2012 DOE Vehicle Technologies Program Review

AMD-1001 Development of Corrosion Inhibiting E-coat System for Body-in-White Assemblies

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Automotive Metals Division

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This presentation does not contain any proprietary, confidential, or otherwise restricted information

Overview

- **Timeline**
  - July 10, 2010
  - September 30, 2011
  - 100 % complete

- **Budget**

– Total cost	$577,000
• DOE share	$289,000
• Contractor share	$289,000
– Funding received	
• FY 2011	$227,000
• FY 2012	$ 31,000

- **Barriers**
  - Performance
  - Cost

- **Targets**
  - Treat mixed-metal (Mg, Al, Galvanized steel) assemblies in one conversion bath, followed by applying conventional automotive E-coat

- **Stretch goal**
  - Combining conversion coating and electro-coating steps into one step

•**Partners:**

- USAMP (Chrysler and General Motors)
- Missouri University of Science and Technology
- PPG Industries

Relevance

- **Goal**
  - To facilitate the use of lightweight magnesium in automotive applications by developing and validating new conversion coating for mixed-metal assemblies which are compatible with the existing automotive paint line.
    - Currently, Mg parts have to be processed offline.
    - This project is considered an enabling to facilitate vehicle lightweight through increased use of magnesium by addressing galvanic corrosion in dissimilar metal joints, is one of the fundamental barriers to the used of magnesium as cited in the “Magnesium Vision 2020” publications.

- **Objectives**
  - Develop a new conversion coating for mixed-metal (Mg, Al, GS) assemblies, which is compatible with existing automotive paint line
  - The new finish should have equivalent or better corrosion performance than the existing automotive finishes (Phosphate conversion coating for Al and GS; Alodine 5200 conversion coating for Mg)

- **Expected results**
  - Successful development of this new conversion coating will enable improved fuel economy through vehicle lightening by providing a <u>low cost</u> solution for <u>corrosion protection</u> of Mg-intensive vehicles.

Milestones

Month year	Milestones (Tasks)	Deliverables
Aug-10	I. Conversion coatings (desired coating thickness based on corrosion performance) • Individual alloys (Mg, Al, GS) • Bimetallic couples (Mg-Al)	• Surface pretreatment • Optimum CeCC solution composition and • Coating thickness
April 11	II. Conversion coating and E-coat • CeCCs on bimetallic couples (Mg-GS, Al-GS) • E-coating on CeCCs individual alloys and bimetallic couples • Coating characterization (SEM, FIB, TEM, adhesion test) and corrosion tests (EC, B117, GMW 14872)	• Optimization of CeCC solution composition and E-coat parameters for corrosion protection • Coating thickness (Bimetallic couples)

Sept 11	III. Conversion coating and E-coat
	• CeCC on trimetallic couples (Mg-Al-GS)
	• E-coat on CeCCs coated trimetallic couples
	• Coating characterization
	  • SEM, FIB, TEM, adhesion test
	  • Corrosion tests (EC, B117, GMW 14872)
	• Benchmarking with other conversion coatings
		• CeCC solution composition and coating procedure
		• E-coat parameters for trimetallic couples
		• Benchmarking results

Approach and strategy

- The project established a two phase approach
  I. Conversion coating development on individual alloys (Mg, Al, GS), bimetallic couples (Mg-Al, Al-GS, GS-Mg) and trimetallic couples (Mg-Al-GS)
     - Success indicator will be a conversion coating that performs equal or better than the Alodine 5200 coating on Mg, and Zn phosphate on current OEM substrates (or commercial Zr coating) in terms of corrosion resistance and adhesion properties

  II. E-coat on conversion coatings of interest for above combinations
     - Success indicator will be a conversion coating/E-coat that performs equal or better than the Alodine5200/E-coat coating system or Zn phosphate/E-coat coating system (current OEM coatings) in terms of corrosion resistance and adhesion properties.

Technical accomplishments and progress

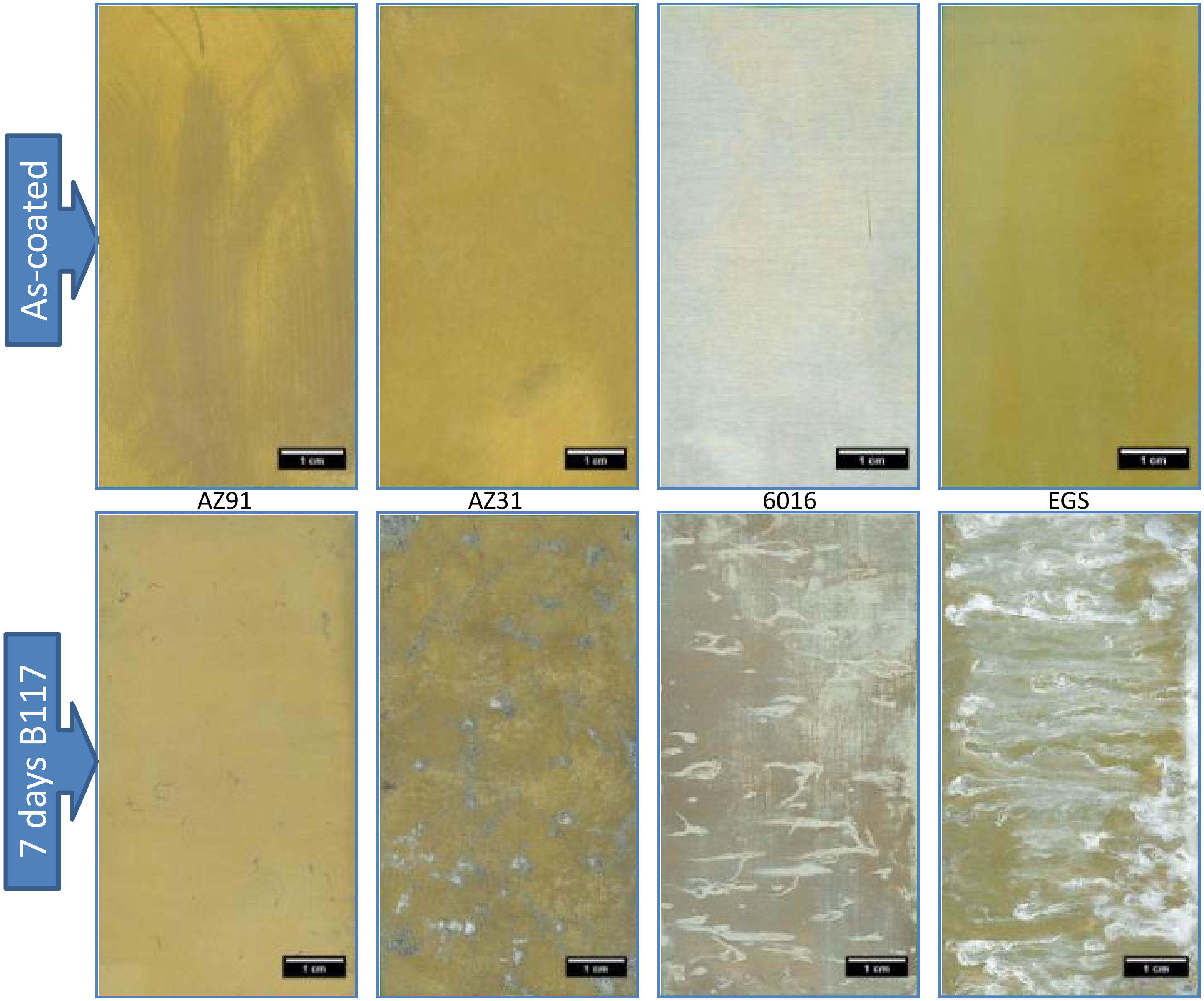
(Evaluation plan)

- Corrosion testing
  - Salt spray screening (ASTM B117)
  - Cyclic testing (GMW 14872)
  - Electrochemical (impedance, polarization)
- Adhesion testing
  - Cross hatch
  - PATTI (Pneumatic Adhesion Tensile Testing Instrument)
- Coating characterization
  - SEM, Focused Ion Beam (FIB), XRD

