Imaging and Characterization of Multiple Stress Corrosion Cracks in AA2024-T3 by X-Ray Radiography

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The intergranular stress corrosion cracking (SCC) of high strength aluminum alloys in seawater anad other chloride solutions has been studied for decades. However, the detailed interactions of stress and environment at a crack tip and the mechanism of crack propagation are still disputed. Moreover, the conventional fracture mechanics methods for studying SCC constrain the study to the propagation of a single crack. In this work, a new non-destructive evaluation (NDE) approach was developed to investigate SCC in AA2024-T3. Microfocal x-ray radiography was employed along with a novel sample configuration and electrochemical cell design to image multiple intergranular stress corrosion cracks in situ. A modified ASTM G49 stressing jig was used to apply a fixed tensile displacement to a thin sheet sample and a small electrochemical cell containing flowing 1 M NaCl was attached to the edge of the sample. Potentiostatic polarization was applied at a potential that promoted intergranular corrosion. The initiation and growth of multiple intergranular stress corrosion cracks have been characterized.

An example is given in Figure 1 for a sample stressed in the short transverse direction and exposed to solution at the longitudinal face so that the attack grew in the longitudinal direction As was observed in many experiments, the deepest crack at the beginning of the experiment (site 1 on the left) was found to slow and stop growing, and was surpassed by another crack that eventually penetrated through the sample (site 2). The possible mechanisms underlying this competition between cracks are discussed.

Figure 2a shows the depth of the two main cracks as a function of time. In figure 2b, the data from figure 2a are combined to show the depth of the deepest site as a function of time. These data are in good agreement with the kinetics of intergranular corrosion under an applied stress as determined by a completely different technique, foil penetration [1].

Reference

1. Xiaodong Liu, Z. Zhao, G.S. Frankel, B. Zoofan and S.I. Rokhlin, "Effects of Stress on Localized Corrosion in Al and Al Alloys," Proceedings of Triservice Corrosion Conference, Las Vegas, 2003.

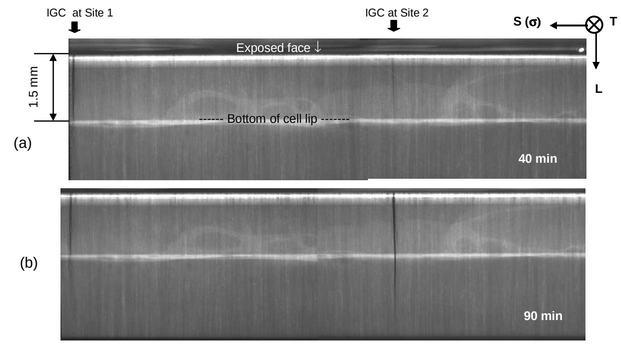

Figure 1: X-ray microfocal radiography images of IGSCC growth in L orientation in AA 2024-T3 with 0.18% strain applied in the S direction at 20x projection magnification. The potential was –580 mV SCE and the solution was 1.0 M NaCl. (a) after 40 min. (b) after 90 min.

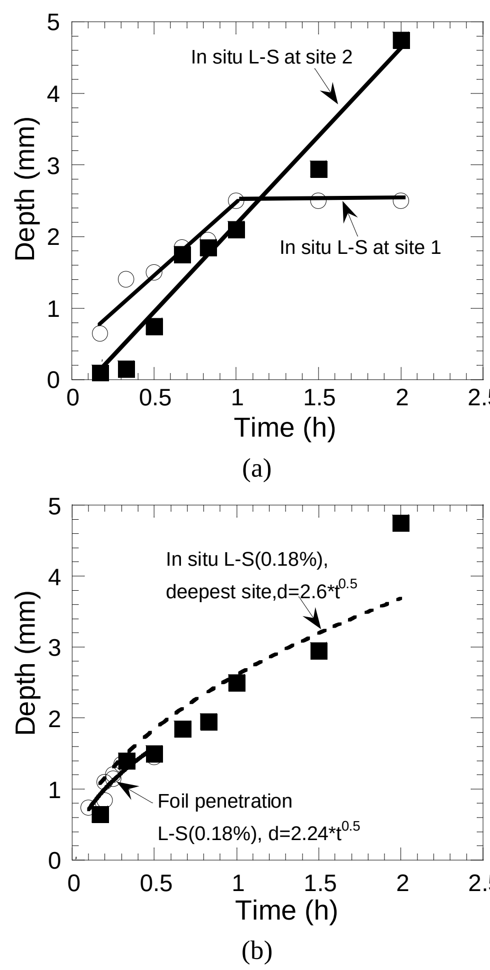

Figure 2: (a) Growth rate of individual IGSCC sites in AA2024-T3 L-S sample from *in situ* radiographic images compared to foil penetration data. Site 2 (filled squares) started later but grew to failure. (b) Combination of the data from sites 1 and 2 to show the deepest site at any time (filled squares) compared to foil penetration data (open circles) [1].