ABSTRACT

The present work deals with the influence of microstructural features on intergranular and pitting corrosion in austenitic stainless steel. Strain annealing-based one-step thermo-mechanical processing (OTMP) and iterative thermo-mechanical processing (ITMP) have been employed to optimize the grain boundary character distribution (GBCD). The OTMP comprising of low pre-strain (~ 5 and 10%) followed by annealing at 1273K for 1 hour has resulted in a large fraction of $\Sigma3^n$ boundaries and significant disruption in random high-angle grain boundaries (RHAGBs) connectivity owing to the occurrence of prolific multiple twinning. Among ITMP, the schedule comprising two cycles of 10% and 5% deformation followed by annealing at 1173K for 1 hour has yielded the optimum grain boundary engineering (GBE) microstructure with the grain size and residual strain akin to the as-received condition. The individual and synergistic effects of the microstructural features *viz.* grain size, residual strain, GBCD and its connectivity on intergranular corrosion (IGC) behavior have been evaluated. Straining accelerated sensitization by promoting chromium carbide precipitation via Cr diffusion through dislocations. Coarse-grained microstructure has suppressed IGC by delaying both the onset and progression of sensitization. GBE microstructure has exhibited remarkable resistance to IGC due to the reduction of chromium depletion zone in the vicinity of the grain boundaries owing to the substitution of RHAGBs by $\Sigma3$ and its variants. Impressively, evidence suggested that GBCD has higher implication than grain size or residual strain in controlling the IGC behavior. The individual influence of the microstructural features (i.e., grain size, residual strain, and GBCD) on the semiconducting behavior of the passive film has been critically investigated through electrochemical impedance spectroscopy and Mott-Schottky analysis. Further, the critical evaluation of the individual effect of the aforementioned microstructural parameters on the metastable pitting corrosion is also established through potentiodynamic and potentiostatic polarization tests. It has been found that the deformed and fine-grained microstructures have lower resistance to pitting corrosion. This behavior has been attributed to the lower stability of passive film due to the presence of a higher concentration of point defects. However, a significant fraction of $\Sigma3^n$ boundaries and J_3-type triple junction in the GBE-treated specimen resulted in greater stability of the passive film, which ultimately has led to remarkable resistance against pitting corrosion. The nucleation of pits has predominantly been found to happen at J_0 and J_1-type triple junctions and RHAGBs.

Keywords: Austenitic stainless steel; Grain boundary character distribution; Grain boundary engineering; Intergranular corrosion; Metastable pitting; Microstructure; Multiple Twinning; Passive film; Pitting corrosion; Sensitization; Thermo-mechanical processing.