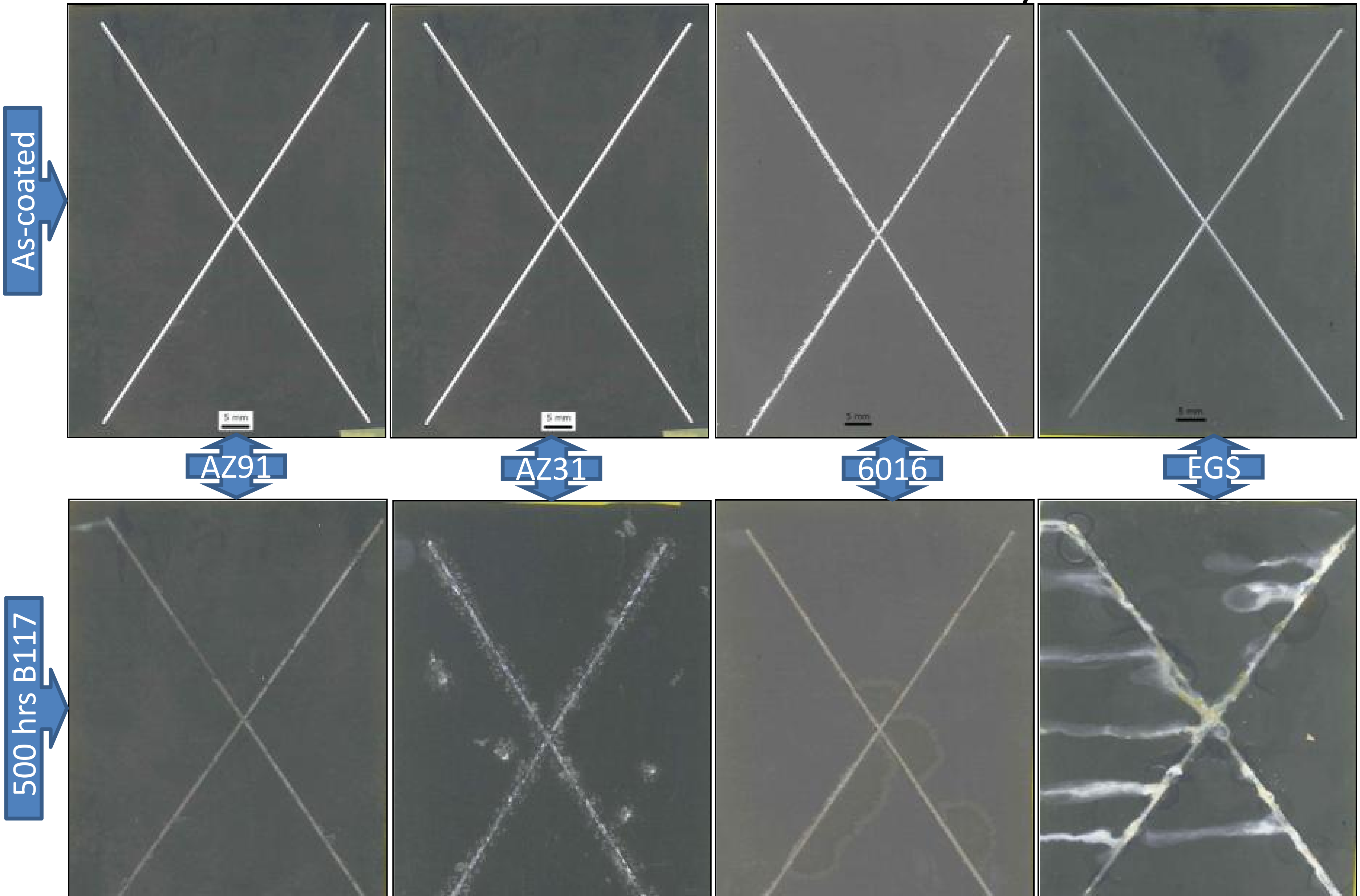
Test	Electrolyte Description	Cycle Description
ASTM B117	5% sodium chloride - pH 6.5 to 7.2 Continuous application of salt mist	Continuous application of salt mist
GMW 14872	0.9% sodium chloride, 0.1% calcium chloride, 0.25% sodium bicarbonate - pH 6 to 9	Four applications of salt mist at 1.5 hour intervals, 8 hours humidity cabinet, 8 hours elevated temperature drying

Optical images of cerium conversion coatings (CeCCs) deposited on individual alloy panels

(before and after B117 salt spray testing)



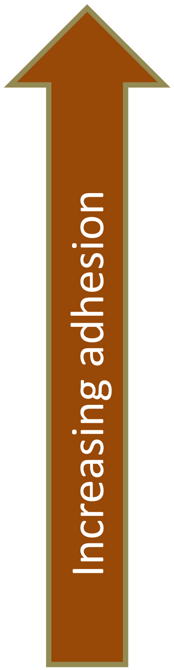
E-coat on cerium coated individual alloys

