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The effect of pre-deformation on corrosion resistance of the passive film formed on 2205 duplex stainless steel

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ABSTRACT

Effect of pre-deformation on the corrosion resistance of 2205 duplex stainless steel was investigated by microstructure observations, electronic work function measurement and electrochemical experiments. Transmission electron microscope observations showed that the dislocation density in ferritic and austenitic phases increased with the increasing of strain. Moreover, the strain induced α'-martensite was observed in sample with large strain based on XRD analysis and Transmission electron microscope observations. The electron work function of ferrite was higher than that of austenite. In addition, the surface electron work function of ferritic and austenitic phases decreased with the increasing of strain. More dislocations and chloride ions promoted to form more oxygen vacancies and cation vacancies in the passive film based on point defect model and autocatalytic reaction. Therefore, the corrosion resistance of the passive film formed on 2205 duplex stainless steel decreased with the increasing of strain in borate buffer solution with chloride ions. These results were proven by further immersion test.

1. Introduction

Duplex stainless steels which contain the δ-ferritic and γ-austenitic phases are known to have good mechanical property and corrosion resistance. In addition to high strength, these steels also exhibit improved corrosion characteristics in chloride-rich media due to the high Cr and Mo content [1]. The evolution of the passive films on 2205 duplex stainless steel and AISI 316L austenitic stainless steel in artificial saliva and artificial saliva with the addition of fluoride were carried out [2]. The extent of the passive range increased for the 2205 duplex stainless steel compared with the AISI 316L austenitic stainless steel in both solutions. The passive films on both steels predominantly contained Cr-oxides, whereas the Fe species were markedly depleted. Electrochemical polarization and in-situ Atomic Force Microscope measurements in 1 M NaCl solution at room temperature showed a passive behavior of the duplex stainless steel despite the presence of the quenched-in nitrides in the ferritic phase [3]. The study indicated that 2205 duplex stainless steel had a higher corrosion resistance than AISI 316L austenitic stainless steel [4]. Galvanic current measurements revealed that austenitic phase was anode in HNO_3 solution, but became cathode when exposed in 2 M H_2SO_4 + 0.5 M HCl mixed solution for 2205 duplex stainless steel [5].

Several studies paid more attention to effects of elastic stress and cold working on corrosion behavior of the duplex stainless steel. The corrosion resistance of SAF 2205 duplex stainless steel decreased slightly with increasing of elastic stress level and noticeably with increasing of pre-strained level in 3.5% NaCl and 2 mol/L HCl solution [6]. The electrochemical behavior of the duplex steels could be correlated to the surface stress state measured in the austenitic phase under a mechanical stress below the yield strength [7]. The passive film on UNS 2202 duplex stainless steels was thinner due to cold-working [8]. It was shown that austenitic sites containing extremely small ferritic grains were precursor sites for pitting in 4 M NaCl [9]. With the increase of strain, the increase tendency of acceptor density was more significant than that of donor density for 304 austenitic stainless steel in borate buffer solution. The investigation indicated that the more

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acceptor densities might directly decrease corrosion resistance of the 304 stainless steel [10]. This study investigated the dependence of corrosion resistance on pre-strain level for 2205 duplex stainless steel in borate buffer solution with chloride ions.

2. Experimental methods

The chemical composition of 2205 duplex stainless steel in weight percent was 0.05% C,1.05% Mn, 0.022% P, 0.0008% S, 0.75% Si,

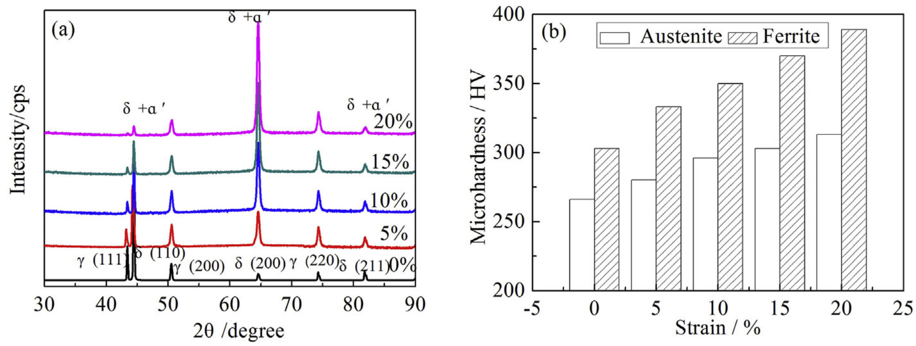

Fig. 1. (a) The XRD patterns for solid solution annealed and strained 2205 duplex stainless steels, (b) The effect of strain on the microhardness values of ferritic and austenitic phases in 2205 duplex stainless steel.

