Low Impedance Passivates for Electrical Connectors

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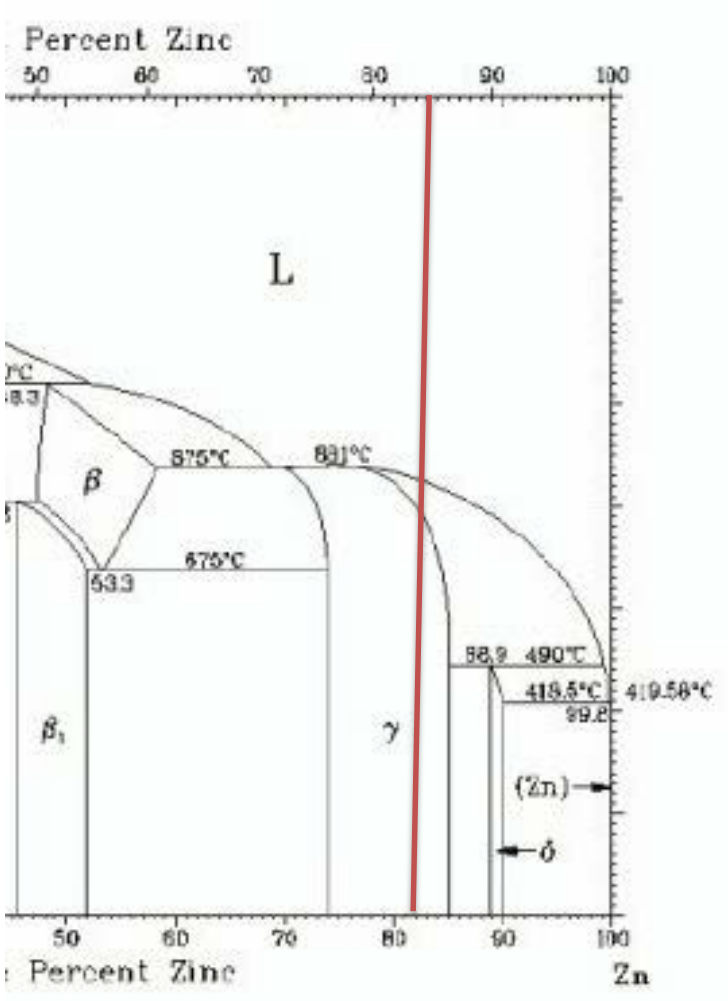
FY 15 SEED Statement of Need

- Develop Technologies for the Passivation of Corrosion Resistant Coatings used in DoD Electrical System Components that do not use Hexavalent Chromium
- Must be Compatible with Low Hydrogen Embrittlement (LHE) alkaline ZnNi Coatings

γ-ZnNi Coating

- Zn-14Ni Advantages
  - Environmentally benign
  - Sacrificial to steel during corrosion
  - Corrodes slowly
  - Low hydrogen embrittlement
  - Approved for aerospace applications
- Requires Passivation Coating:
  - Maintain low contact resistance in corrosive environment