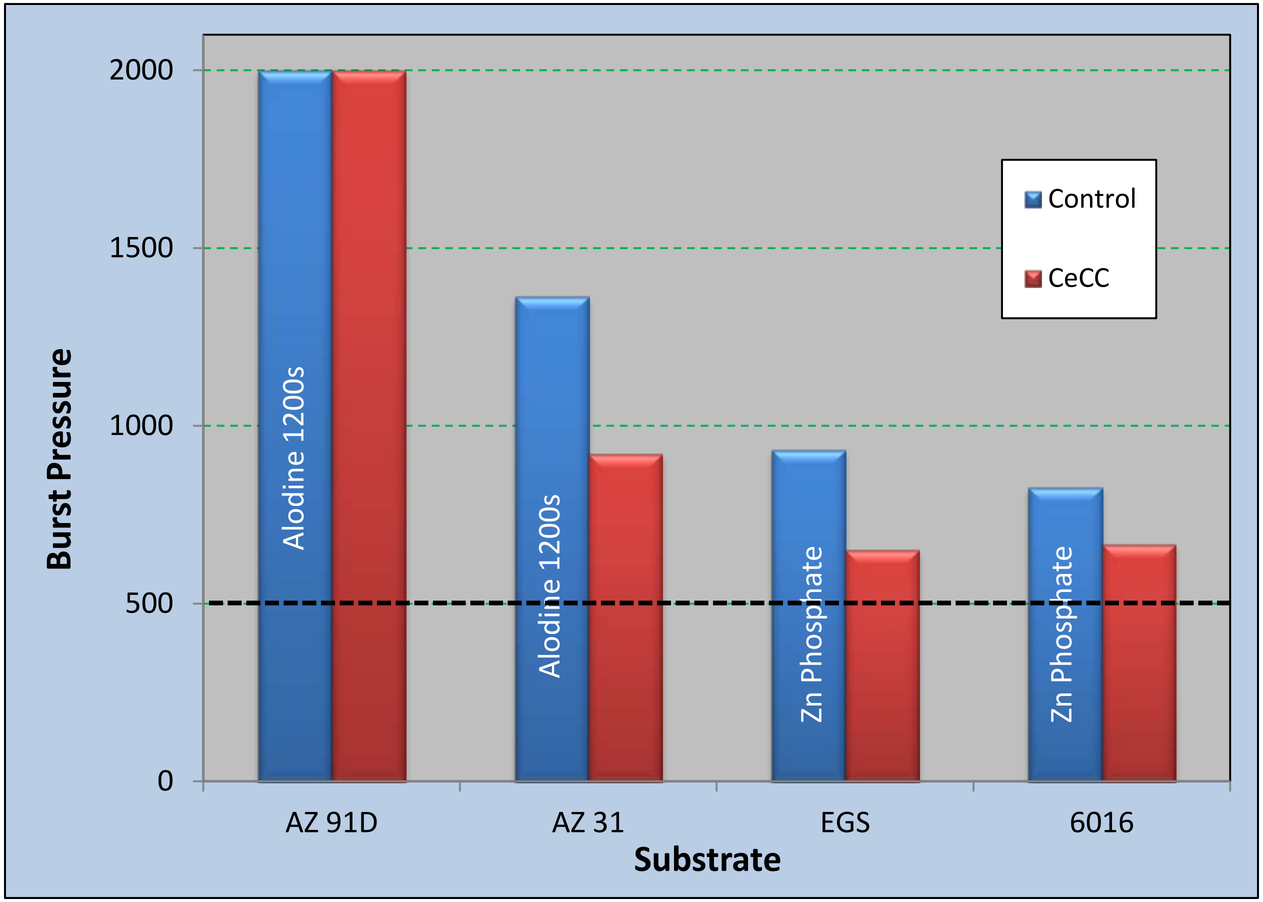


AZ91 results promising; B117 typically is more severe than the field performance

PATTI Adhesion Testing

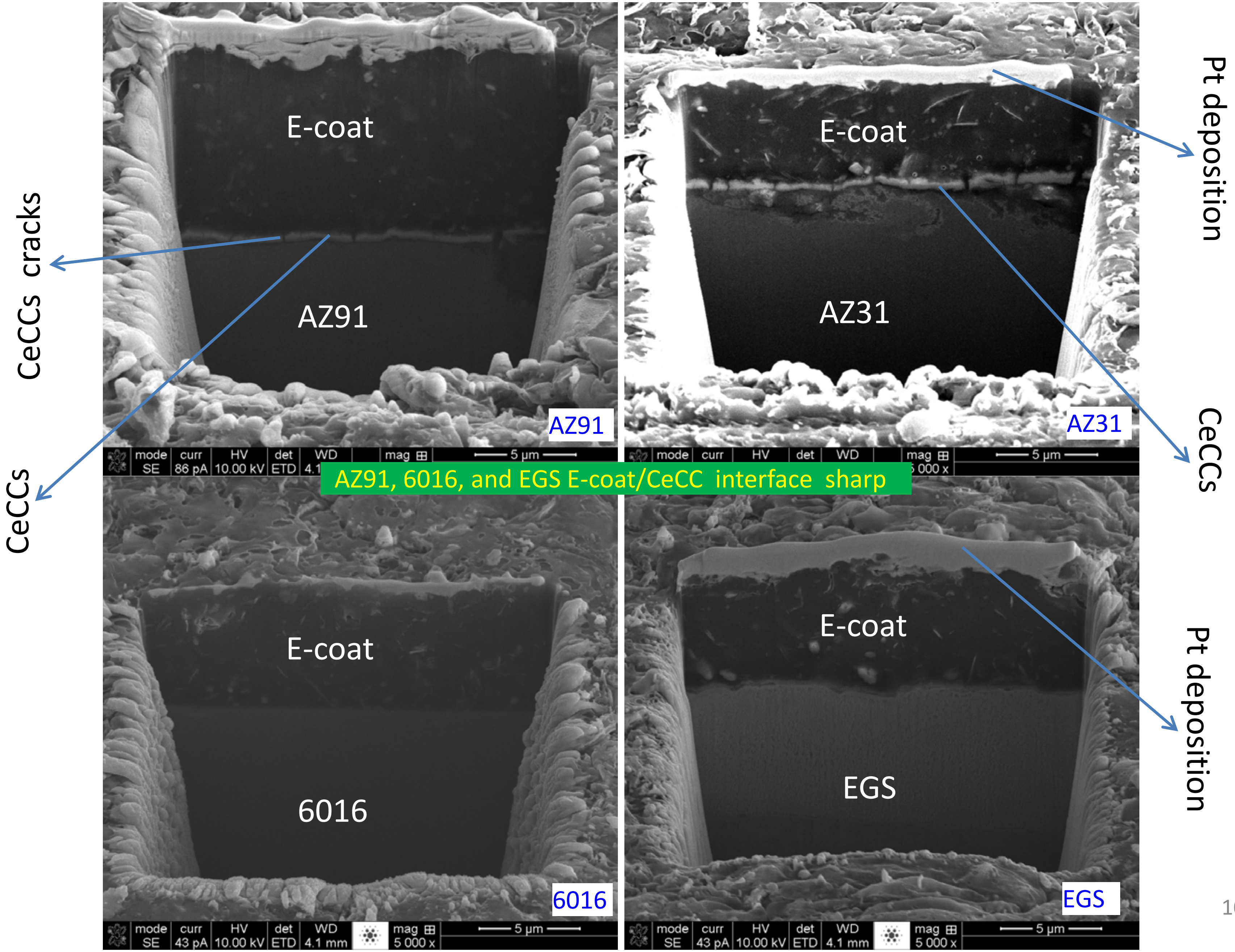
(Electro-coat on CeCCs deposited individual alloys)



