Surface Characterization of Metals to Understand Corrosion Behavior

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Kellogg Honors College Capstone Project

I. What is Corrosion?

Corrosion is a natural degradation process in which metallic materials lose their engineering functionality overtime. If overlooked, corrosion may cause devastating and irreversible damages that may result in equipment loss or human injuries. According to the National Association of Corrosion Engineers (NACE), the global cost of corrosion is nearly $2.5 trillion dollars[1]. To prolong component service life, it is important to understand the science of corrosion.

II. The Scanning Kelvin Probe Microscopy (SKPM)

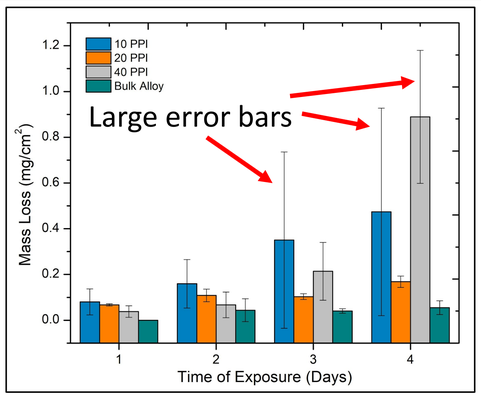

Figure 1. Large error bar from salt fog testing of aluminum materials[2]

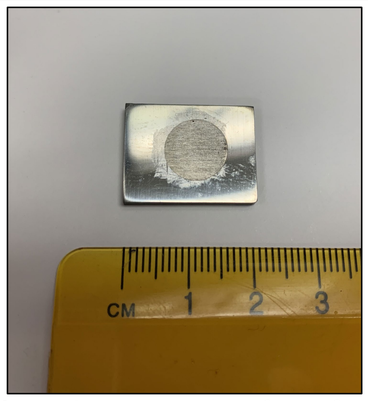

Figure 2. Destroyed surface after polarization testing

Traditional corrosion testing methods often provide results with high deviation (**Figure 1**). Samples are also destroyed after and cannot be re-tested unless reground (**Figure 2**). SKPM provides the ability to examine surfaces non-destructively by determining the natural Volta potential that exists between two dissimilar materials[3]. By utilizing a reference material, the relative thermodynamic stabilities of scanned surfaces can be determined and correlated to corrosion behavior[4]. To measure the Volta potential, a probe can be placed very close to the scanned surface to generate a measurable capacitance (**Figure 3**).

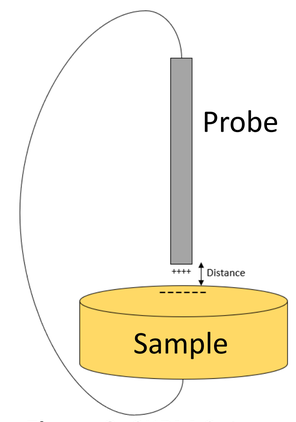

Figure 3. SKPM Setup

III. Objective

To investigate the reliability and repeatability of Scanning Kelvin Probe Microscopy (SKPM) in the determination of corrosion behavior.

IV. Methodology

- SS-304L, Ti-64 and Al-6101 were selected for testing.
- All samples were half-coated with insulating paint (**Figure 4**) to create heterogenous surfaces.
- Surfaces were scanned at 250µm steps from top left to bottom right.
- Probe is kept at 100µm from the surface through a capacitive height tracking technique.
- All SKPM were performed across a 3x3mm^2 area under ambient conditions (**Figure 5**).

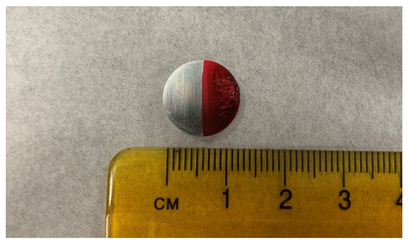

Figure 4. Half-coated Titanium

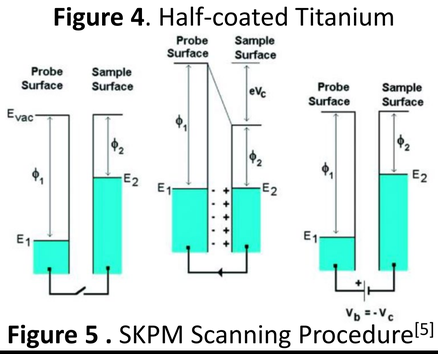

Figure 5 . SKPM Scanning Procedure[5]

V. Results and Discussion

- An increase in nobility can be observed at the coated region for all samples (**Figure 6,7,8**).
- Results showed great deviation overall. This may be due to the ambient condition such as humidity or temperature[6].
- Despite differences in measurements, the general surface trend for all duplicates are very similar.
- Ti-64 showed less deviation when compared to SS-304L and Al-6101. This follows the trend of the galvanic series, in which Ti-64 is more noble than SS-304L and Al-6101 is the least noble.

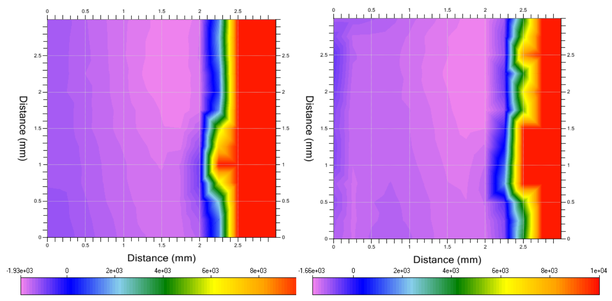

Figure 6. SS-304L SKPM Duplicate Scans in mV

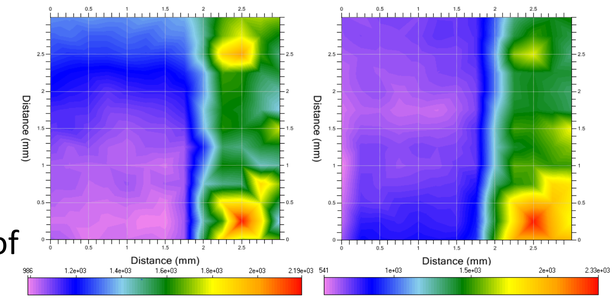

Figure 7. Al-6101 SKPM Duplicate Scans in mV

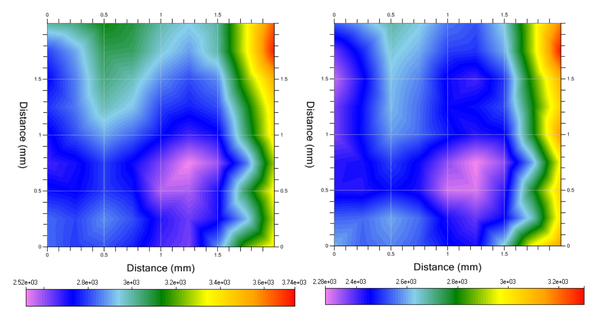

Figure 8. Ti-64 SKPM Duplicate Scans in mV

Table 1. Average Delta mV

Avg. ΔmV	Run 1	Run 2
SS	11791.54	11537.85
Al	677.38	1099.08
Ti	752.78	758.89

VI. Summary

- SKPM is a valuable technique that can test samples non-destructively.
- SKPM is efficient at detecting surface heterogeneity despite large deviation.
- As suggested by literature, measurements variability may depend upon humidity or temperature. A controlled testing chamber is necessary to validate this finding.
- Nobler materials provide more consistent results.

VII. Acknowledgements

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VIII. References

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