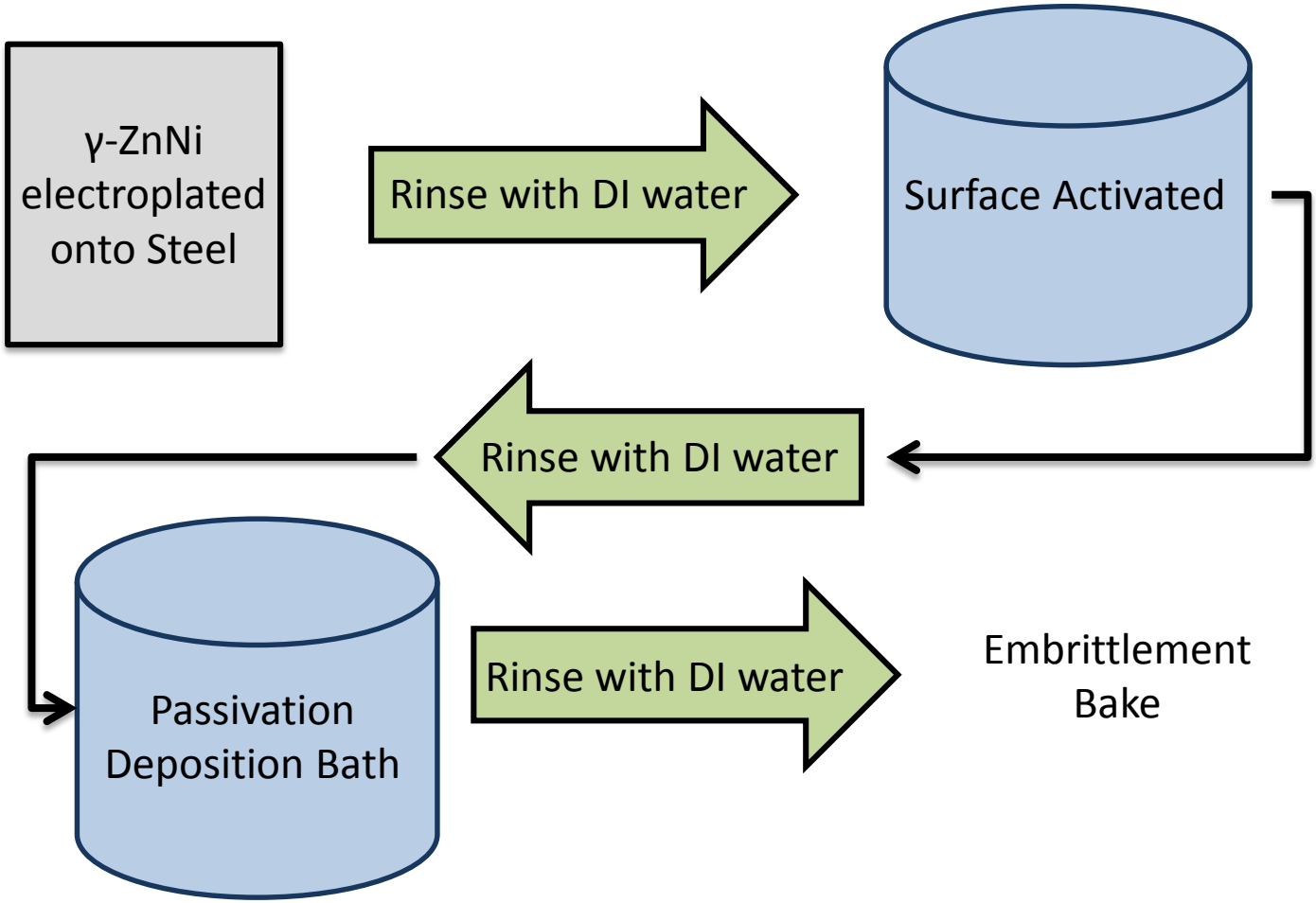


Passivations Investigated

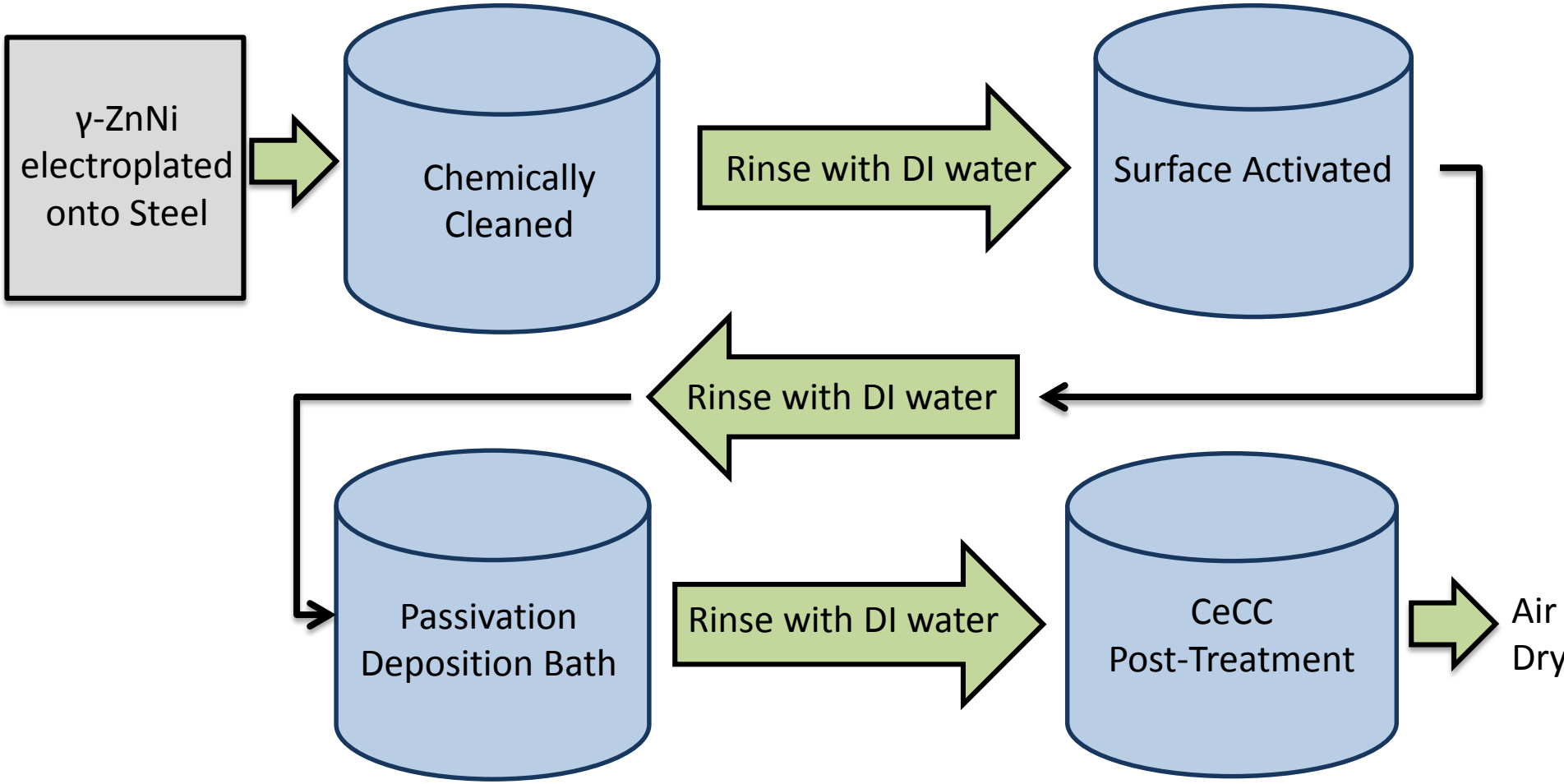
- Dipsol passivations
  - Trivalent chromium passivation (TCP); IZ-264
  - Cobalt-free trivalent chromium passivation (Co-Free)
  - Modified Cobalt-free trivalent chromium passivation (Co-Free Mod)
  - Hexavalent Chromate (CrCC) used as control; IZ-258

- S&T passivations
  - Cerium-based passivation (CeCC)
    - Cerium Chloride or Cerium Nitrate deposition based solution