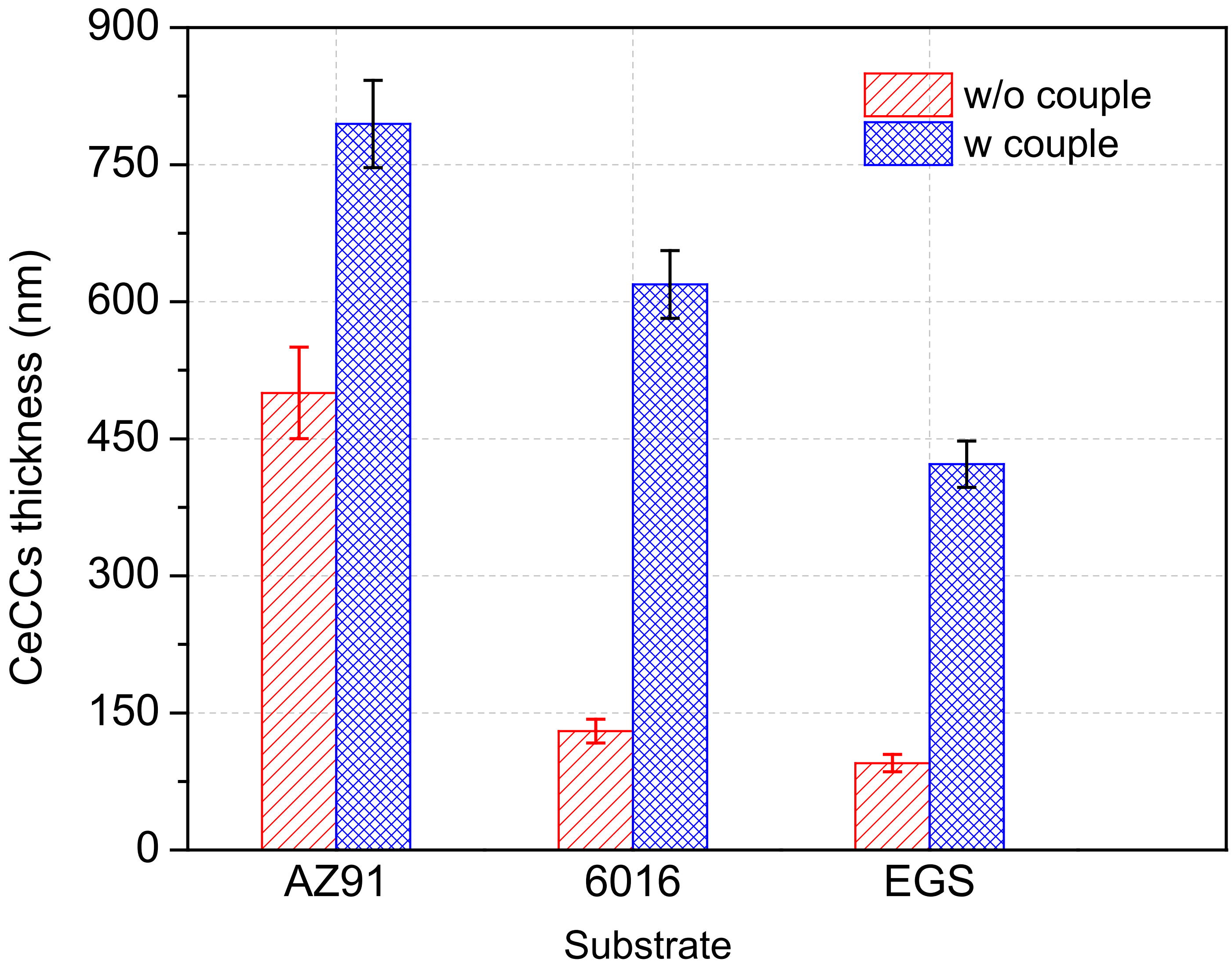


Values above 500 good adhesion

FIB cross-section of E-coat on CeCCs deposited individual alloys



CeCC thickness with and without couple



Galvanic current significantly influence coating thickness

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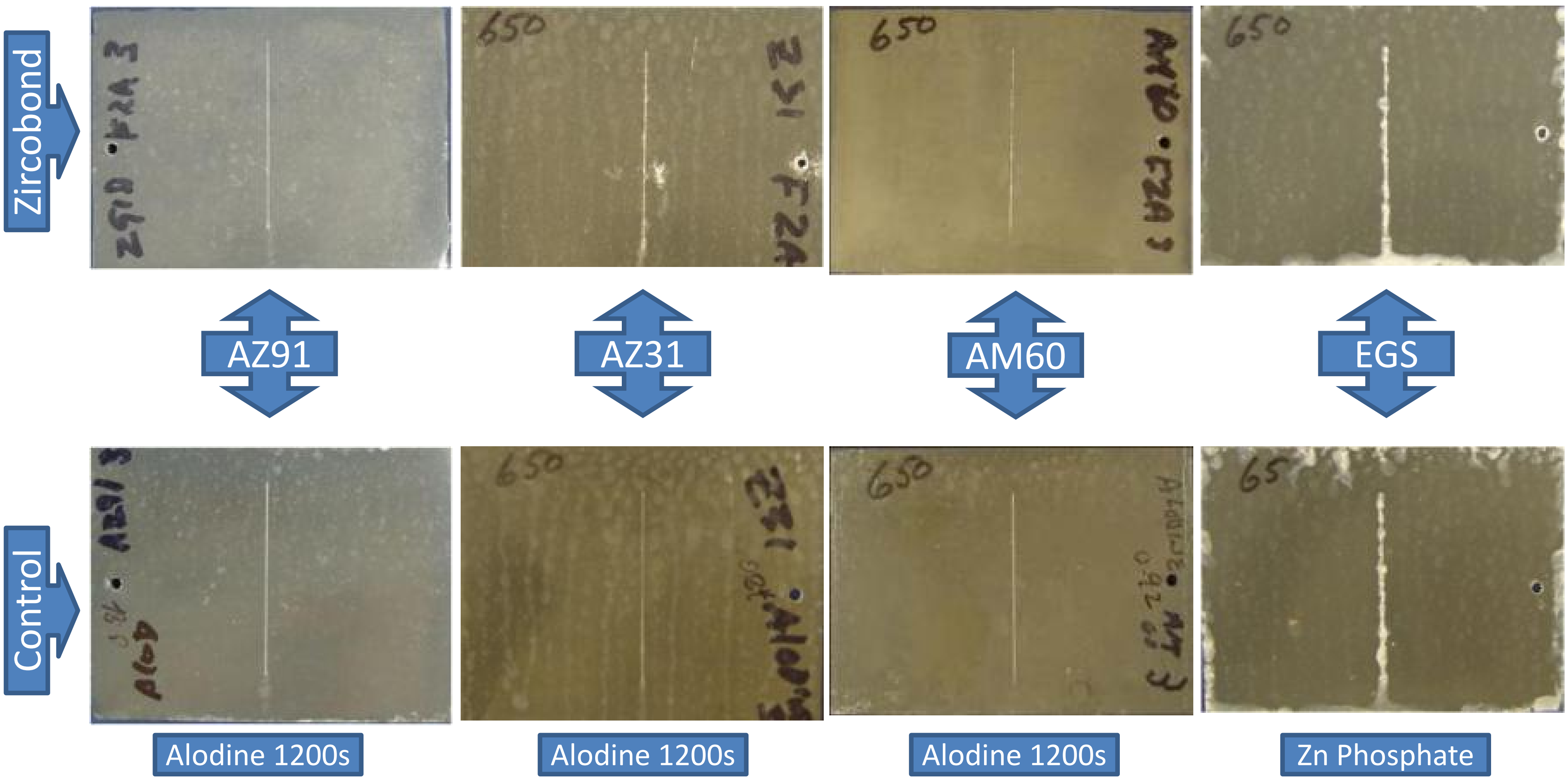
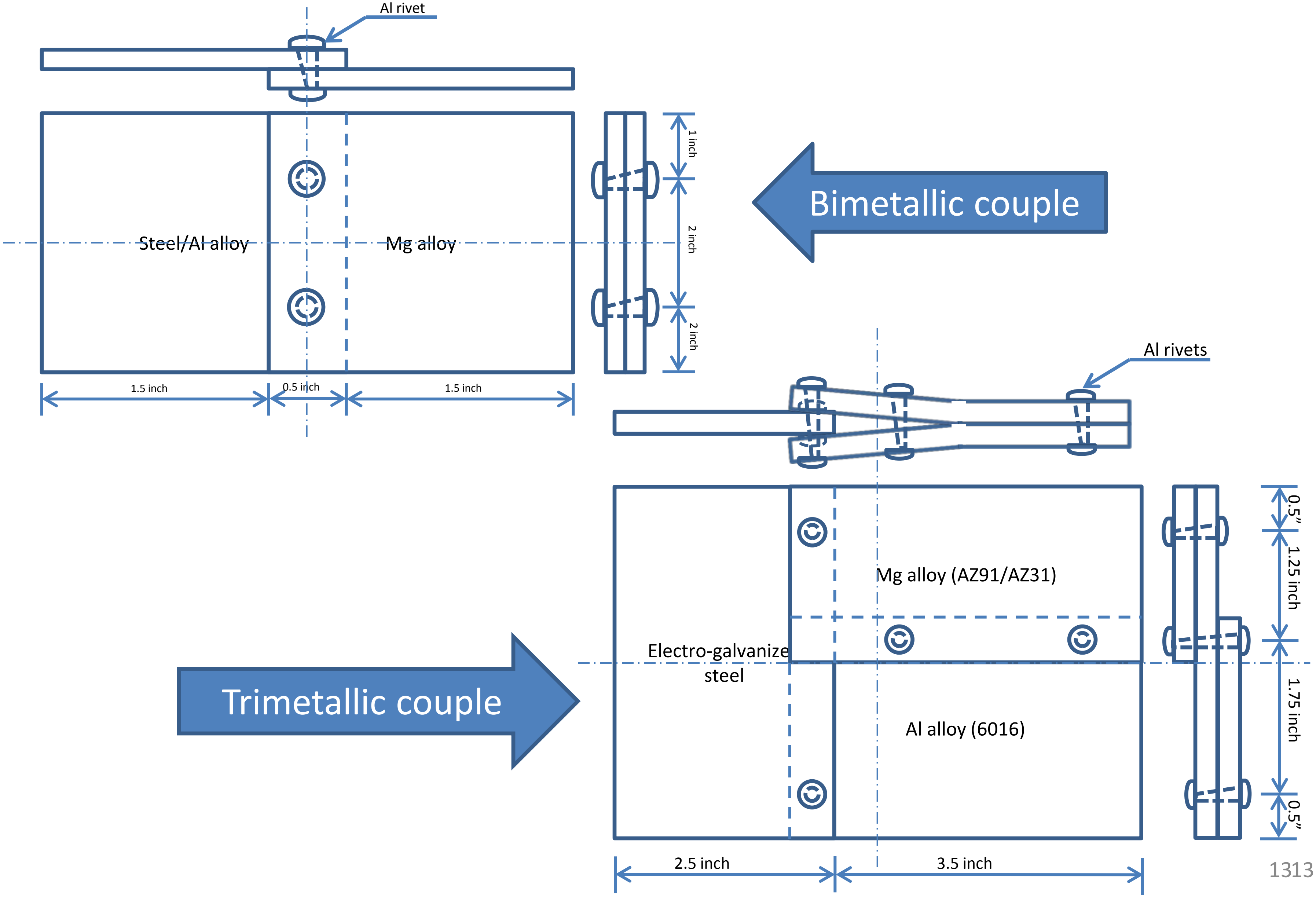
E-coat on Zircobond individual alloys 40 cycles GMW 14872

