PO4071

Low-temperature plasma nitriding of ferritic Fe-Al alloys

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Low-temperature thermochemical treatments have been strongly studied for stainless steels. As these treatments are performed at low temperature, the diffusion of substitutional alloying elements of the substrate is negligible and the diffusion of interstitial atoms like carbon and nitrogen is significant, characterizing the so called para-equilibrium state. Under this state, metastable phase formation, which sometimes presents very interesting properties, is favored. Regarding the works found in literature, most of them are dedicated to low-temperature nitriding/carburizing of alloys containing nitride/carbide forming elements like Cr. Differently, the present work aims to study the low-temperature nitriding of ferritic Fe-Al alloys, considering that Al is a strong nitride former element, and verify if such alloys can present a behavior similar to those verified for low-temperature nitrided stainless steels. For this purpose pure iron samples and Fe-Al alloys containing 1, 3, 5, 7 and 10 wt.% Al were produced trough melting Fe-Al powder mixtures using PTA technique. The samples were plasma nitrided at 250, 300, 350, 400 and 450 °C for 4 h, using a gas mixture composed of 10%Ar+70%N_2+20H_2 at a flow rate of 200 sccm. The plasma was excited using a 4.2 kHz pulsed dc power supply set at 700 V. The samples were characterized by MEV, EDS, WDS, XDR and microhardness measurements. The obtained results are very distinct from that obtained for stainless steels. The microstructure of the obtained nitrided layers is strongly related to the Al content of the samples, which also significantly influence the treated surface morphology, hardness and nitrogen content. The presence of Al leads to the formation of saw-like layer-substrate interfaces. The higher the Al content the higher is the treated surface hardness and N-content. Differently to the observed in stainless steels, the presence of N solved in the steel matrix is not evident and the hardening effect is mainly attributed to nano-precipitates of nitrides, probably a cubic (Fe,Al)N para-equilibrium nitride.

Keywords
Low-temperature
Nitriding
Nano-precipitates
Para-equilibrium