Pencil electrode study on the effect of microstructure on CPT of DSS 2205

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Duplex stainless steels are used typically in approximately equal volume fraction of ferrite and austenite phases to offer the favorable properties of both phases(1). Subjecting to thermal cycles like welding could change this balance and microstructure, affecting the corrosion resistance(2). After Brigham who introduced critical pitting temperature (CPT) as a temperature below which there is no stable pit(3), many researchers have used CPT as a criterion to rank pitting susceptibility in stainless steels(4). The influence of different ions on CPT has been investigated and further studies, corresponds the shift in CPT values to Change in pit chemistry (5), however the effect of microstructure on the pit chemistry has not been studied yet. The aim of this work is to study the effect of microstructural changes due to various solution annealing temperatures on CPT. Mechanistic approach has been done by focusing on the effect of microstructural changes on diffusion limiting current density (i_{lim}) of duplex stainless steels.

In the present work, critical pitting temperature of DSS 2205 alloy solution annealed at 1050°C and 1250°C was first estimated potentiostatically at 650mV (vs. SCE) by increasing temperature at a rate of 0.6 °C/min until the current density exceeds 100 μA/cm^2. The temperature associated to this current density was considered as a criterion for CPT assessment(6). Obtained results revealed approximately 8°C decrease in critical pitting temperature (CPT) value for the specimen solution annealed at 1250°C (fig 1.). This is probably due to precipitation of undesirable phase in the form of chromium nitride (Cr_2N) in ferrite phase during rapid cooling from higher temperature. The presence of this secondary phase in specimen heat treated at 1250°C confirmed by optical microscopy. (fig 2.).

In a point of view that CPT is a temperature which $i_{lim}=i_{crit}$ where i_{lim} is limiting current density and i_{crit} is the critical current density necessary for passivity(7), microstructural influence on diffusion limiting current density was investigated on the 80μm dia. DSS 2205 pencil electrode that were solution annealed at 1050°C and 1250°C by conducting potentiostatic tests in 850 mV (vs. SCE) at 65°C.

Linear proportion between i^2 and inverse of time that shown in fig. 3 is an indication of diffusion controlled dissolution as a consequence of salt film precipitation at the bottom of the pit. The slope of these curves is proportional to the $D.C_{Sat}$ where D and C_{sat} are diffusion coefficient and saturation concentration of the dissolving (Fe, Cr) cations at the pit bottom(5). Hence, a decrease in slope of i^2 vs. t^{-1} curves demonstrates a decrease in $D.C_{Sat}$ value. Based on combination of Faraday's second law and Fick's first law, $D.C_{Sat}$ has a linear proportion to $i_{lim}.\delta$ were δ is the pit depth(8). Therefore by comparing the results, it could be concluded that base on Salinas-Bravo and Newman proposal for CPT, the lower value of limiting current density is a possible reason for lower CPT value measured for specimen solution annealed at 1250°C.

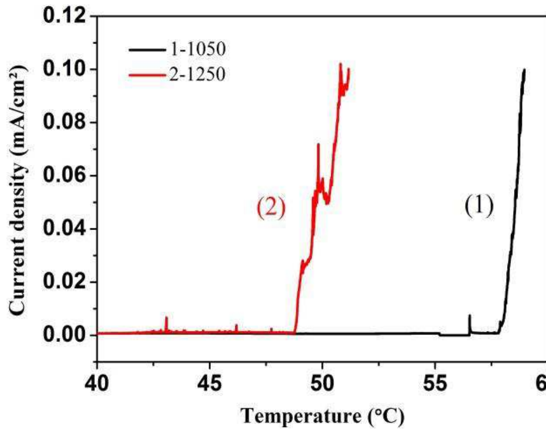

Figure 1. Current-temperature curves obtained from potentiostatic CPT determination of DSS 2205 alloy solution annealed at 1)1050°C and 2)1250°C at 650 mV (vs. SCE) in 3.5wt% NaCl solution

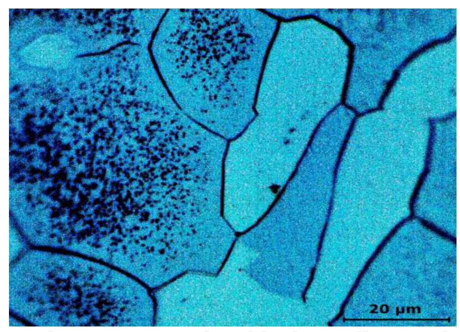

Figure 2. Chromium nitrides (black needles) in the ferrite matrix of 2205 alloy, solution annealed at 1250°C.

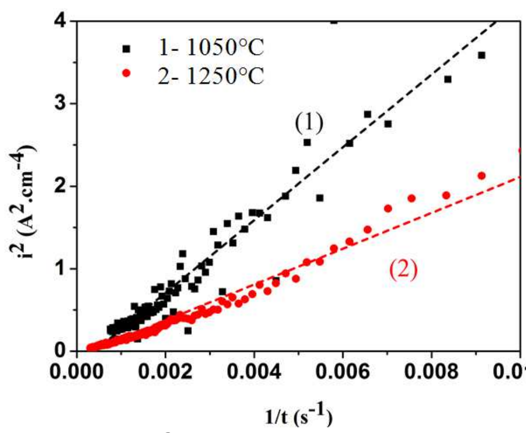

Figure 3. Plot of i^2-1/t obtained from the current density-time curves of DSS 2205 pencil electrode solution annealed at 1)1050°C and 2)1250°C at 850 mV (vs. SCE) in 3.5wt% NaCl solution at 65°C.

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