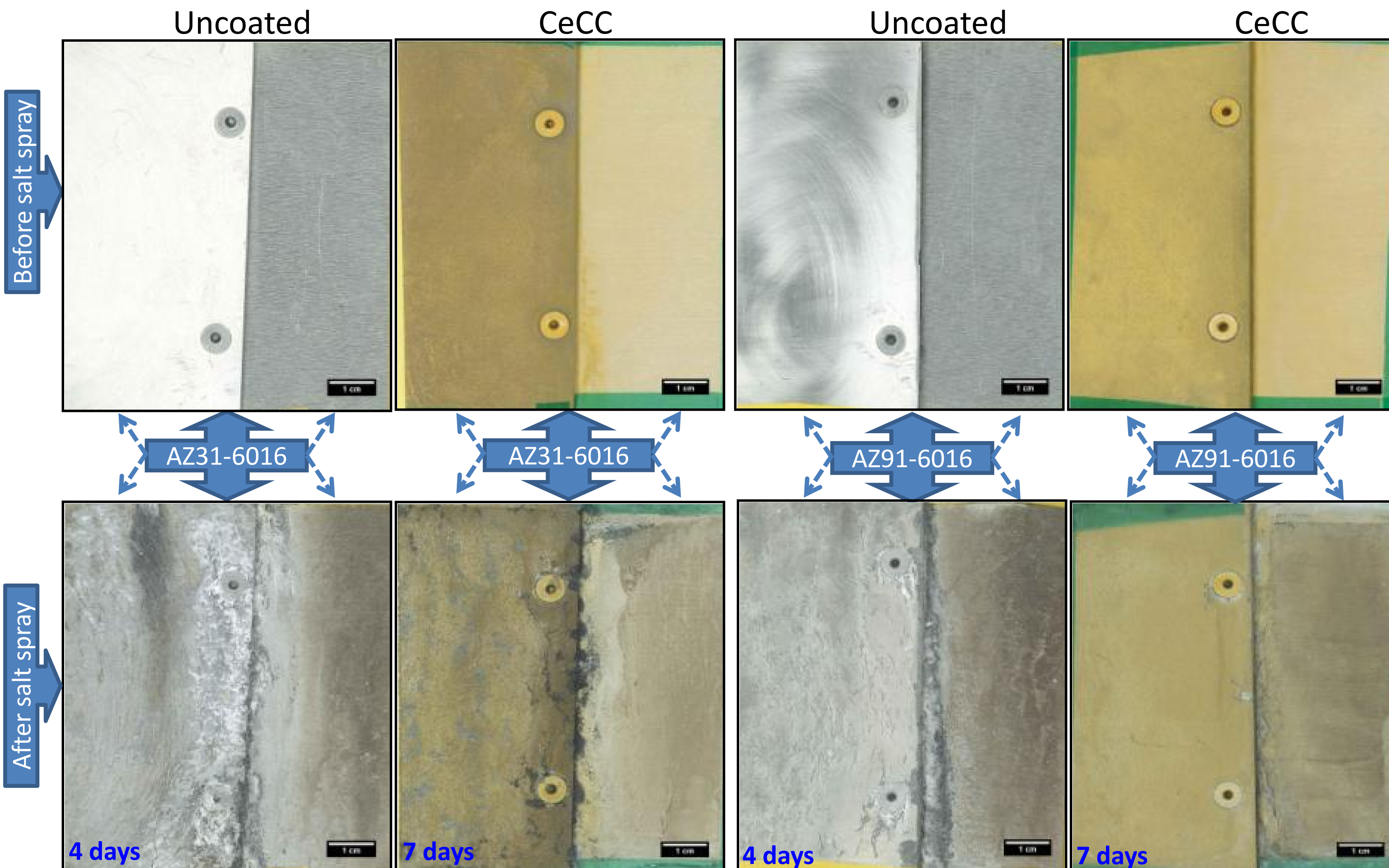


Scribe creep of Zircobond treated panels are equal to “control” pretreatment

Schematic diagrams of bi-metallic and tri-metallic couples

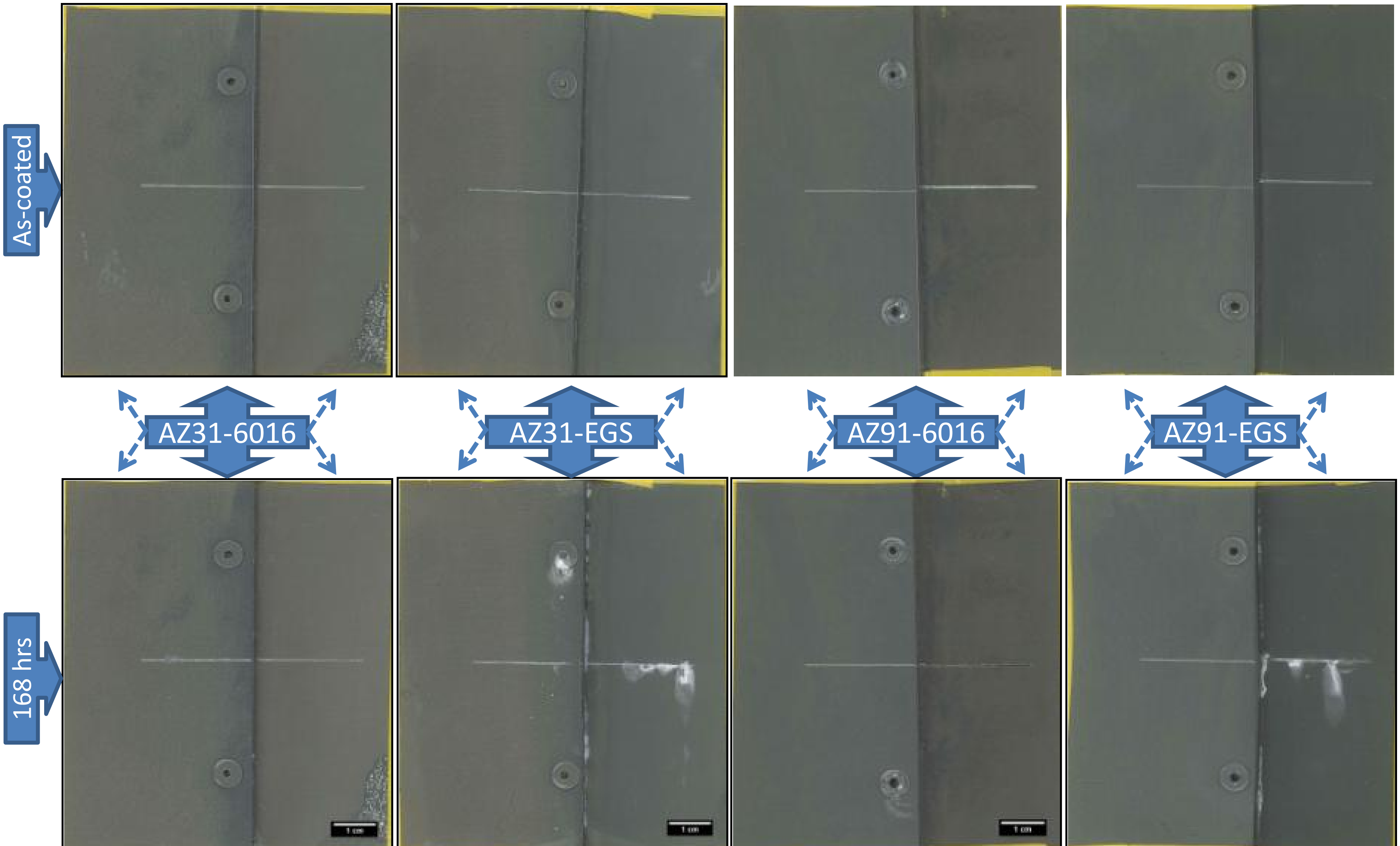


Optical images of bi-metallic couples (before and after salt spray)



