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Nitriding of Super-Ferritic Stainless Steel by Plasma Immersion Ion Implantation in Radio Frequency and Microwave Plasma System

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Abstract : The 470 Li-24 Cr and 460Li-21 Cr are two alloys belonging to the next generation of super-ferritic nickel free stainless steel grades, containing titanium (Ti), niobium (Nb) and small percentage of carbon (C) and nitrogen (N). The addition of Ti and Nb improves in general the corrosion resistance while the low interstitial content of C and N assures finer precipitates and greater ductility compared to conventional ferritic grades. These grades are considered an economic alternative to AISI 316L and 304 due to comparable or superior corrosion. However, since 316L and 304 can be nitrided to improve the mechanical surface properties like hardness and wear; it is hypothesize that the tribological properties of these super-ferritic stainless steels grades can also be improved by plasma nitriding. Thus two sets of plasma immersion ion implantation experiments have been carried out, one with a high pressure capacitively coupled radio frequency plasma at PUC Chile and the other using a low pressure microwave plasma at IOM Leipzig, in order to explore further improvements in the mechanical properties of 470 Li-24 Cr and 460Li-21 Cr steel. Nitrided and unnitrided substrates have been subsequently investigated using different surface characterization techniques including secondary ion mass spectroscopy, scanning electron microscopy, energy dispersive x-ray analysis, Vickers hardness, wear resistance, as well as corrosion test. In most of the characterizations no major differences have been observed for nitrided 470 Li-24 Cr and 460Li-21 Cr. Due to the ion bombardment, an increase in the surface roughness is observed for higher treatment temperature, independent of the steel types. The formation of chromium nitride compound takes place only at a treatment temperature around 4000C-4500C, or above. However, corrosion properties deteriorate after treatment at higher temperatures. The physical characterization results show up to 25 at.% of nitrogen for a diffusion zone of 4-6 □m, and a 4-5 times increase in hardness for different experimental conditions. The samples implanted with temperature higher than 400 °C presented a wear resistance around two orders of magnitude higher than the untreated substrates. The hardness is apparently affected by the different roughness of the samples and their different profile of nitrogen.

Keywords : ion implantation, plasma, RF and microwave plasma, stainless steel
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