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Ordering of Nitrogen-Supersaturated Interstitial Solid Solution in Fe-Cr-Ni Austenitic Alloys and Steel Modified by Plasma-Based Low-Energy Ion Implantation

Honglong Che, S. Tong, K.S. Wang, M.K. Lei

Dalian University of Technology, Dalian, China

hlche@mail.dlut.edu.cn

The formation of a metastable and nitrogen-supersaturated f.c.c. interstitial solid solution layer on Fe-Cr-Ni austenitic stainless steel at a moderate temperature around 400° C is not completely understood. In this work, seven designed Fe-Cr-Ni austenitic alloys containing of 0-17.66 wt.% chromium and the commercial AISI 304L austenitic stainless steel are modified by the plasma-based low-energy nitrogen ion implantation at 380° C for 4 h. A duplex layer structure is confirmed on all the nitrided Fe-Cr-Ni austenitic alloys and AISI 304L austenitic stainless steel by optical and magnetic force microscopy, X-ray diffraction and transmission electron microscopy, although a single layer was usually observed on the austenitic alloy and steel composed of a high Cr content above 12.00 wt.% by metallography, X-ray diffraction and electron probe micro-analysis, respectively. The outer sublayer is characterized as a nitrogen-supersaturated γ'-Fe4N-like ordered phase (γ'N), and the inner sublayer is as nitrogen-supersaturated disordered f.c.c. phase (γN). All the γ'N phases on the Cr-varied Fe-Cr-Ni austenitic alloys are isostructural with the stable γ'-Fe4N phase, moreover the γN phases are isostructural with a nitrogen-saturated f.c.c. solid solution (γ*N) on the Cr-free austenitic alloy. A cell model, considering atomic interaction between nitrogen atom and octahedral interstice consisting of six varied Cr, Fe and Ni atoms, is established to understand the mergence of duplex layer when Cr content above 12.00 wt. % in alloys, which based on the addition of Fe4N-like long-rang ordered Fe-N interaction in the γ'N phase together with the short-rang ordered Cr-N interaction as in the γN phase. The ordering of the nitrogen-supersaturated f.c.c. interstitial solid solution from the γN to γ'N phase carry out over a critical concentration dependent on the Cr-N interaction and Fe4N-like Fe-N interaction in the nitrided Fe-Cr-Ni austenitic steel and alloy.

Keywords
Plasma-based low-energy ion implantation
Austenitic alloy
High nitrogen f.c.c. phase
Isostructurality
Cell model