Characterization of Corrosion at the Metal-Paint Coating Interface Using ToF-SIMS and SEM

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Introduction

- Corrosion on equipment and infrastructure adds a multibillion cost to many industries each year
- Paint coating is the most common means for corrosion prevention
- Illustration of the corrosion process at the metal-paint coating interface helps visualization of the corrosion process
- However, it is challenging to map the trace amount inhibitor metal (i.e., Cr) distribution, as well as interesting organic molecules, mixed in aluminum (Al) at the metal-paint coating interface.

Fig. 1 A photo of Al corrosion

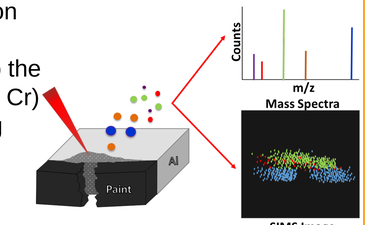

Fig. 2 Schematic of ToF-SIMS interfacial imaging

Method

Instrumentation and Materials

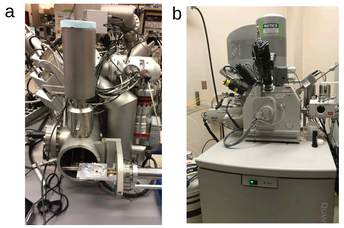

Fig. 3 (a) ToF-SIMS and (b) SEM.

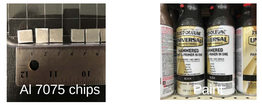

Fig. 4 Al and paint used in this work.

Table 1. Aluminum 7075 Composition

Typical Chemical Composition %										
Weight %	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Each	Total
Minimum			1.20		2.10	0.18	5.10			
Maximum	0.40	0.50	2.00	0.30	2.90	0.28	6.10	0.20	0.05	0.15

- The Al chips were cleaned, polished, and fixed with resin before paint application
- The paint was scratched with a sharp blade to expose the unprotected metal to different conditions

Corrosion Sample Preparation

Al blocks exposed in different conditions: air (a), DI water (b), synthetic sea water (pH 8.4) (c), NaOH (pH10) (d), and H_2SO_4 (pH 3) (e)

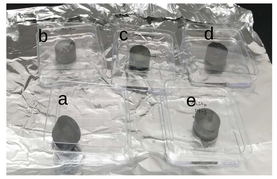

Fig. 5 The Al surfaces coated with paint exposed in different conditions.

Results

Optical Microscope Imaging

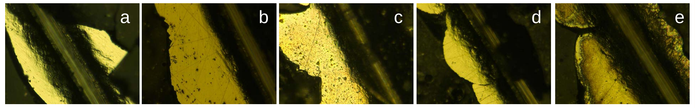

Fig. 6 Optical images showing corrosion development after 3-weeks of exposure.

SIMS Positive Mass Spectral Comparison

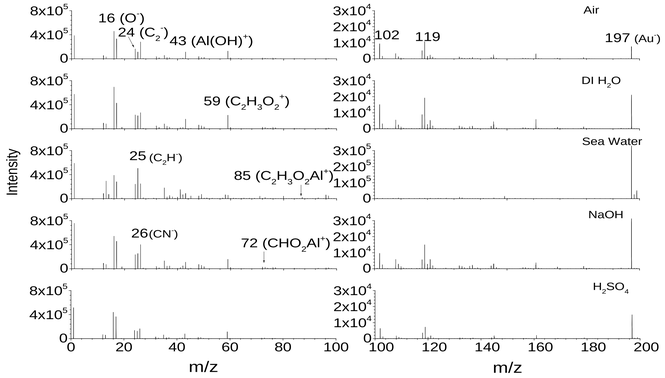

Fig. 7 SIMS spectra show different characteristic peaks at the interface after exposure.

Correlative Imaging of SIMS and SEM

The of H_2SO_4 treated sample was used as an example.

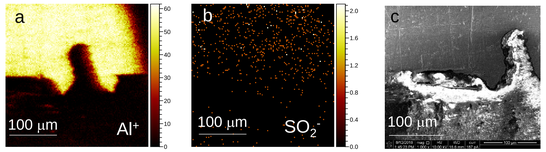

Fig. 8 Correlative SIMS (a & b) and SEM (c) images.

SIMS 2D Image Comparison

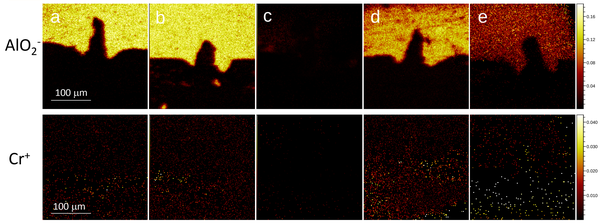

Fig. 9 Normalized 2D SIMS images corresponding to exposure in Fig. 5.

SIMS 3D Images Showing Corrosion Development

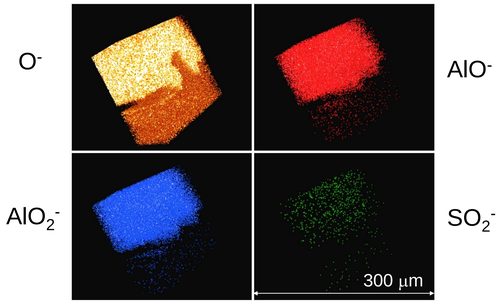

Fig. 10 3D SIMS images showing corrosion and oxidation at the interface.

Conclusion

- We demonstrated that ToF-SIMS, a highly surface sensitive technique, can be used to image the metal-paint interface
- Correlative SIMS and SEM imaging offer complementary information of the corrosion interface
- SIMS spectra, 2D, and 3D images give more insights of the chemical (i.e., elemental and molecular) spatial distribution at the metal-paint corrosion interface
- We provide a useful quasi non-destructive multimodal approach to study corrosion.

Reference

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