Critical pit solution concentration for repassivation of stainless steel

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Abstract The critical pit solution concentration for repassivation (C_{crit}) is a key parameter that determines the pit repassivation process[1]. Unfortunately, there is no such a method that can determine the C_{crit} accurately, thus the C_{crit} reported in previous work varies greatly. Generally, the C_{crit} is considered as a fixed value located between 50%–80% of the saturation pit solution concentration (C_{sat})[2]. However, this consideration ignores the effect of potential and temperature. To gain a deep insight into pit repassivation process, it is necessary to develop an approach for accurate determination of C_{crit}, and to reveal its dependence on potential and temperature.

In this work, the downward potential scan was performed on growing one-dimensional (1D) artificial pit to determine the critical point for repassivation. To locate the critical point accurately, the variation of potential at pit surface (E_{surf}) during the growth in charge-transfer-control stage must be obtained, thus the potential drop of pit solution (Φ_{sol}) needs to be estimated accurately. Based on this consideration, we have developed a calculation model for Φ_{sol}, which takes the effect of concentration gradient inside the pit into account. Further analysis shows that the calculated E_{surf} in the charge-transfer-controlled growth stage decreases with pit current density, but to a critical point it increases. Further verification experiment shows that this lowest point corresponds to the critical point for pit repassivation. Clearly, the concentration of pit solution at this critical point is the C_{crit}, and it can be calculated by considering both diffusion and electro-migration. Based on this approach, the effect of surface potential (E_{surf}) and temperature as well as the alloy composition on C_{crit} was investigated. The C_{crit} was found to range from 75% to 89%, and it increase with the increase of E_{surf} and decrease with the increase of temperature. Additionally, the Mo addition was found to increase the C_{crit}.

Keywords Pitting repassivation, Critical pit solution concentration C_{crit}

Reference

[1] T. Li, J.R. Scully, G.S. Frankel, Erratum: Localized Corrosion: Passive Film Breakdown vs Pit Growth Stability: Part III. A Unifying Set of Principal Parameters and Criteria for Pit Stabilization and Salt Film Formation [J. Electrochem. Soc., 165 C762

(2018)], J Electrochem Soc. 167 (2020) 109001.
[2] K. Wang, T. Li, G.S. Frankel, M. Iannuzzi, On the critical pit stability product of stainless steel as a function of pit depth, Corros Sci. 231 (2024) 111955.