Study of Grain Boundary Precipitation in High Cr-Ni Corrosion Resistant Alloy

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Grain boundary (GB) phenomena including diffusion induced grain boundary migrating (DIGM) and discontinuous precipitation (DP) reaction are of great interest both for their effect upon mechanical and corrosion properties of alloys applied in petrochemical and nuclear industries [1,2]. The present investigation is developed in the Alloy 33 with FCC matrix and chemical composition 32.75Cr-bal.Fe-31.35Ni-1.49Mo-0.54Cu-0.40N-0.012C-0.63Mn-0.30Si, which presents excellent mechanical and corrosion properties. The microstructural evolution and precipitation behavior upon isothermally aging at 800 °C has been studied by scanning electron microscopy (SEM), electron backscatter diffraction (EBSD), transmission electron microscopy (TEM) and X-ray energy dispersive spectroscopy (XEDS).

Figure 1 presents EBSD maps obtained after isothermally aging at 800 °C for 5h. The image of the insertion shows a low magnification EBSD polycrystalline map, where grains having the same crystallographic orientation exhibit the same color. Figure 1, obtained on the region indicated by dark box in the insertion, shows the bulging of 3 GB, significantly varying from boundary to boundary. Clearly, some orientation relationships (OR) between austenitic grains favors more the development of GB migration (red arrow) than others GB with different OR (yellow arrows). This GB bulging is known to be linked to DIGM or DP [3]. In this alloy DIGM has been observed to precede DP reaction. In this figure the grain from which the DP reaction start migrating (grain A) "invades" the adjacent grain (grain B). Then, EBSD shows that the nucleation and growth of the DP colonies is affected by the misorientation across the boundary.

BSE-SEM image shown in Figure 2a presents a complex product of GB precipitation resulting for isothermally aging at 800 °C for 100 h. Here DP growth is in an advanced stage and it is very difficult to define which precipitates constitute the DP colony and which ones were formed within the matrix. During growth of the DP colony after long time aging, the GB reaction front interact with the matrix precipitates resulting in complex topological effects. When conducting EDX mapping on this area, it is verified the existence of, at least, three different precipitate phases at the GB and adjacent regions. XEDS elemental mapping show all precipitates are Cr-rich. However, the clear gray phase in (a) (pointed by arrows) is rich in Cr, Fe and Mo and impoverished in Ni, which suggest the intermetallic sigma phase. Also, it is possible to observe the existence of a Si- rich phase, which has been identified as eta phase (Cr_3Ni_2SiN). Current investigation is focused on the complete identification of the above-mentioned phases in terms of composition, crystallography and orientation relationships.

References

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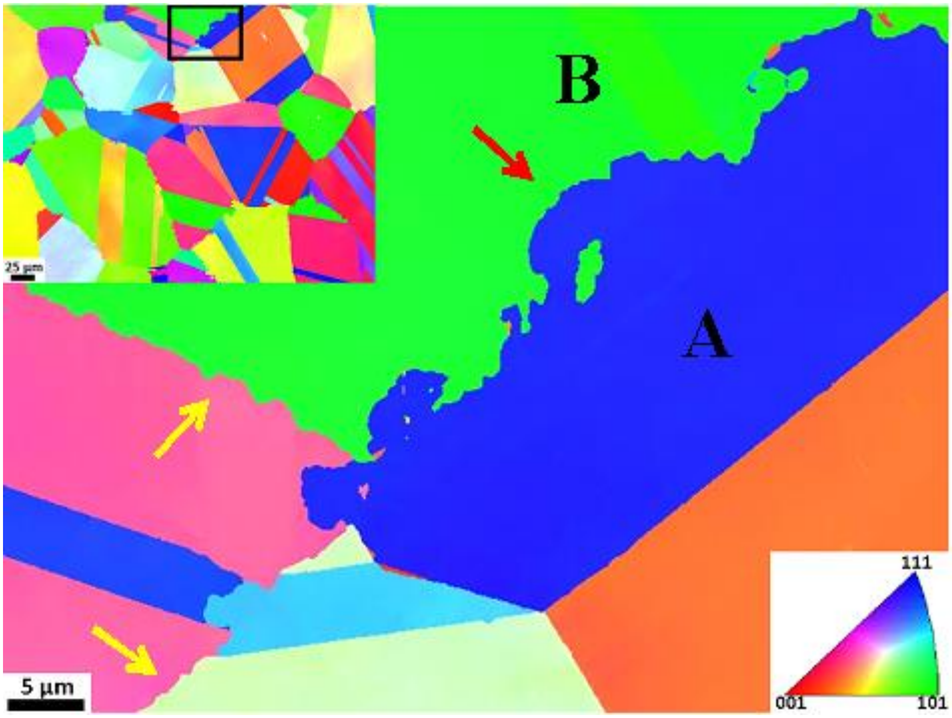

Figure 1 - EBSD maps of Alloy 33 after isothermally aging at 800 °C for 5h.

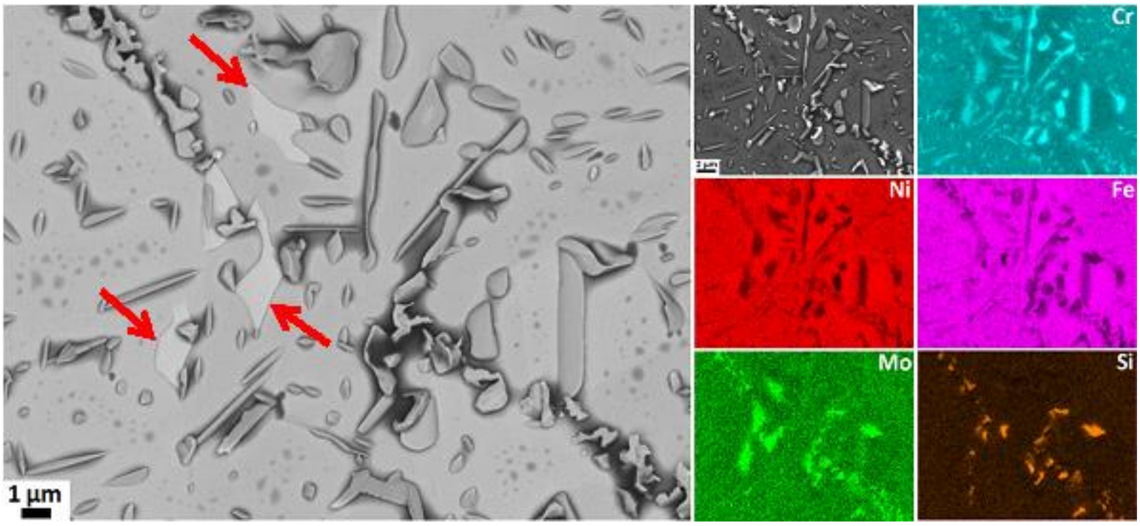

Figure 2 - BSE-SEM image of Alloy 33 after isothermally aging at 800 °C for 100h. Electrolytic polishing/ecthed.