ICSMA19 Metz, France, June 26 - July 1, 2022
International Conference on Strength of Materials

Hydrogen embrittlement of a CrMnFeCoNi high-entropy alloy treated by ultrasonic shot peening

Marc Novelli[a,b], Abbas Mohammadi[c], Makoto Arita[d], Jae Wung Bae[e], Thierry Grosdidier[a,b], Hyoung Seop Kim[f], Kaveh Edalati[c]

a Université de Lorraine, Laboratory of Excellence on Design of Alloy Metals for low-mass Structures (DAMAS), Metz, F-57070, France

b Université de Lorraine, Laboratoire d'Etude des Microstructures et de Mécanique des Matériaux (LEM3 UMR 7239), Metz, F-57070, France

c WPI, International Institute for Carbon-Neutral Energy Research (WPI-I2CNER), Kyushu University, Fukuoka 819-0395, Japan

d Department of Materials Science and Engineering, Faculty of Engineering, Kyushu University, Fukuoka 819-0395, Japan

e Max-Planck-Institut für Eisenforschung GmbH, Max-Planck-Straβe 1, Düsseldorf, 40237, Germany

f Graduate Institute of Ferrous & Energy Materials Technology, Pohang University of Science and Technology, Pohang, 37673, Republic of Korea

corresponding author: marc.novelli@univ-lorraine.fr

The hydrogen embrittlement resistance of a CrMnFeCoNi high-entropy alloy processed by ultrasonic shot peening is characterized and compared to a non-deformed coarse-grain alloy as well as a bulk nanostructured alloy produced by high pressure torsion. The coarse-grain alloy shows high ductility and limited hydrogen diffusion, but its yield stress is limited to 250 MPa. The nanostructured alloy shows an ultrahigh yield stress of 1850 MPa, but its resistance to hydrogen embrittlement is poor because of hydrogen-induced intergranular cracking. However, the introduction of gradient microstructures leads to high yield stresses of 500-700 MPa with 15-33% plasticity in the presence of hydrogen. The good combination of high strength and high ductility in gradient microstructure HEAs is presented by considering the hydrogen-enhanced localized plasticity and by attributing the high strength and high plasticity to nanostructure and coarse structure.

Keywords: Hydrogen embrittlement; High-entropy alloys (HEAs); Surface mechanical attrition treatment (SMAT); Severe plastic deformation (SPD); Deformation Twin