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Intragranular Formation of Austenite During Delta Ferrite Decomposition in a Duplex Stainless Steel

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Abstract - A SAF2205 (UNS31803) duplex stainless steel was solution treated at 1325℃ for 1 hour, quenched in water and isothermally treated at 900℃ for 5,000 seconds. The crystallography of austenite was studied using EBSD technique. Intragranular austenite particles formed from delta ferrite are shown to nucleate on inclusions, and to be subdivided in twin-related sub-particles. Intragranular austenite appears to have planar-only orientation relationships with the ferrite matrix, close to Kurdjumov-Sachs and Nishyiama-Wassermann, but not related to a conjugate direction. Samples treated at 900℃ underwent sparse formation of sigma phase and pronounced growth of elongated austenite particles, very similar to acicular ferrite.

Studies were conducted on a Fe-22.5%Cr-4.53%Ni-3.0%Mo-0.3%N duplex stainless steel. Samples approximately 1 cm^3 in volume were solution treated at 1325℃ in air and water quenched. A set of samples was treated isothermally at 900℃ for 5,000 seconds. The solution treatment resulted in significant ferritic grain growth, yielding a ferritic grain size of ca. 2 mm. During quench, austenite formation took place on grain boundaries and in the interior of ferritic grains. Due to the large nitrogen content of the analyzed steel, extensive formation of chromium nitrides took place from the supersaturated ferrite, as well as nitride-free zones surrounding the austenite particles. Intragranular austenite particles were nucleated at inclusions. Electron Backscatter-Diffraction (EBSD) measurements were taken of the intragranular particles. The EBSD measurements show particles subdivided in twin-related units, indicating that each cluster of austenite crystals resulted from a single nucleation event followed by successive twinning. This bears a strong similarity with a solidification microstructure observed tin alloys used in electronics[(1)], known as "beach ball". An EBSD analysis of intragranular particles is shown in figure 1. The orientation relationships between austenite and ferrite, and between austenite grains were determined both using pole figures and with an algebraic method based on misorientation described as Euler angles, extracted from EBSD analyses. The particle labeled γ1 in figure 1 has a nearly exact Kurdjumov-Sachs relationship with the matrix. The particles labeled γ2 and γ3 are the result of later twinning. Particles were found also with no rational orientation relationship with the ferrite matrix, as well as particles with a planar orientation relationship close to K-S, but without an associated conjugate direction. This may derive from twinning outside the polishing plane or may be due to the austenite particles maintaining orientation relationships with the inclusion onto which they nucleated,.

On samples treated at 900℃, there was evidence of sigma phase particles inside the, austenite, probably nucleated at former gamma/delta interfaces; austenite growth later entrapped the newly formed sigma. The formation of elongated, intragranular particles of austenite was also observed. This is shown in figure 2. The elongated austenite particles carry a remarkable resemblance to acicular ferrite, such as the structures reported by Madariaga *et al.* [(2)] and Pan *et al.*[(3)]. The microstructure depicted in figure 2 probably contains acicular ferrite parallel and oblique to the polishing plane, indicating the occurrence of multiple variants of K-S and N-W orientation relationships.

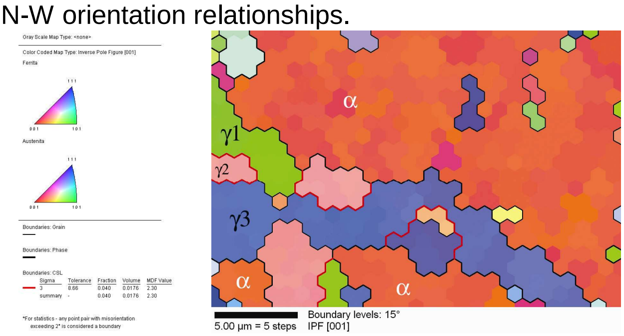

Figure 1 – EBSD analysis of intragranular austenite particles after solution treatment at 1325℃ and water quench

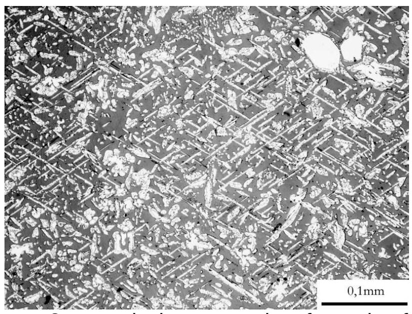

Figure 2 – acicular austenite formed after treatment at 900℃ for 5,000 seconds.

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