Hardness and elastic modulus gradients in plasma nitrided 316l polycrystalline stainless steel investigated by nanoindentation tomography

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Abstract

Austenitic stainless steel (ASS) suffers low hardness which can be enhanced by plasma nitriding. This treatment is performed at moderate temperature; typically around 400∘C, to maintain the corrosion resistance of the ASS. The insertion of nitrogen leads to the formation of the metastable γN phase (or "expanded" austenite) within a layer several micrometers thick after a few hours of treatment In this study, the correlation between the grain orientation and the elastic properties of plasma nitrided polycrystalline ASS is investigated. Polycrystalline 316L ASS was plasma nitrided at 400∘C for 8 h under a pressure of 7.5 Pa using a 60 sccm N2 and 40 sccm H2 mixture. The grain orientations (hkl) in a delimited area were obtained from electron backscatter diffraction (EBSD). Elastic modulus Ehkl and hardness Hhkl were obtained using nanoindentation tomography. The method consists in performing large regular indentation arrays (more than 1000 indents) in order to obtain hardness and elastic modulus mapping. By repeating this method in a same area after successive partial removals of the nitrided layer, the elastic modulus and hardness cartographies can be reconstructed in 3D, and compared to the nitrogen concentration, which depends on the crystallographic orientations of the investigated grains. The results show that plasma nitriding leads to a complete reversal of the elastic behavior anisotropy: while the non-nitrided 316L ASS shows the typical elastic anisotropy of fcc-type metals with a maximum of Ehkl for the oriented grains, the maximum of Ehkl is observed for the oriented grains in the nitrided layer. A similar anisotropy reversal is observed for the hardness. These observations are discussed on the basis of the microstructural changes induced by the nitrogen incorporation as well as the residual stress effects.

Keywords: naoindentation, hardness, stainless steel, plasma nitriding

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