CeCC couples showed better corrosion performance than bare couples

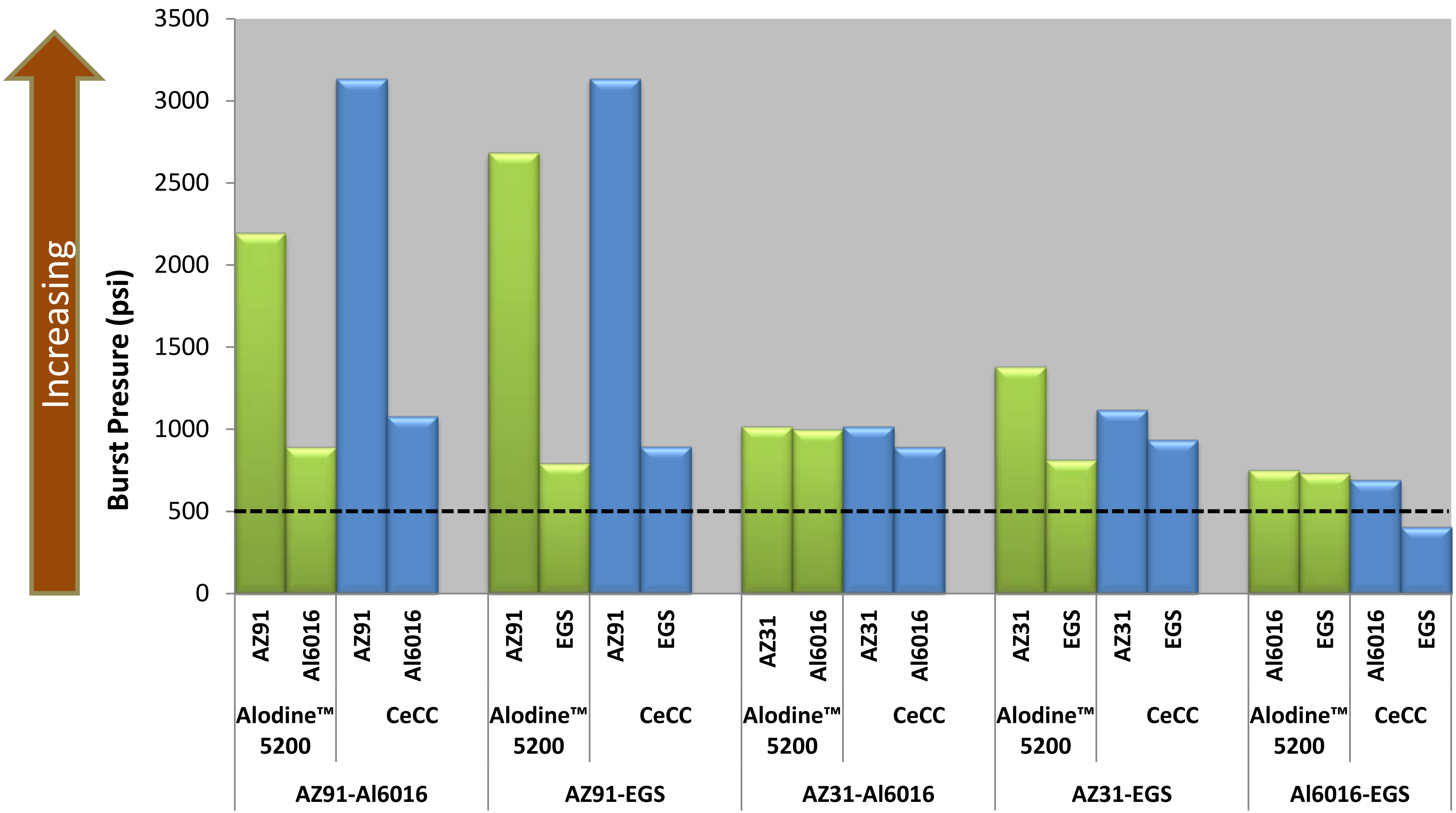
Optical images of E-coat bi-metallic couples



Minimal corrosion product in scribe after 1 week B117

PATTI Adhesion Testing

(E-coat on CeCC deposited bi-metallic couple)



CeCC treated binary panels showed good PATTI adhesion, comparable to the Alodine™ 5200 controls

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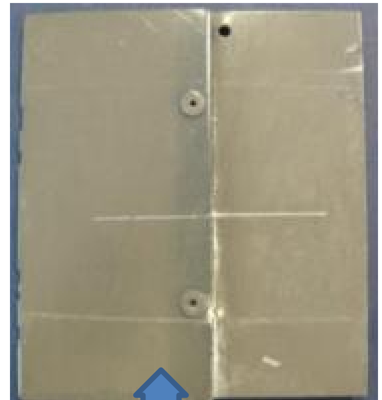
GMW 14872 test on E-coated CeCC Binary Alloys AZ31-Al6016, AZ91-Al6016