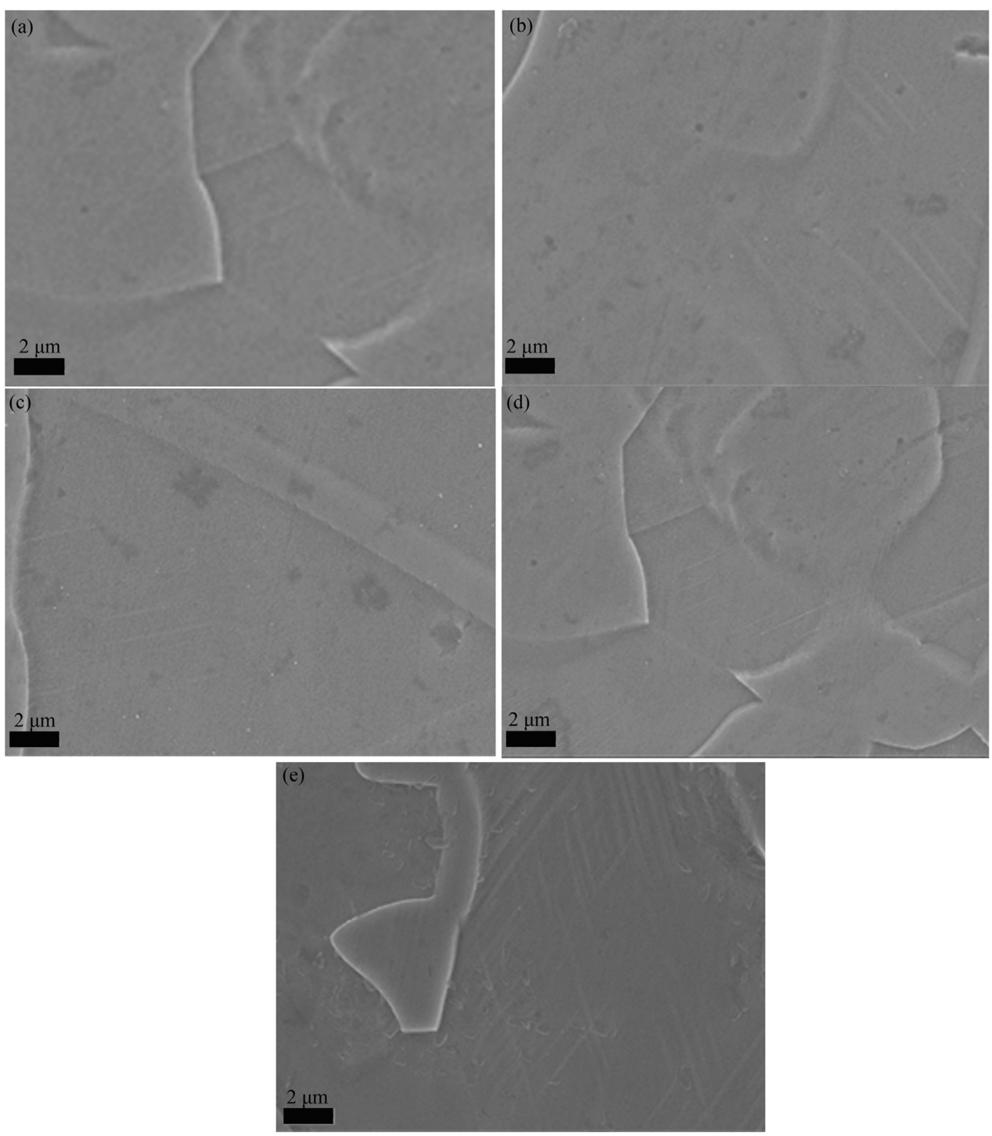

Fig. 2. SEM images of 2205 duplex stainless steel with strain of (a) 0%, (b) 5%, (c) 10%,(d) 15% and (e) 20%, respectively.