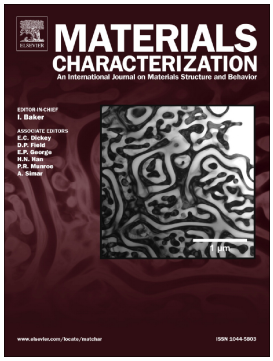

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PII: S1044-5803(17)33282-5
DOI: doi:10.1016/j.matchar.2018.03.024
Reference: MTL 9113

To appear in: *Materials Characterization*

Received date: 25 November 2017
Revised date: 23 February 2018
Accepted date: 18 March 2018

Please cite this article as: Vahid A. Hosseini, Leif Karlsson, Cem Örnek, Pierfranco Reccagni, Sten Wessman, Dirk Engelberg , Microstructure and functionality of a uniquely graded super duplex stainless steel designed by a novel arc heat treatment method. The address for the corresponding author was captured as affiliation for all authors. Please check if appropriate. Mtl(2017), doi:10.1016/j.matchar.2018.03.024

Microstructure and functionality of a uniquely graded super duplex stainless steel designed by a novel arc heat treatment method

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Abstract

A novel arc heat treatment technique was applied to design a uniquely graded super duplex stainless steel (SDSS), by subjecting a single sample to a steady state temperature gradient for 10 h. A new experimental approach was used to map precipitation in microstructure, covering aging temperatures of up to 1430ºC. The microstructure was characterized and functionality was evaluated via hardness mapping. Nitrogen depletion adjacent to the fusion boundary depressed the upper temperature limit for austenite formation and influenced the phase balance above 980°C. Austenite/ferrite boundaries deviating from Kurdjumov–Sachs orientation relationship (OR) were preferred locations for precipitation of σ at 630-1000°C, χ at 560-1000°C, Cr_2N at 600-900°C and R between 550°C and 700°C. Precipitate morphology changed with decreasing temperature; from blocky to coral-shaped for σ, from discrete blocky to elongated particles for χ, and from polygonal to disc-shaped for R. Thermodynamic calculations of phase equilibria largely agreed with observations above 750°C when considering nitrogen loss. Formation of intermetallic phases and 475ºC-embrittlement resulted in increased hardness. A schematic diagram, correlating information about phase contents, morphologies and hardness, as a function of exposure temperature, is introduced for evaluation of functionality of microstructures.

Keywords: Functionally graded microstructure; Sigma phase; 475ºC-embrittlement; Chi phase; R-phase; Nitrogen loss.