Tri/Hex Chrome Deposition Procedure

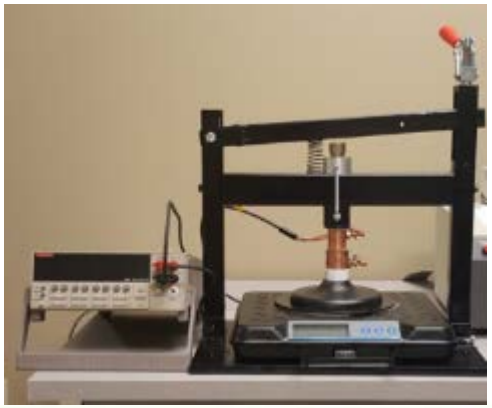


Cerium-based Passivation Deposition Procedure

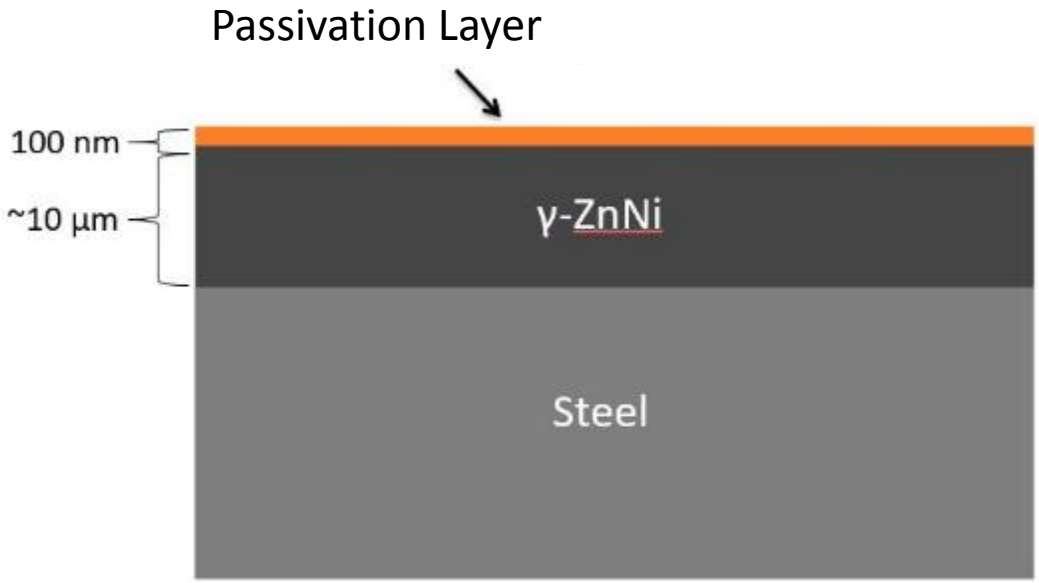


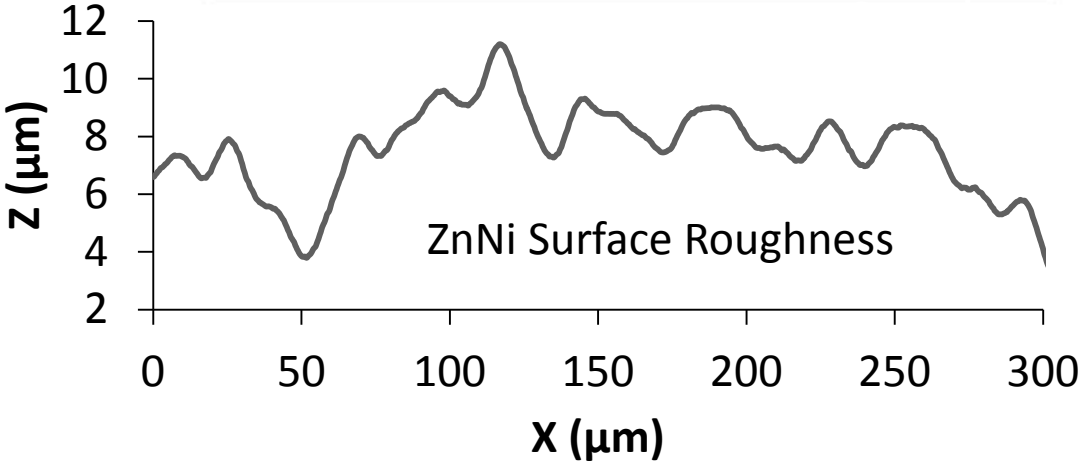
Sample Evaluation

- Electrochemical analysis
  - Cyclic Potentiodynamic Scan
  - Electrochemical Impedance Spectrocopy
    - Electrolyte: 0.6 M $(NH_4)_2SO_4$ and 0.6 M NaCl
- Corrosion performance
  - ASTM B117
    - Evaluated at 100 hr. intervals for 1000 hrs.
- 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

