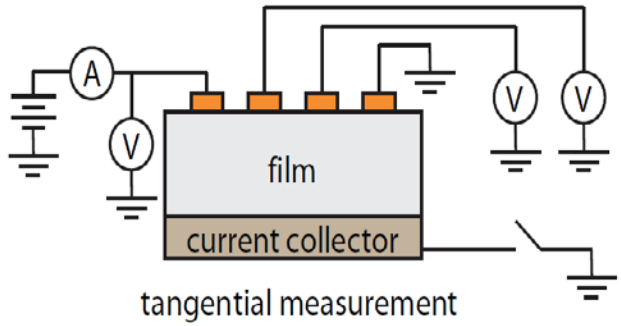
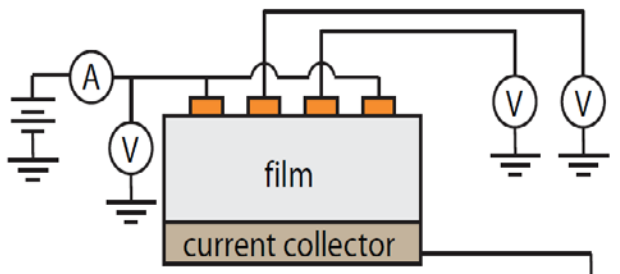
Alternative Electrical Contact Resistance Method



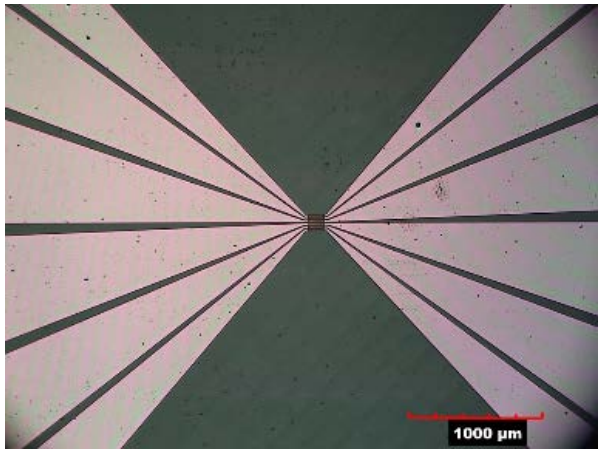


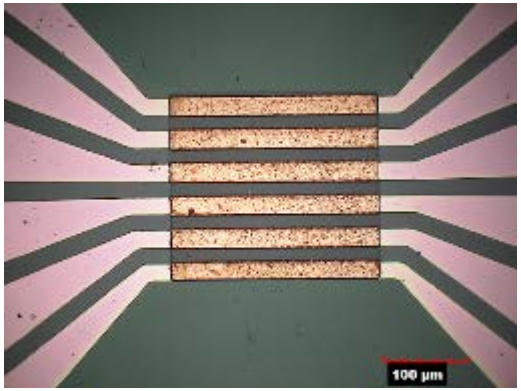


tangential measurement



orthogonal measurement





> Capable of measuring resistance on curved surfaces

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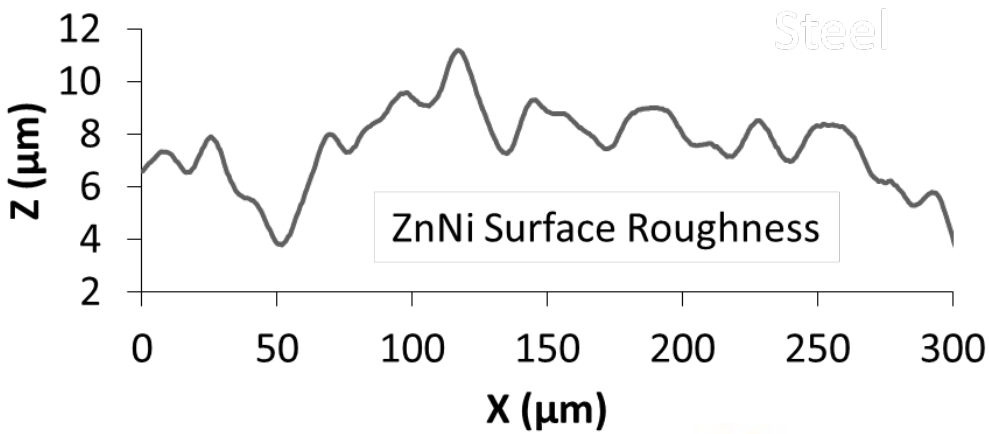
Deconvolution of Electrochemical Impedance Spectroscopy Data

- Test samples show large variability in surface roughness
- Compare polished and unpolished substrates to determine effect of roughness
- Vary passivate thickness and use XPS + XRD to give Bode plot peaks physical meaning



Future Work

- Design of experiments process parameter optimization of Dipsol IZ-264 TCP and Co-Free Mod passivates
- Develop, test, and iterate on the microprobe for an alternate contact resistance testing method to MIL-STD-81706
- Test against MIL-DTL-38999 and analyze optimized TCP passivates on fabricated DoD electrical connector assemblies
- Create a comprehensive model for TCP protection on LHE ZnNi coatings in corrosive environments