80 Cycles



AZ31-Al6016
Alodine™ 5200

AZ31-Al6016
CeCC

80 Cycles

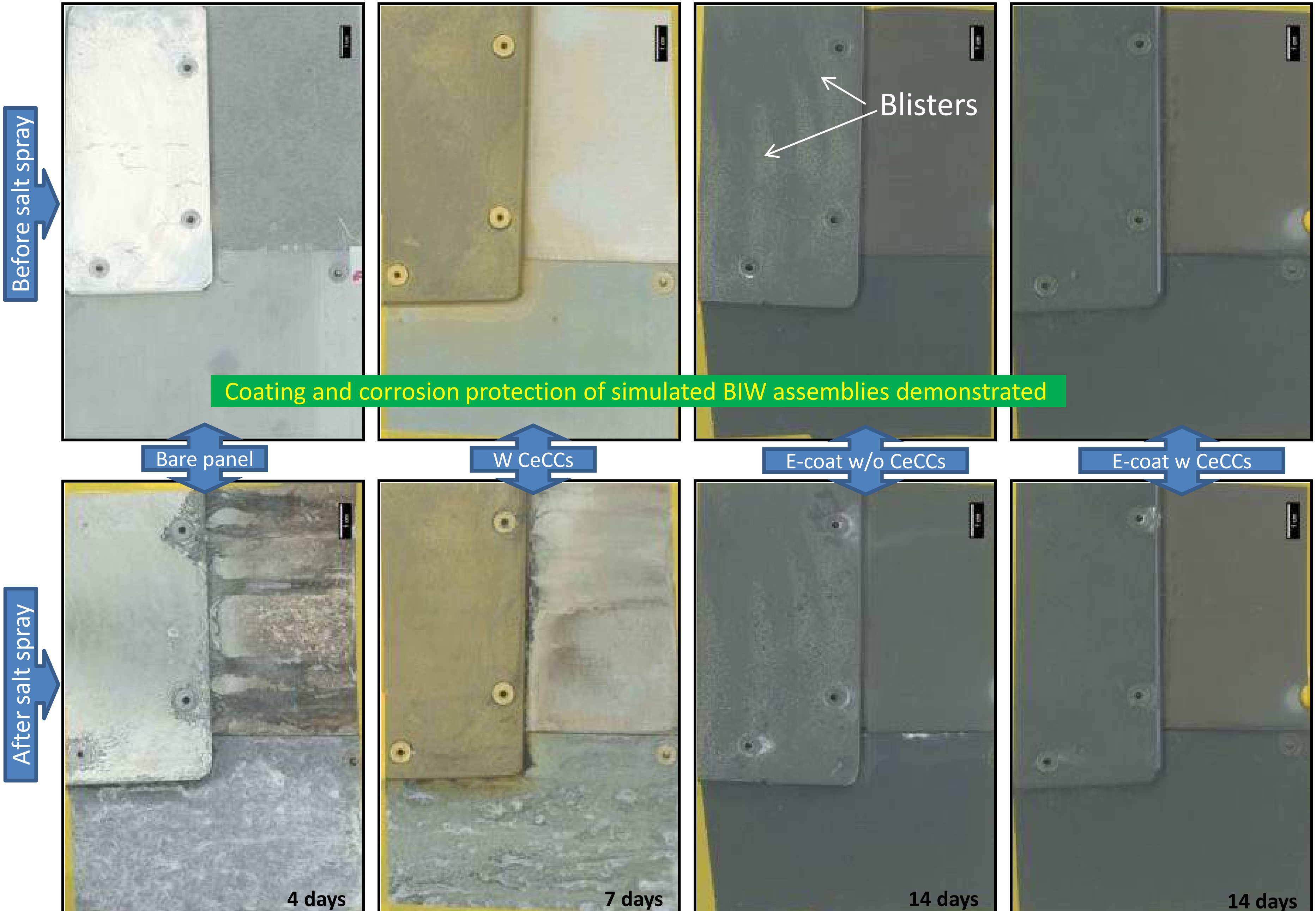
AZ91-Al6016
Alodine™ 5200

AZ91-Al6016
CeCC

- CeCC treated panels performed well with little scribe creep, comparable to the controls
- Similar performance between vertical and horizontal scribes

To assess full extent of corrosion, panels were taped to remove any loosely adhering coating

Optical images of tri-metallic (AZ91-6016-EGS) couples



Summary

- Cerium conversion coatings and zirconium pretreatments were successfully deposited on individual alloys, bi-metallic couples and tri-metallic couples without contaminating the deposition bath.

- Cerium conversion coatings and zirconium pretreatments significantly improve the corrosion resistance of E-coated bi-metallic and tri-metallic couples.

- The adhesion strength of E-coat over CeCC was as good as, or better, than over Alodine 5200 (benchmark coating). The adhesion strength of E-coat over zirconium pretreatment was equal to, or better than, Alodine 1200 (benchmark coating).

- This project demonstrated that cerium conversion coatings or zirconium pretreatment can be deposited on mixed-metal assemblies (galvanized steel, aluminum alloys, and magnesium alloys) in the same conversion coating bath without cross contamination. This means that magnesium-intensive vehicles can be pretreated with new coating using the existing paint line.

Collaboration

Project team:

Yar-Ming Wang, Jim Quinn, Kevin Cunningham, Harry Kuo

Adam Stals

Surender Maddela, Matt O'Keefe

Thor Lingenfelter, Roy Dean, Michael J. Pawlik

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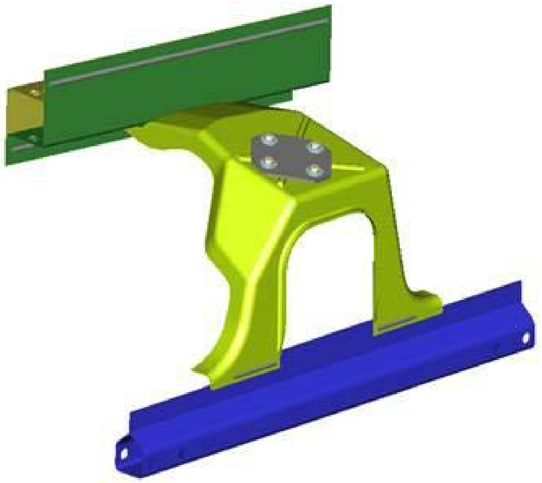
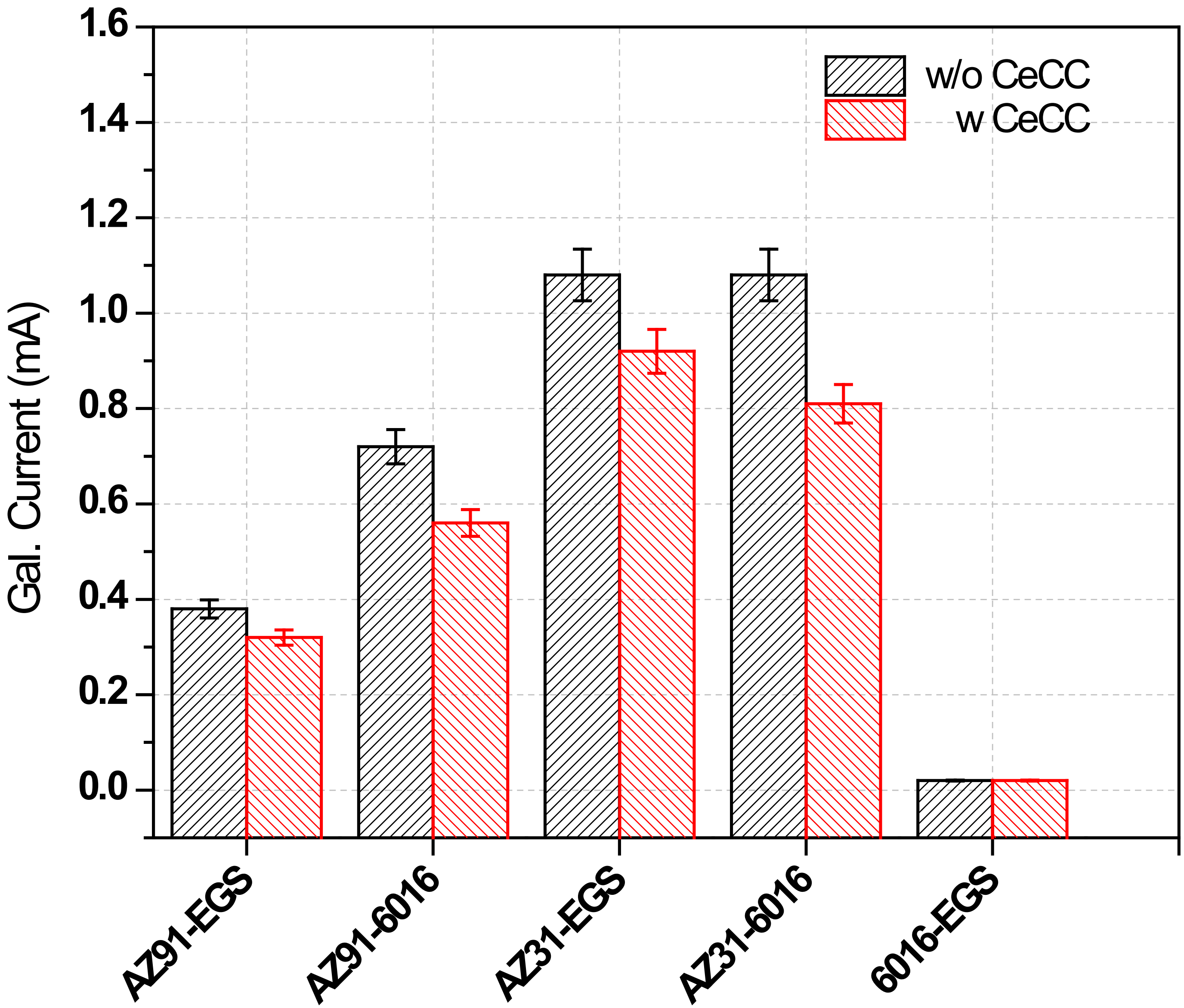
Proposed future work

- Further development of coating technologies (CeCC and Zr-based Coating)
- Demonstrate ability to scale up
  - Both are anticipated in the 2012 Magnesium Front End Research and Development (MFERD) project
- Technical cost modeling of the process



