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Analytical microscopy studies of nitrogen solubility in austenite and ferrite upon welding of hyper duplex steel

Geronimo Perez[1], André Pimenta[2], Jefferson F. D. F de Araujo[3], juan Pardal[4], Sergio Maior Tavares[4], Marilia Diniz[5] and Guillermo Solorzano[6]

[1]Departamento de EngenhariaMecânica, Universidade Federal Fluminense, Niterói, Rio de Janeiro, Brazil, [2]Laboratório de Instrumentação e SimulaçãoComputacionalCientíficasAplicadas, Instituto Federal do Rio de Janeiro, Paracambi, Rio de Janeiro, Brazil, [3]Departamento de Física, PontifíciaUniversidadeCatólica do Rio de Janeiro, Rio de Janeiro, Rio de Janeiro, Brazil, [4]Departamento de EngenhariaMecânica, Universidade Federal Fluminense, Niteroi, Rio de Janeiro, Brazil, [5]Programa de Pós-graduaçãoemEngenhariaMecânica, UniversidadeEstadual do Rio de Janeiro, Rio de Janeiro, Brazil, [6]Departamento de EngenhariaQuímica e de Materiais, PontifíciaUniversidadeCatólica do Rio de Janeiro, Rio de Janeiro, Rio de Janeiro, Brazil

Hyper-duplex stainless steel and gas-shielded tungsten arc welding (GTAW) have been important research fields in technology and steel industry in recent times [1-4]. The effects of the addition of nitrogen during welding on the balance of the austenite/ferrite volume fraction ratio were studied in this work. The welding technique used was arc welding with tungsten gas (GTAW). The welded joints in tubes UNS S32707 of hyper-duplex steel were produced using a mixing of argon and nitrogen gas, with nitrogen added in ratios of 1.5 to 5.5%. Microstructural characterization of this material under the different processing condition was conducted by means of optical microscopy, scanning electron microscopy (SEM), local chemical analysis by X-ray energy dispersive spectroscopy (EDS), electron backscatter diffraction (EBSD) and Vickers micro hardness test. All welding conditions resulted in welded joints with equiaxial grains microstructure containing austenite both at the boundaries and in the ferrite matrix. The use of welding gases with higher percentages of nitrogen resulted in increases in the austenite volume fraction in the order of 39 to 57% when considering the nitrogen content ranging from 1.5 to 5.5%. The material used for this work was hyper-duplex tubes with 19.05 mm in diameter and 2.24 mm in thickness. Those tubes were welded in our laboratory in an automated manner using the gas tungsten arc welding (GTAW) process. The increase of the nitrogen content used in the shielding gas had no significant effect in the microhardness of the welded joints [1]. FIG.1 shows a focused ion beam (FIB) micrograph of the sample welded whit 1,5% of N content in the gas mixing. The channeling contrast induced by FIB allows observing the difference of orientation between the grains of the sample, different contrast for different orientations. The EBSD results showed that the fraction of austenite increases slightly with the increase in nitrogen. The results of the phase maps obtained by EBSD and the chemical maps obtained by EDS, allows to observe that nitrogen is found in higher concentration in the austenitic phase as well as nickel, which is a well-known as austenite stabilizer (FIG.2). The phase map of FIG.2 shows the austenite (Iron Gama) in green color. TSL software was used to collect and analyze the EBSD results.

