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Plasma assisted nitriding of Fe, Ni or Co-based fcc alloys: influence of the alloying elements on nitrogen profile in the expanded phaseLuc PICHON¹, Sébastien Chollet¹, Jean-Baptiste Dubois¹, Jonathan Cormier¹, Patrick Villechaise¹, Claude Templier¹, Michel Drouet¹¹Institut P¹ - CNRS - U. Poitiers - ENSMA, Chasseneuil-Futuroscope, France

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Moderate temperature (400°C) and low pressure N₂-H₂ plasma assisted nitriding was performed on various fcc metallic alloys: Fe austenitic stainless steels, Ni-Cr alloys, Ni-based superalloys and a Co-based alloy. All these materials present a common fcc γ -phase made from substitution solid solution by the alloying elements (Cr, Mn, ...) and with a lattice parameter about 0.360 nm. Some of them have additional precipitates (e.g. γ' Ni₃(Al,Ti) ; γ'' Ni₃Nb, δ Ni₃Nb) and carbides.

The nitrided samples were characterized by Glow Discharge Optical Emission Spectroscopy (GDOES), X-Rays Diffraction (XRD), Scanning Electron Microscopy (SEM) and White Light Interferometry (WLI). They all exhibit a nitrided fcc γ_N phase over a few microns, resulting from the insertion and diffusion of the nitrogen atoms in the γ phase, thus inducing a very high expansion of the γ phase cell (more than 10%). CrN precipitates have been also detected in few alloys. The SEM and WLI surface examination shows that the grains have been submitted to an important swelling due to the expansion of the lattice and to a partial plastic relaxation of the in-plane stresses. The maximum nitrogen content in the γ_N phase can be obtained at the surface and can reach 20-30 at%, depending on the alloys. Deeper, the nitrogen profile is roughly flat (plateau-like) over few microns and followed by a rapid decrease at the γ_N / γ interface.

As expected with the trapping-detrapping mechanism proposed in the literature, the nitrogen content in the γ_N phase at the end of the plateau is equivalent to the "trapping" elements contents (mainly Cr). On the contrary, the maximum nitrogen content achievable in the γ_N phase at the surface is not correlated to its "trapping" elements content such as Cr. It is proposed that the nitrogen content in the γ_N phase is likely limited by a steric effect once about half of the octahedral sites are occupied. Post-annealing of the nitrided samples under neutral atmosphere seems to confirm this hypothesis.

Keywords

nitriding

Ni superalloys

trapping