Technical Back-Up Slides

Galvanic corrosion current between different couples



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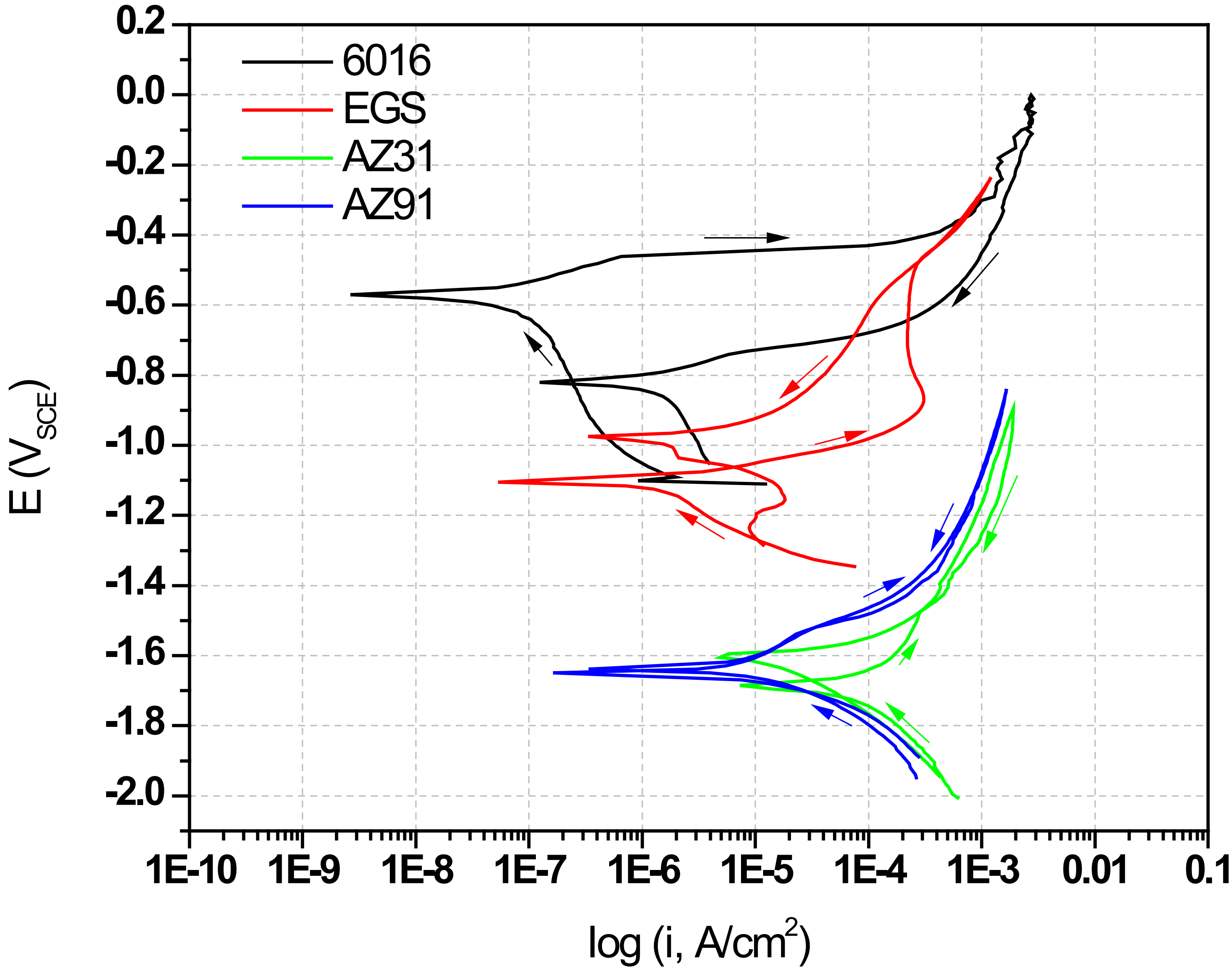
Cyclic polarization behavior of E-coat on CeCCs deposited individual alloys



Mg alloys and EGS panels exhibit self healing behavior

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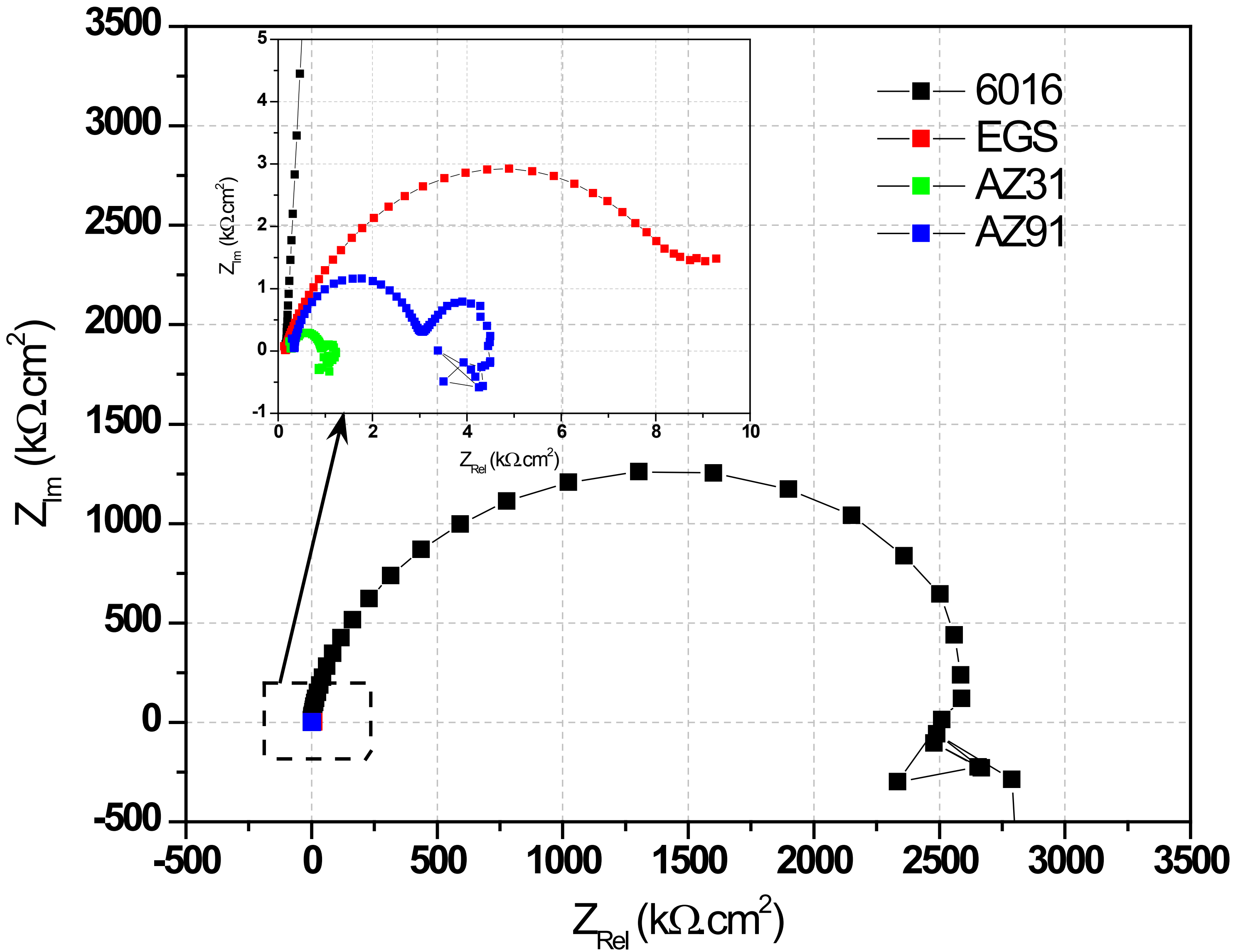
Impedance spectra of E-coat on CeCCs deposited individual alloys (with artificial defect in coating)



E-Coat on CeCCs deposited 6016 alloy panels had highest impedance; AZ31 had lowest impedance