Investigation of Intergranular Corrosion Propagation Promoted by Interactions between Sensitized Grain Boundaries using Closely Packed Electrode Arrays

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Intergranular corrosion (IGC) can be defined as the phenomena in which the corrosion rate of the grain boundary is higher than that of the bulk grain body. Austenitic stainless steels can become "sensitized" to this type of corrosion when the bulk metal experiences a temperature excursion above that necessary to make chromium carbides dissolve. As the metal cools, chromium carbide preferentially precipitates at the grain boundaries causing the local Cr concentration adjacent to the grain boundary to decrease relative to the Cr concentration in the bulk of the grain (Figure 1). This relative drop in Cr concentration adjacent to the grain boundary is called sensitization. A single loop electrochemical potentiokinetic reactivation (SL-EPR) method, originally developed for the nuclear industry and now an ASTM Standard, will be used to quantitatively measure the DOS of material in each array. A modification of this test can be made to show that IGC could occur in sensitized stainless steel adjacent to pits that grow by the acid-pitting mechanism.

Since a sensitized stainless steel does not necessarily experience IGC, this study has been broken into four parts. First, the environmental conditions for IGC to occur were determined. Second, the statistical nature of DOS as a function of grain size was analyzed and compared with previous works. Third, the temperature and acidification needed to promote IGC in a low level chloride solution was examined. And finally, the effect that the occurrence of localized corrosion has on neighboring grain boundaries will be determined. The proposed method for exploring these phenomena is to use close packed simple cubic arrays (Figure 2) of appropriately sized, electrically isolated, sensitized AISI 304, flush mounted to simulate a continuous planar electrode, tested in a 50 ^{o}C, neutral solution of 0.06M NaCl. Our main goal is to examine whether pitting and IGC on selected sites can trigger IGC on adjacent sites. Interactions that would promote IGC include acid pitting (which changes local proton concentration) and potential drop.

A polarization method originally used in studying interactions of local pit sites will be adopted to look at the interaction between grain boundaries and the propagation of IGC. It is believed that sensitized grain boundaries adjacent to sites of localized corrosion will preferentially corrode when their potential drops below the E_{pp} due to ohmic potential drop and local acidification. The potential drop is brought on by the flow of the passivation current (i_{pass}) through the resistance of the electrolytic environment (R_{elect}). (i.e., $E_{applied} = E_{pp} - i_{pass}*R_{elect}$). Acidification is due to hydrolysis of the base metal. In this study, we will hold one row (in an array of separately addressable electrodes) at a potential below the primary passivation potential (E_{pp}) or pit one row while holding all remaining rows above E_{pp} in a dilute NaCl (Figure 3). In this way, we will examine whether changes in local chemistry and potential drop "triggers" IGC at nearby grain boundaries.

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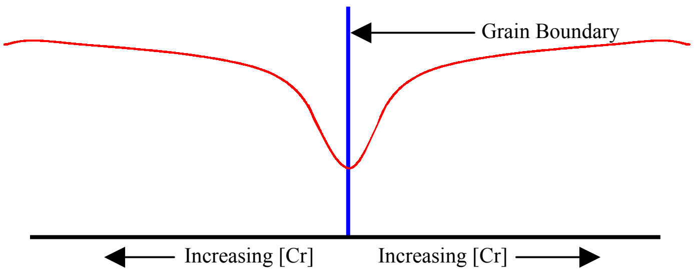

Fig-1. Relative Cr concentration near a sensitized Grain Boundary.

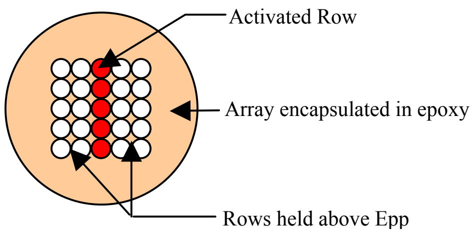

Fig-2. Close packed simple cubic wire array.

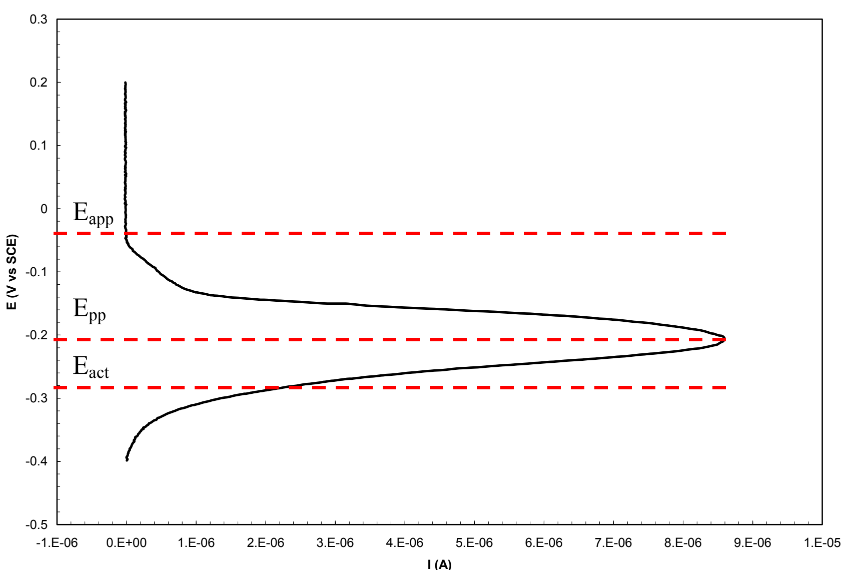

Fig-3. E vs I for 304 S. S. SL-EPR Test