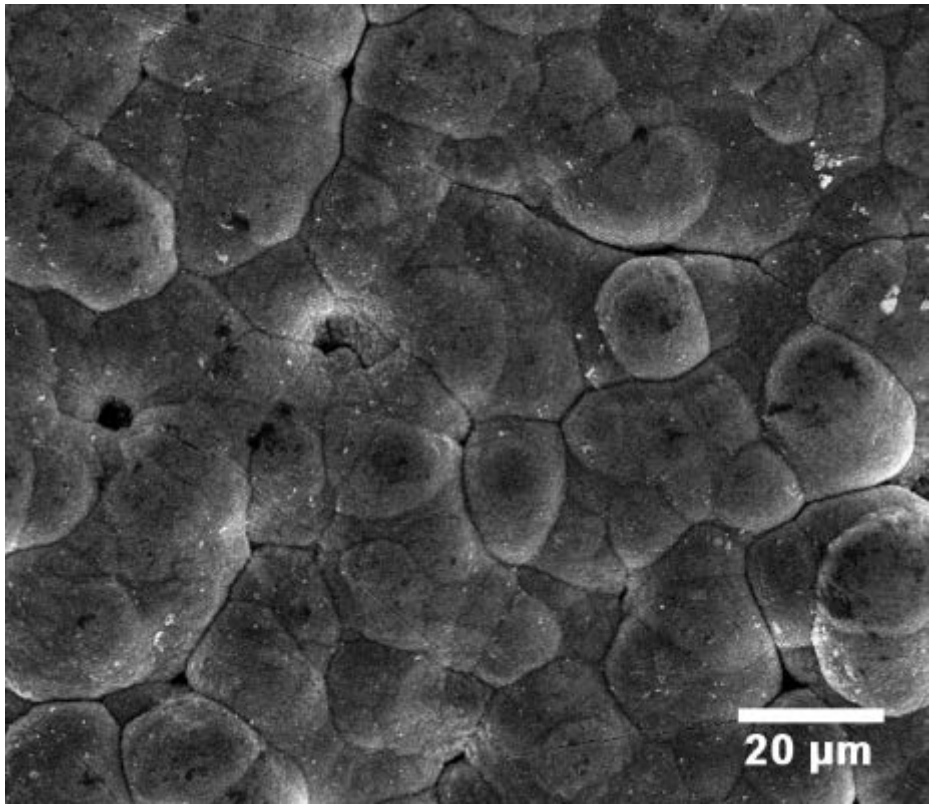


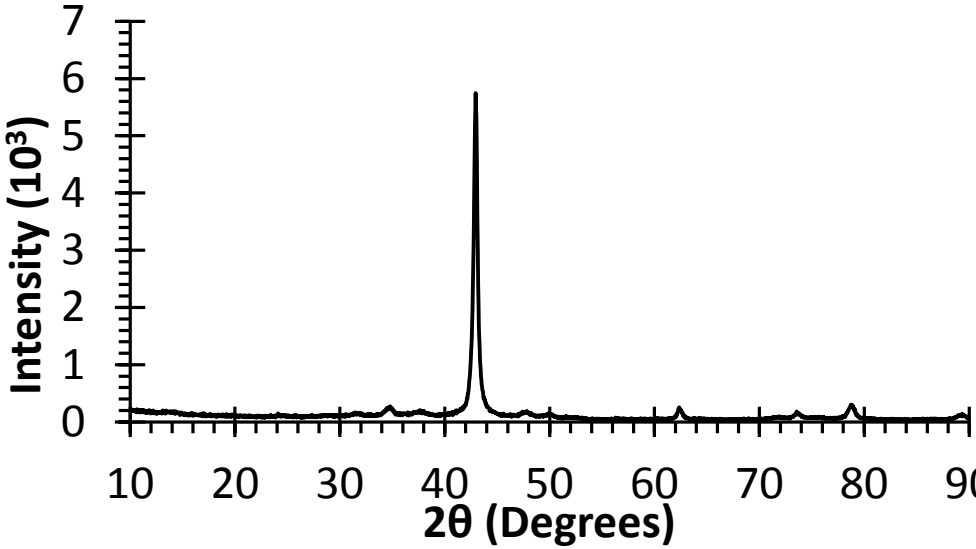
Coating System

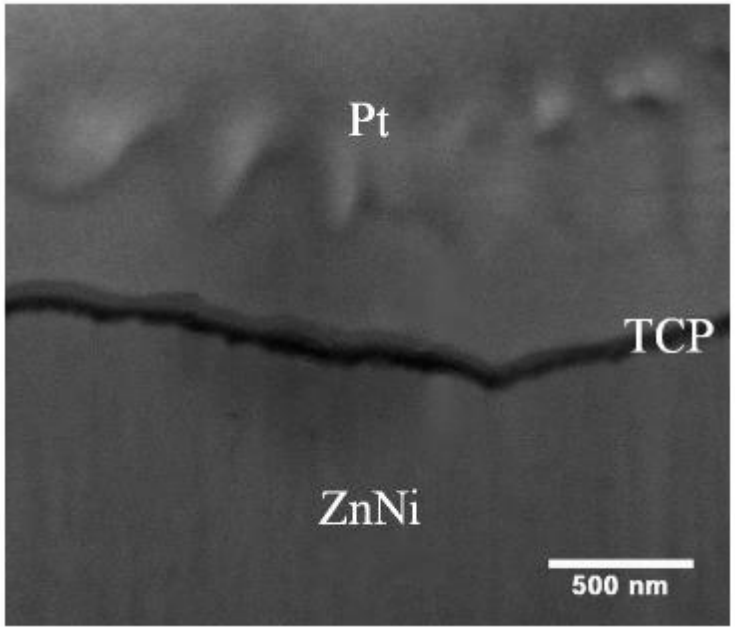




γ-ZnNi Coatings

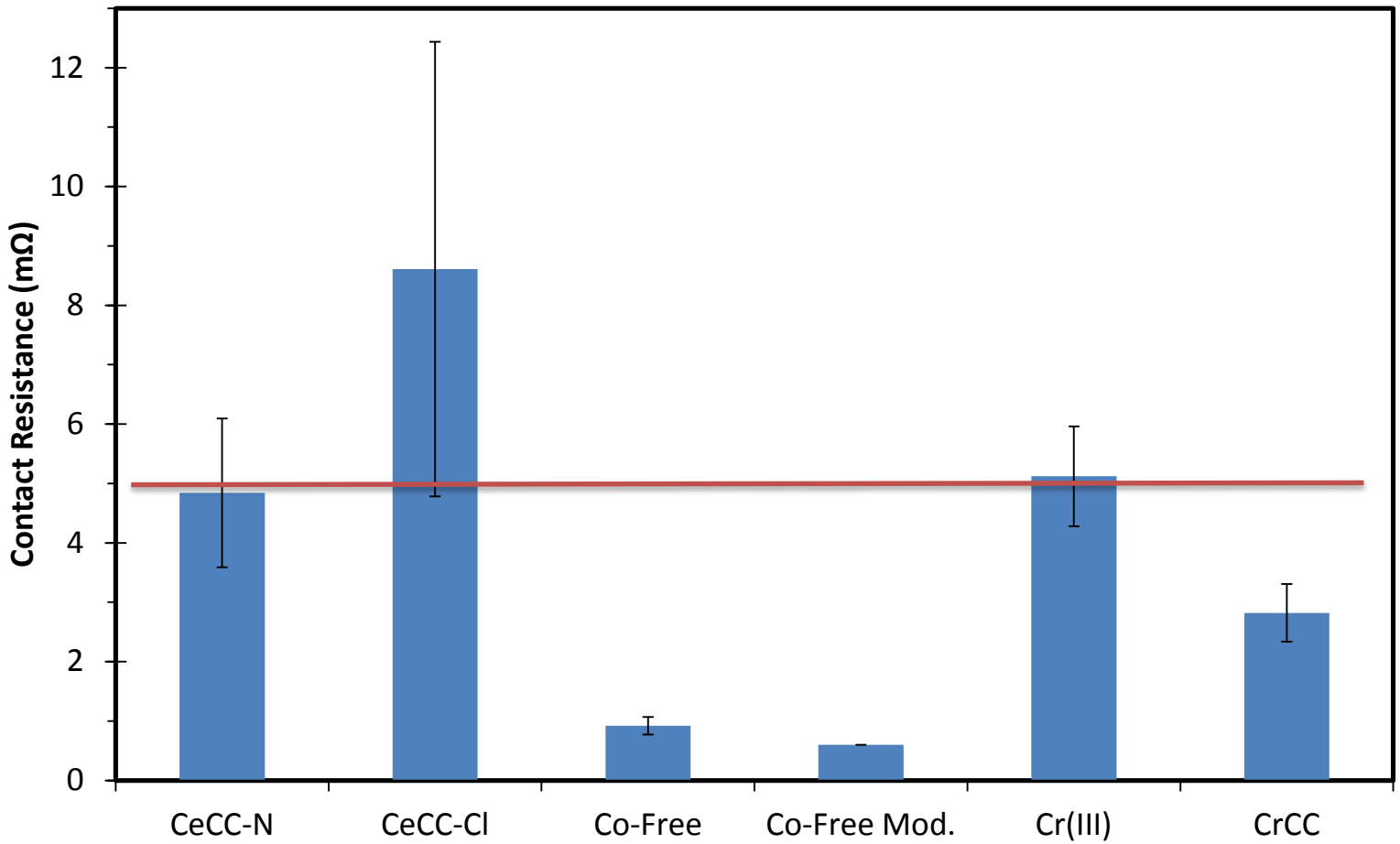




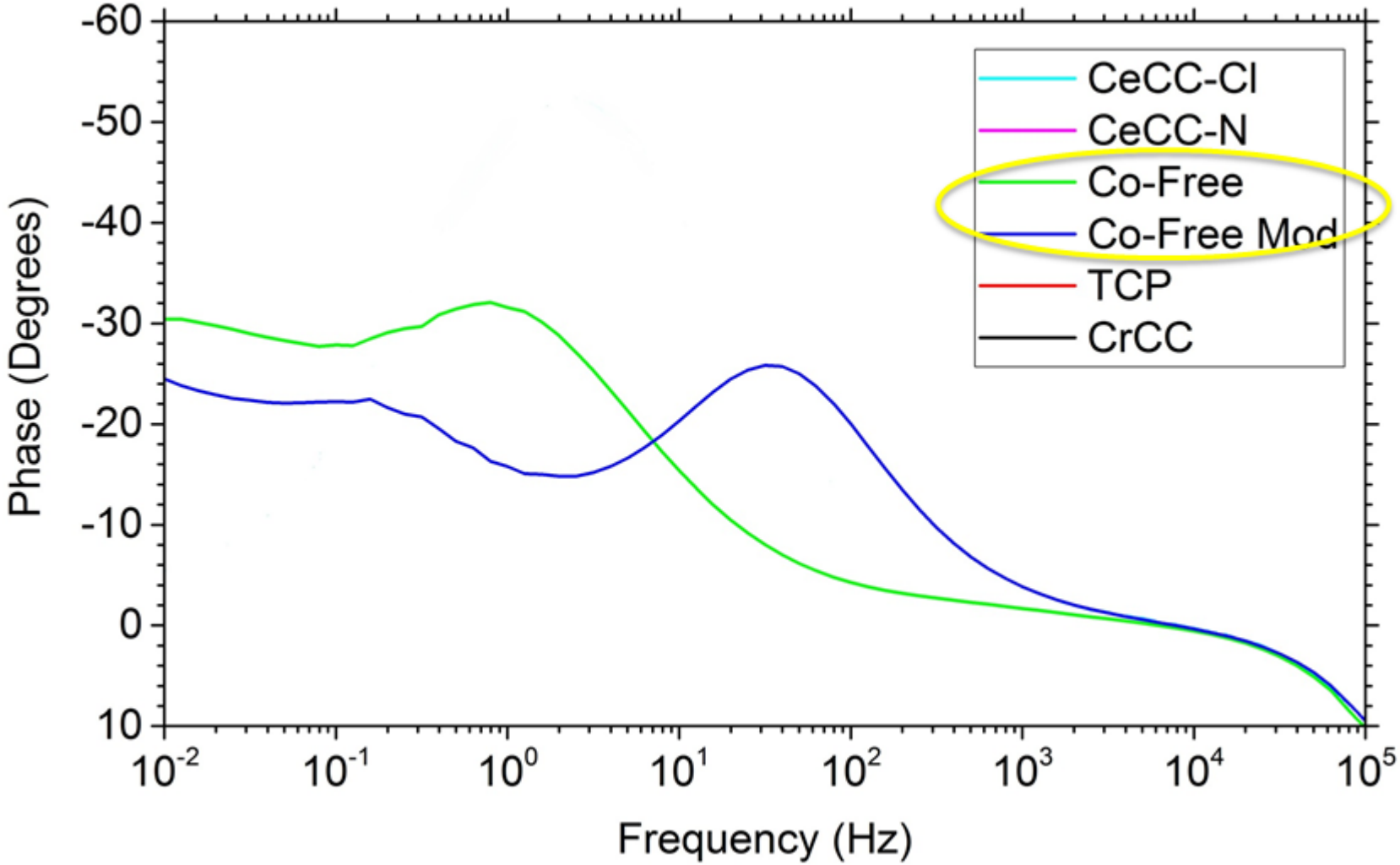


- Grain size is ~20 µm for as-deposited γ-ZnNi
- XRD only detected γ-ZnNi
- Passivations are ~100 nm thick

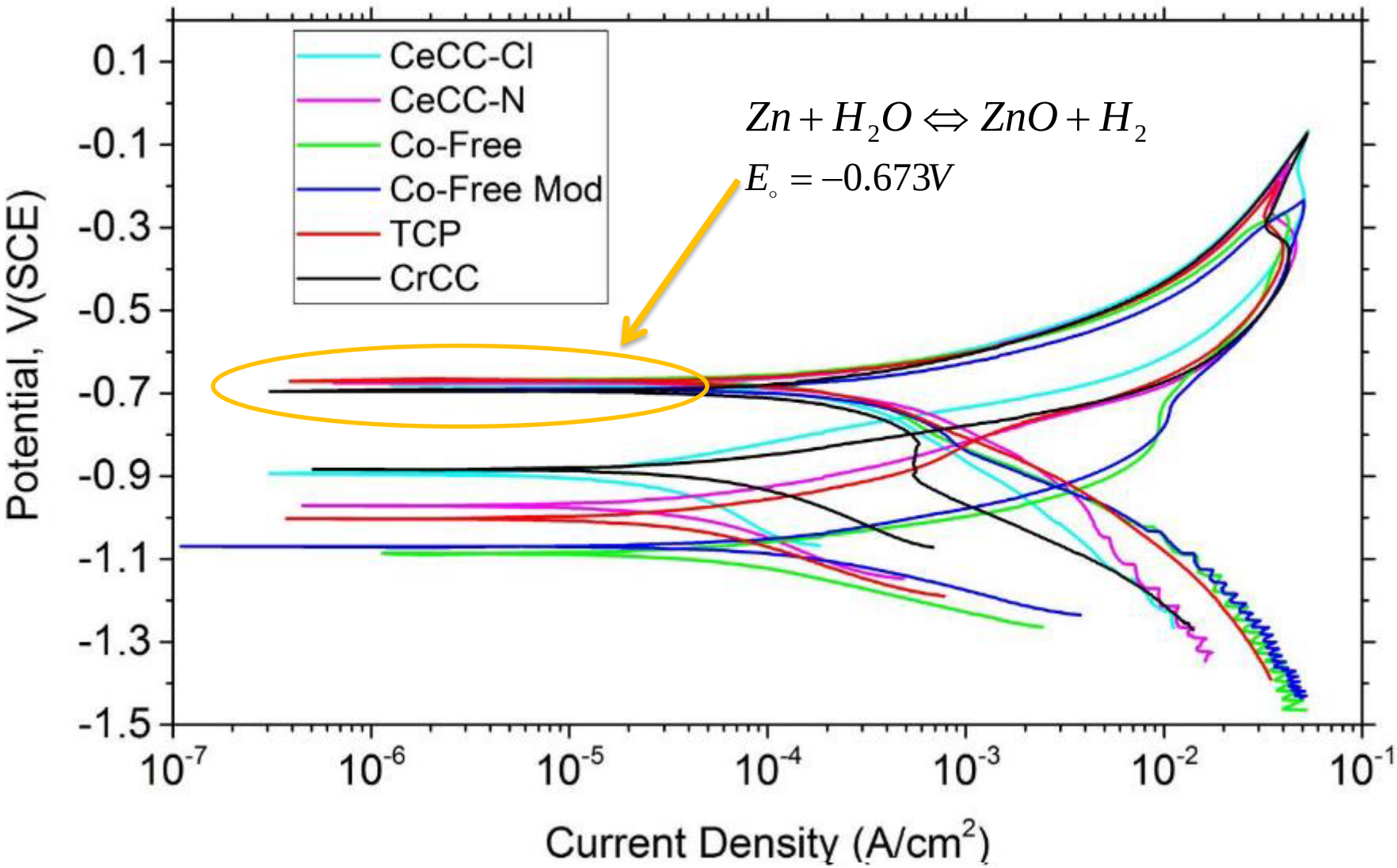
As-Deposited Contact Resistance



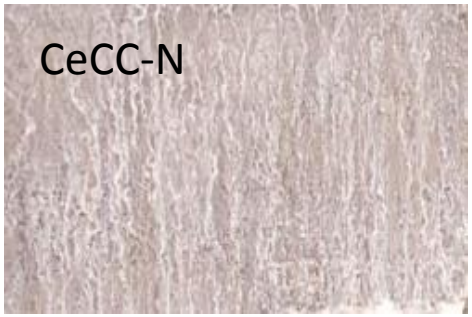
As Deposited Electrochemical Impedance Spectroscopy

