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Effect of applied stress on passivation kinetics and passivation modelling of 304L stainless steel in acidic medium

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1 Passivation Role in Stress Corrosion Cracking (SCC):
- Film rupture-dissolution model (FRM): describes intergranular SCC, shown in Fig. 1, as repetitive cycles of local surface activation, dissolution, and passivation near the crack tip [1]. Fig. 2 illustrates one of these cycles as described next:
  - To develop a model quantifying the passivation kinetics and parameters of passive films constructed in acidic medium.
  - To use this model to check the influence of stress on stainless steel passivation and passive film quality.

2 Quantification of Passive Film Thickness and Quality in Acidic Medium:
- Stressed and non-stressed samples of 304L stainless steel are subjected to potentiodynamic cycling tests as shown in Fig. 2. These serve as an electrochemical simulation of SCC activation/passivation cycle as described by FRM.
- Experiments were performed in 2 M H2SO4 solution at room temperature.
- In-situ atomic emission spectrophotometry (AESSEC) [3] was coupled with conventional electrochemistry during the tests. By this, the passivation current due to metallic dissolution can be quantified, as shown by Fig. 4.

3 Influence of Stress on Passive Film Thickness and Quality:
- For stressed samples, slightly higher charge exchange and thicker passive film (1.64 vs 1.58 nm ±0.03).
- Slopes of curves in Fig. 6 = CBV, a direct measure of the passivation rate and the film ionic conductivity.
- eBV is inversely proportional to the film quality [4]. Fig. 7 shows this factor for stressed and unstressed cases.

Fig. 1: SCC of 304L stainless steel after 88 h immersion in 2 M H2SO4 + 0.5 M NaCl.
Fig. 2: Representation of crack propagation by the film nature-dissolution model.
Fig. 3: Polarization curve showing an activation/passivation cycle.
Fig. 4: AESSEC experiment showing the metallic dissolution current densities during a potentiodynamic activation/passivation cycle. A: open circuit potential (OCP). B: Passivation pulse. D: OCP.

References: