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Fracture and structural modifications induced by cathodic hydrogenation after nitriding on AISI 304

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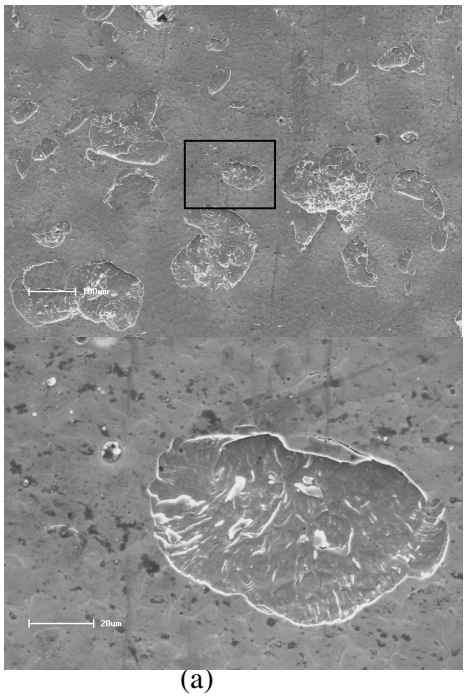
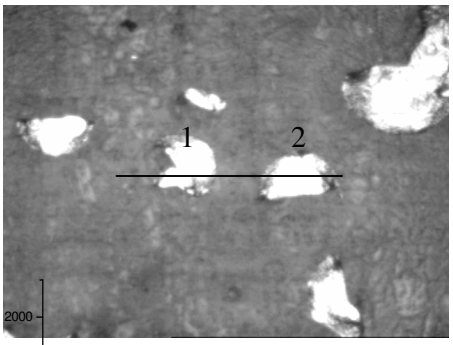
Abstract – Hydrogen embrittlement in steels is a well known process. In this work we investigate hydrogen evolution in the AISI 304 steel samples that were nitrided by glow discharge. After nitriding samples were submitted to cathodic hydrogenation. Untreated and nitrided samples show very different fracture patterns after hydrogenation. The fractures of nitrided samples are mostly of chipping type, while the not nitrided samples show fractures that are normal to the surface.

Hydrogen embrittlement occurs in steels submitted to atmospheres rich in hydrogen. Austenitic steels are less affected by H embrittlement than other steels but, when exposed to hydrogen, fractures occur at surface. Nitriding processes are employed to increase the mechanical resistance to surface contact with other materials. The nitrided layers are hard but more brittle.

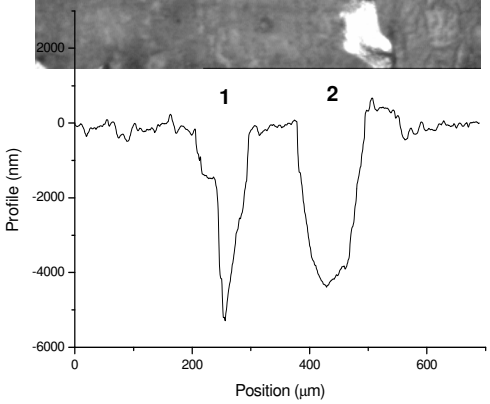
The AISI 304 austenitic steel samples were nitrided by DC glow discharge in temperatures from 400 ºC to 600 ºC in a chamber with gas mixtures of 20% N – 80% H. After nitriding the samples were submitted to cathodic hydrogenation in a sulfuric acid solution with current density of 1000 Am^{-2}. X-ray diffractometry was employed to determine the structure of the modified layer at the surface of nitrided samples and after outgassing processes that follows the cathodic hydrogenation. The type of fracture depends on the hydrogen evolution (hydrogenation and outgassing) in the steel that varies according the nitrided layer structure. The characterization of chipping type fracture is shown in Fig. 1. The depths of nitrided hard layer were estimated as 3-10 μm by instrumented indentation hardness and they depend on the working temperature.



(a)



(b)



(c)

Figure 1 – (a) SEM of chipping fractures on AISI 304 steel nitrided at 550 °C and hydrogenated. (b) Image of region where the profile was made. (c) Profile indicating the depth of chipping due to hydrogen accumulation under the nitrided layer.