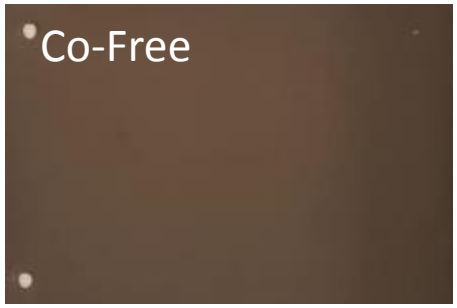


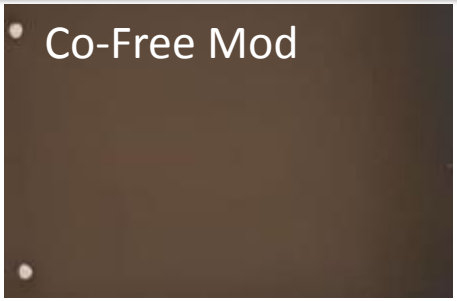
As Deposited Polarization Curves

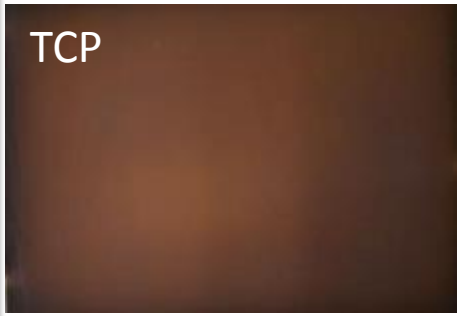


Before and After Salt Spray Testing (SST) for 1000 Hours

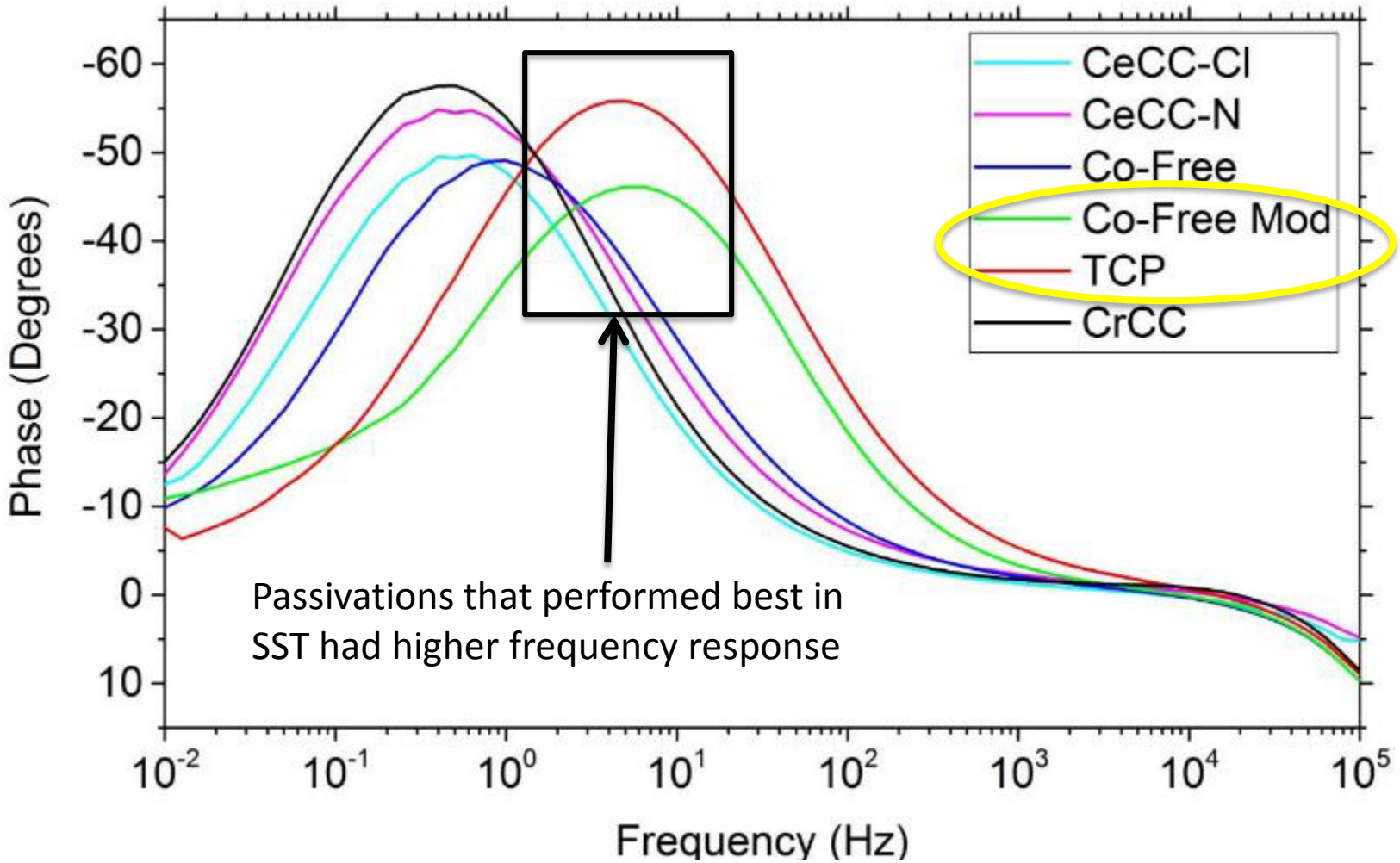




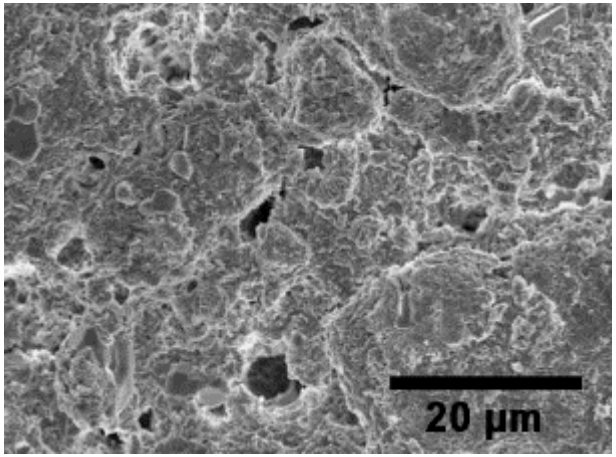




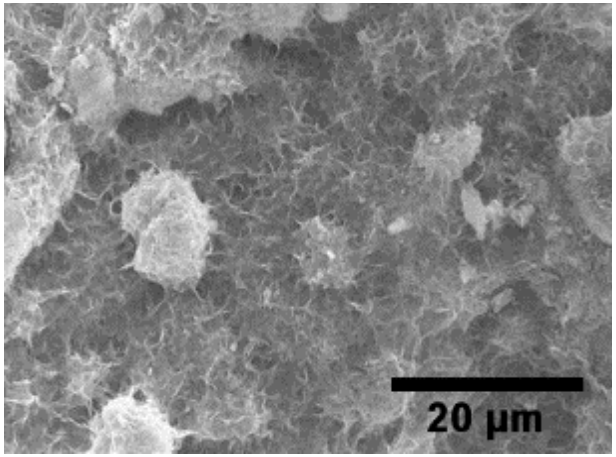
Electrochemical Impedance Spectroscopy After 1000 Hours of SST



