Investigation of Effect of Oxide and Nitride on Initiation of Pitting Corrosion in Ferritic Stainless Steel by Micro-droplet Cell

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It is well documented that manganese sulfides (MnS) among non-metallic inclusions act as initiation sites for pitting corrosion in commercial stainless steels[1]. However, independent effects of other non-metallic inclusions such as oxide and nitride on localized corrosion in stainless steel have hardly investigated because of the low lateral resolution of the standard electrochemical experiment methods. Traditional macroscopic electrochemical behavior is simply the sum of the contributions of the different grains or phases, multiplied by their individual degree of coverage. A new electrochemical device, the capillary-based micro-droplet cell[3] gives facilities for micro-electrochemical investigations at high resolution. Small electrolyte droplets are positioned on the sample surface and enable a spatially resolved surface analysis or modification. The small area of the working electrode determined by the tip size of the capillary with a diameter of 20 ~600 µm enables the investigation of localized corrosion or passivation of small areas within a single grain or a phase.
In this study, using the micro-droplet cell and electrochemical noise analysis[2], we examined quantitatively the effects of oxide and nitrides on the initiation of pitting corrosion in 409L SS.

Commercial 409L SSs employed in this study were found to be different in the amount, morphology and type of non-metallic inclusions depending on the decarburization method applied in the refining process. Total amount of non-metallic inclusions in the alloy produced by argon oxygen decarburization (AOD) was much larger than that in the alloy produced by vacuum oxygen decarburization (VOD). non-metallic inclusions in the AOD alloy were round (Ti, Ca)-oxide with 10 ㎛ ~15 ㎛ in diameter, however, those in the VOD alloy were angular Ti-nitride less than 2 ㎛ in size. The differences in total amount and type of non-metallic inclusions caused large differences in the resistance to pitting corrosion of the alloy; the resistance to pitting corrosion of VOD alloy was much higher than that of the AOD alloy when evaluated in terms of the pitting potential determined from potentiodynamic polarization response and metastable pitting event density from ENA in 0.5 M NaCl solution. It was found from the micro-probe technique using a micro droplet cell that pitting corrosion initiated at the interface between round (Ti, Ca)-oxide and matrix(Fig.1).

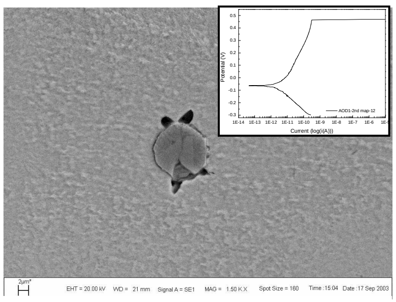

Fig.1. SEM images of pitted inclusions in 409L AOD alloy after potentiodynamic test in 0.5 M NaCl solution and its potentiodynamic curve.

On the other hand, Ti-nitrides in VOD alloy were inactive to pitting corrosion. For 409 alloy refined by AOD, the resistance to pitting corrosion increased linearly with Ti content in the (Ti, Ca)-oxide, but decreased with Ca content in the (Ti, Ca)-oxide(Fig.2).
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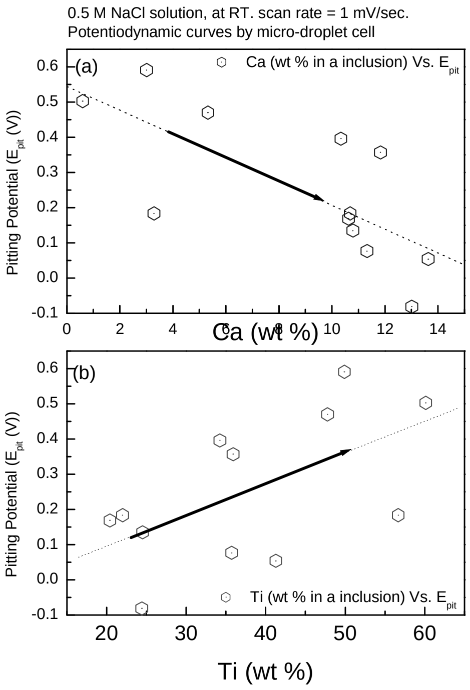

Fig.2. Effect of (a)Ca and (b)Ti concentration in a (Ti, Ca)-oxide inclusion on Epit obtained in 0.5 M NaCl solution at RT with the scan rate of 1 mV/s.

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