

# Insights into Electrochemical Noise of Aluminum in Chloride Environments

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Electrochemical noises, *i.e.* fluctuations of potential and/or current during electrochemical processes are well-known and easily observable phenomena. The use of the electrochemical noises as a method for investigating corrosion phenomena has been adopted increasingly. Aluminum and its alloys are susceptible to pitting corrosion in chloride environments, and their corrosion behavior is known to be quite different from that of stainless steels. However, although many studies have been carried out, the basic mechanisms that control the corrosion processes are poorly understood. The aim of this study is to investigate the pitting corrosion mechanisms of aluminum and its alloys by examining connections between the corrosion processes and the electrochemical noises.

Electrodes were fabricated from 99.9% purity Al wires of 0.76 mm and 0.20 mm diameters with cross sectional areas of  $4.5 \times 10^{-3} \text{ cm}^2$  and  $3.1 \times 10^{-4} \text{ cm}^2$ , respectively. The double-electrode specimen was fabricated using two wires of the same diameter. The two wires were mounted on both sides of a thin Perspex sheet, in order to separate them electrically, and then were encased in a cylindrical epoxy resin sleeve. Thus, the surfaces of two identical electrodes are exposed to solutions. The distance between the centers of the electrodes was 1.2 mm and 0.44 mm for 0.76 mm and 0.20 mm diameter electrodes, respectively. The surfaces of the specimens were wet-ground on a 600 grit silicon carbide abrasive paper and washed in distilled water. Solutions were made with analytical grade reagents and distilled water (18 M $\Omega$ ). Open-circuit potential of the short-circuited coupled electrodes against a saturated calomel reference electrode (SCE) was measured by a high impedance ( $10^{13} \Omega$ ) electrometer (Keithley, model 614). The current passing the coupled electrodes was also measured by a current mode of another Keithley electrometer. The outputs from these electrometers were fed to a 12 bit digital oscilloscope (Tektronix, TDS 420A) at an acquisition rate of 10 Hz or 25 Hz. All measurements were made at room temperature.

Figure 1 illustrates a 700 s trace of the current transient from the coupled electrodes together with the open-circuit potential in 0.05 M NaCl. After the measurement starts, the open-circuit potential increased from an initial value of  $-0.98 \text{ V(SCE)}$  while the current transient decreased toward zero with time. The current trace in the figure represents the difference between the passivation currents from the coupled electrodes. The potential curve starts to show intermittent rapid transients as the measurement proceeds. Each potential event displays a drop in the potential and a subsequent rise back to the baseline and is accompanied by a current spike, irrespective of its polarity. These events are ascribed to initiation, growth, repassivation of metastable pits, and recovery of the potential [1,2]. The current transient

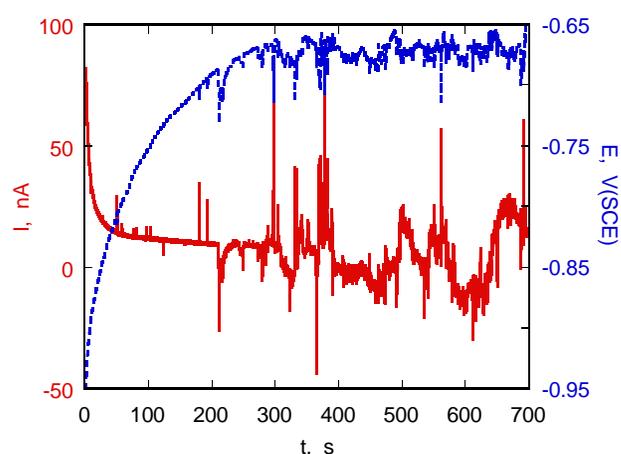
shows either positive or negative spikes, depending on which electrode experienced pitting. Approximately after 300 s, the potential curve fluctuates more vigorously and there is no discernible baseline. This transition denotes a fundamental change in the corrosion behavior of the aluminum. The origins of the transition on the electrochemical noise traces will be discussed in detail. Some observations of periodic oscillations on both potential and current transients during pit propagation will also be presented.

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## References

- [1] H.S. Isaacs, Y. Ishikawa, *J. Electrochem. Soc.*, **132**, 1288 (1985).
- [2] H.S. Isaacs, *Corros. Sci.* **29**, 313 (1989).



**Figure 1** A 700 s trace of the current transient (solid line) from coupled Al electrodes (0.76 mm diameter) together with the open-circuit potential (broken line) in 0.05 M NaCl.