Effects of Hydrogen on Deformation and Fracture of Austenitic Stainless Steel: Deformation Microstructure of 21Cr-6Ni-9Mn Steel

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Hydrogen-metal interaction is the key to development of hydrogen-related materials. In the case of hydrogen storage alloys, which react with hydrogen to form metal hydrides, hydrogenation is accompanied by large volume expansion. This results in introducing lattice strain and defects into alloys. The lattice strain and defects have a great effect on the reaction rates, effective hydrogen capacity, and so on. In hydrogen structural materials such as steels and Al-Ni alloys which are composed of elements with low affinity for hydrogen, hydrogen solute greatly affects mechanical properties of alloys. Phenomena such as hydrogen embrittlement, hydrogen softening, and hydrogen hardening are well known. Therefore, it is important to explain effects of hydrogen-metal interaction on material properties to improve the performance of both storage and structural materials.

Previous studies revealed that hydrogen solute reduced ductility of austenitic stainless steels. In this study, we have investigated effects of hydrogen on deformation and fracture of 21Cr-6Ni-9Mn austenitic stainless steel by transmission electron microscopy (TEM). Two sets of samples were prepared: one was not exposed to hydrogen and another was precharged with 220 ppm. Samples were deformed to strain of 5%, 20% and 35% at 223 K. The hydrogen-charged 21-6-9 sample did not require the strain of 35% to reach the ultimate tensile strength. TEM specimens were prepared by electropolishing in an electrolyte of 10% perchrolic and 90% ethanol. As a result of TEM observation, twins were observed in the hydrogen-charged and non-charged 21-6-9 specimens with the high strain of 20 %. Other planar defects on slip planes of {111} were also visible in the specimens with the low strain of 5%, and seemed to increase with increasing strain. Details of twin and dislocation structures have been analyzed and discussed.

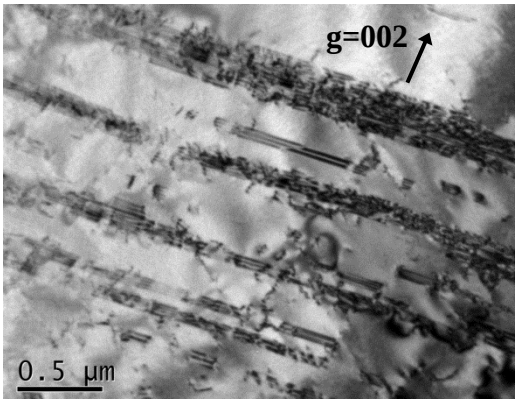

Fig. Bright-field TEM image of hydrogen-charged 21Cr-6Ni-9Mn steel with 5% strain.