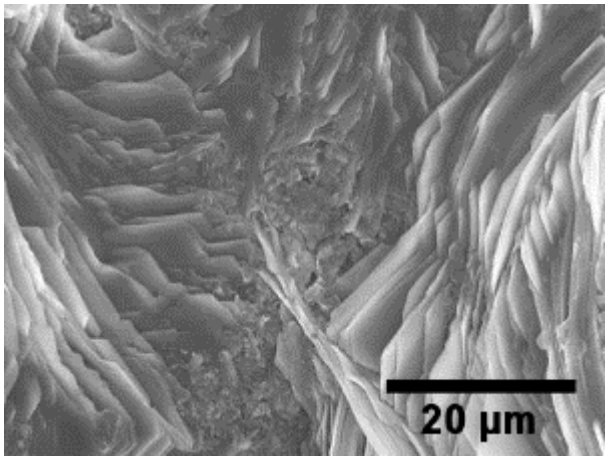
Morphology After 1000 Hours of SST



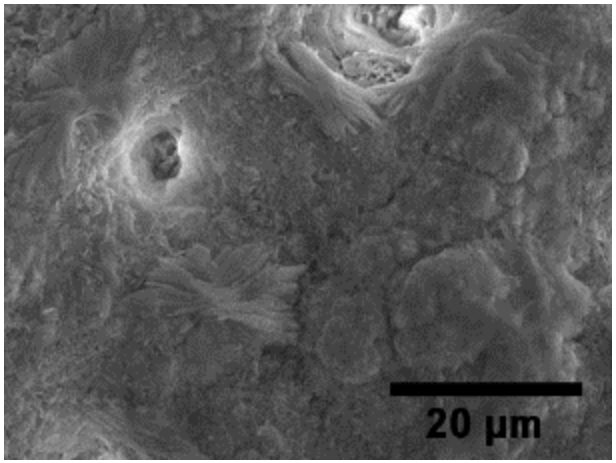
CeCC-Cl



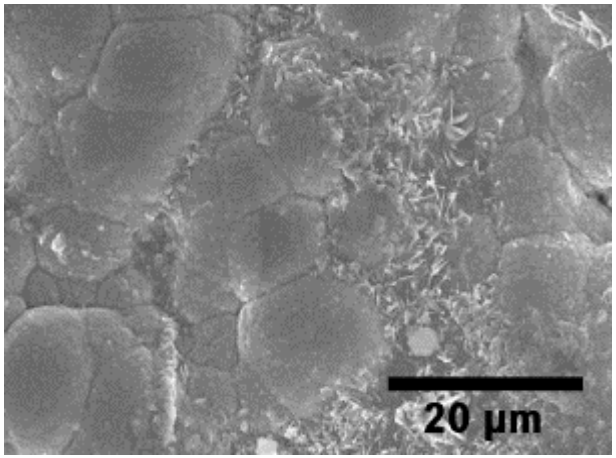
CeCC-N



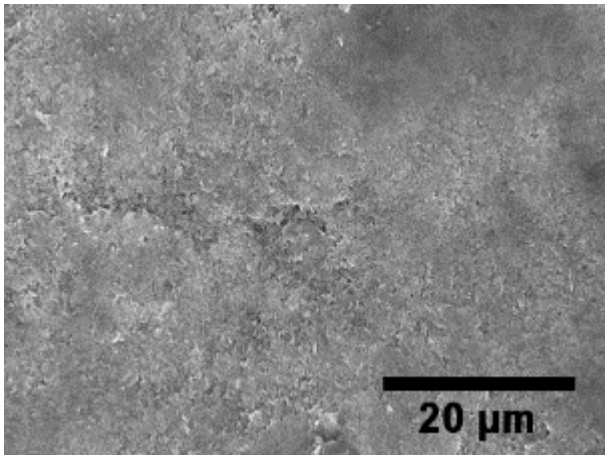
Co-Free



Co-Free Mod



TCP



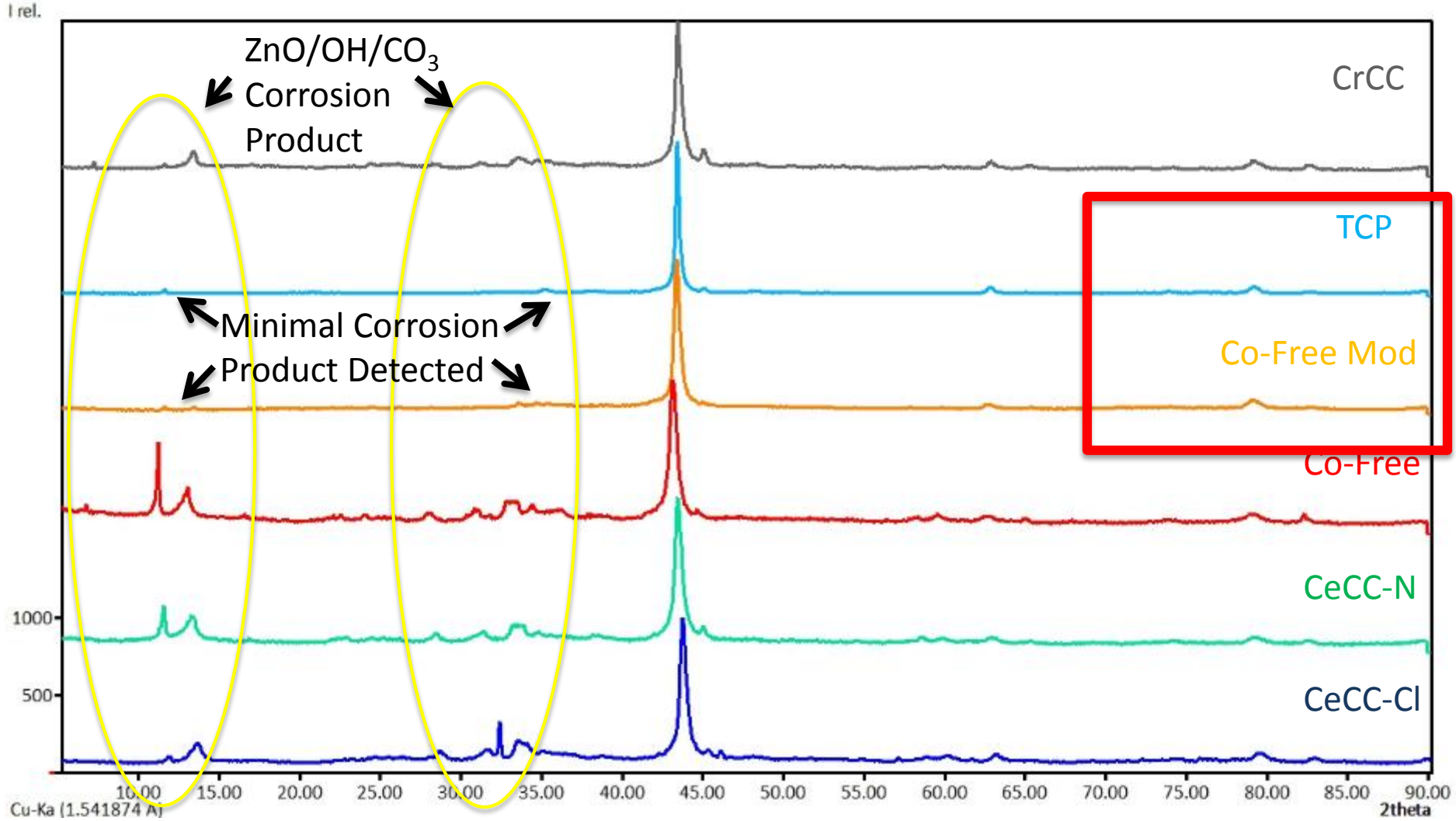
CrCC

Corrosion Product Composition

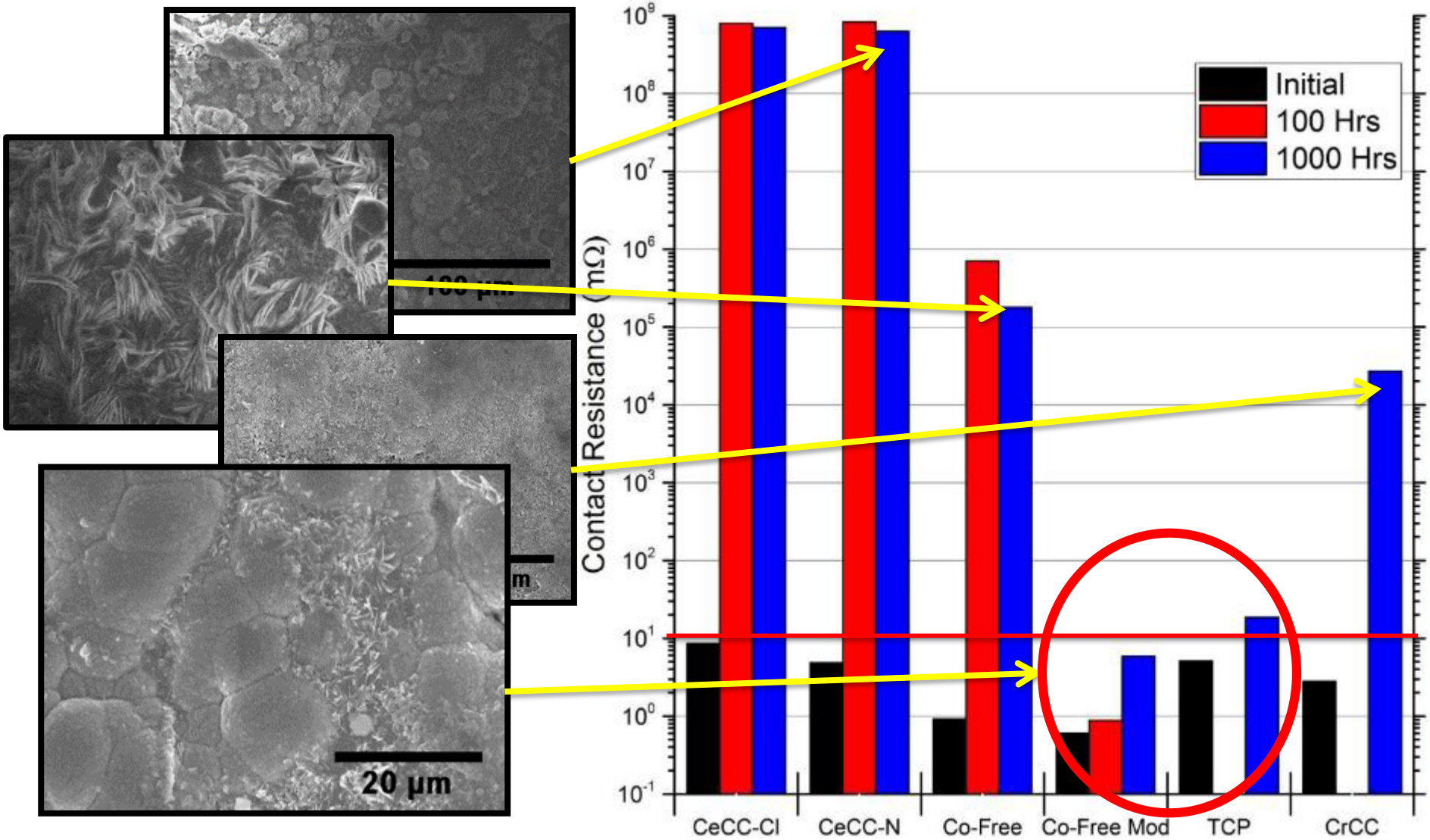
	Atomic % (EDS)						
	CeCC-Cl	CeCC-N	Co-Free	Co-Free Mod	TCP	CrCC	ZnNi (XRF)
Ni	1	1	1	7	11	1	14
Zn	60	43	39	23	63	52	86
O	34	52	46	65	22	44	0

- Co-Free Mod and TCP surface had little/no corrosion product
  - EDS detected higher Ni signal where no corrosion visible

XRD After 1000 Hours of SST

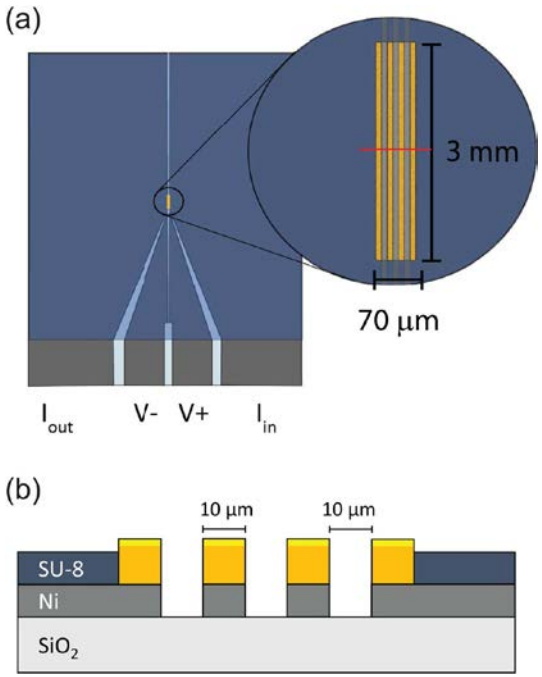


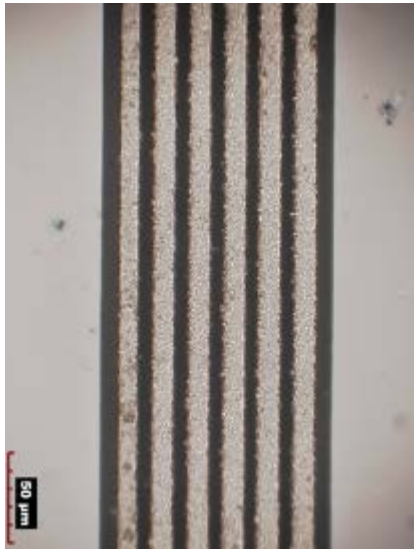
Electrical Contact Resistance

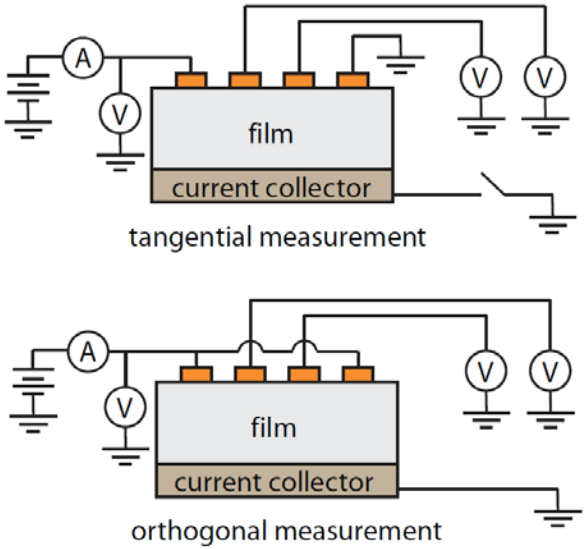


Alternate Contact Resistance Method

Adaptation of BYU Design/Fabricated Microprobe for Thin Film Battery Electrodes







Sample	BYU Probe Resistance (ohms)	MIL-DTL-81706B Probe Resistance (ohms)	T-test comparison
TCP	0.0007 ± 0.0002	0.013 ± 0.001	>99% chance different
Co-Free	0.0013 ± 0.0005	0.00142 ± 0.00007	~22% chance different
CrCC	0.0007 ± 0.0004	0.0062 ± 0.0009	>99% chance different

Summary

- TCP and CeCC Passivations on LHE ZnNi Deposited with Contact Resistance <5 mΩ/in^2
- Electrochemical Response Dependent on Type of Passivation-CrCC and TCP-based Passivations Best Response
- IZ-264 TCP and Co-Free Modified IZ-264 TCP Electrical Contact Resistance <10 mΩ/in^2 After1000 Hours of ASTM B117
- Four Line Microprobe Electrical Contact Resistance Test Method More Sensitive Than MIL-DTL-81706B