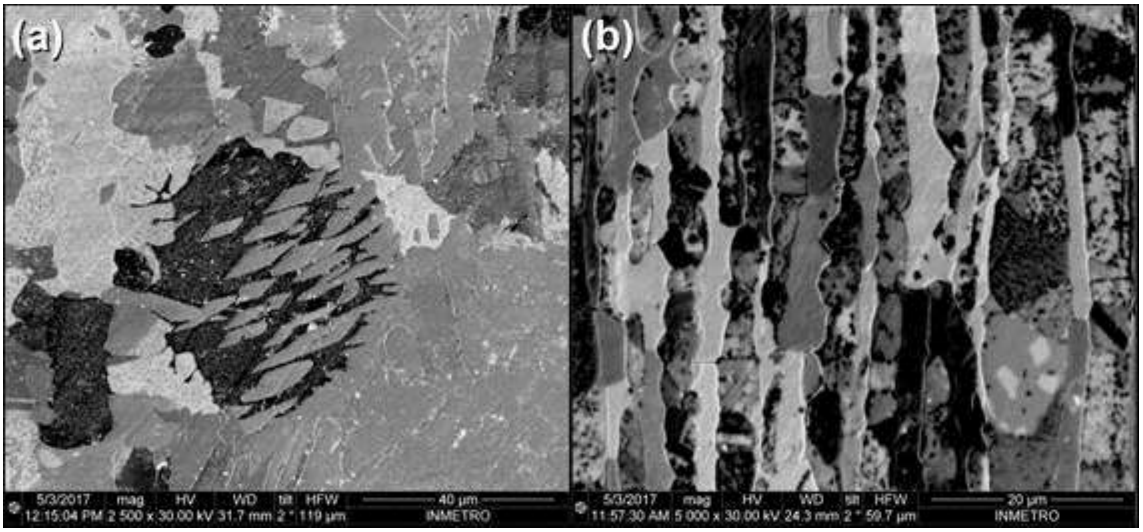

Figure 1. FIB image showing channeling contrast by ion beam of the sample welded whit 1.5% of N content: (a) general region, (b) melted region. Different contrasts represent different orientations.

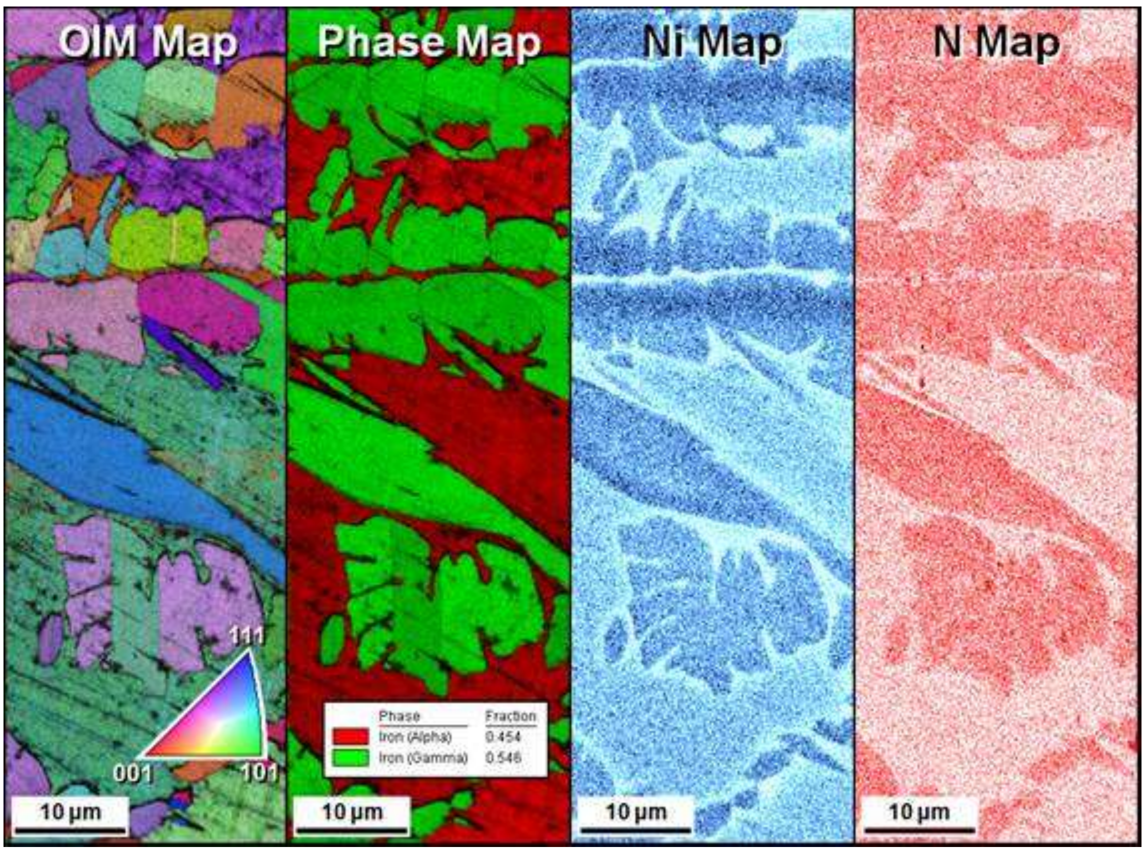

Figure 2. EBSD and chemical EDS maps results of the sample welded whit 1,5% of N content: Orientation map (OIM), phase map, nickel map (Ni) and nitrogen map (N). Note the concentration of nickel and nitrogen in the austenite (green phase on the phase map).

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