Low-cycle-fatigue behavior of CoCrFeMnNi high-entropy alloy at room temperature

Mao-Yuan Lo[1], Tu-Ngoc Lam[1], You-Shiun Chou[1], Tsung-Ruei Suei[1], Yao-Jen Chang[2,], An-Chou Yeh[2,3], Stefanus Harjo[4], Soo Yeol Lee[5], Jayant Jain[6], Bo-Hung Lai[1], and E-Wen Huang[1,*]

[1] Department of Materials Science and Engineering, National Chiao Tung University, 1001 University Road, Hsinchu 30010, Taiwan (R.O.C.)
[2] Department of Materials Science and Engineering, National Tsing Hua University, Hsinchu 30013, Taiwan (R.O.C.)
[3] High Entropy Materials Center, National Tsing Hua University, Hsinchu 30013, Taiwan (R.O.C.)
[4] J-PARC Center, Japan Atomic Energy Agency, 2-4 Shirane Shirakata, Tokai-mura, Naka-gun, Ibaraki 319-1195, Japan
[5] Department of Materials Science and Engineering, Chungnam National University, Daejeon 34134, Republic of Korea
[6] Department of Materials Science and Engineering, Indian Institute of Technology, New Delhi, 110016, India
* Correspondence: EwenHUANG@nctu.edu.tw

Abstract

This study investigates the neutron–diffraction experiments of an equal molar CoCrFeMnNi high-entropy alloy (HEA) and a nickel-based superalloy with low cycle fatigue at room temperature. By using the *in-situ* measurement, lattice-strain analyses can be collected from the evolution of peaks. We clearly obtain the cyclic hardening and softening in both alloys. However, the results show that the deformation of the two systems is dominated by different mechanisms.

Keywords - In-situ neutron diffraction, low-cycle fatigue, high entropy alloy

Introduction

Fracture toughness and fatigue behavior are the key to the practical applications of High entropy alloys (HEAs) [1]. Recently, Niendorf et al.'s[5] tension-compression low cycle fatigue experiments show that there is deformation-induced martensitic transformation during cycling at given plastic strain amplitudes, but there is no intense strain hardening in the cyclic stress-strain response. There are few reports showing the polymorphism of CoCrFeMnNi which is induced by tension[6] and compression[7-9]. Would the phase stability become an issue for CoCrFeMnNi-high-entropy alloy to serve for the cyclic loading?

Experiments

In order to realize the difference of deformation mechanisms between CoCrFeMnNi HEA and the commercially popular corrosion-resistant nickel-based superalloy C-22HS ™ (Ni-21Cr-17Mo in weight percentage), *in-situ* low cycle fatigue was utilized.

The C22 alloy ™ was annealed to dissolve most precipitates into the fcc matrix structure. The CoCrFeMnNi alloy was fabricated by vacuum arc-melting (arc) with equal molar compositions of constituent powders whose purity is more than 99.9% (in weight percent).

The *in-situ* neutron-diffraction measurements for the C22™ alloy with the Spallation Neutron Source were carried out at the Spectrometer for Materials Research at Temperature and Stress (SMARTS) beamline of Los Alamos Neutron Science Center (LANSCE). The *in-situ* neutron diffraction measurements for low-cycle-fatigue of the HEA were conducted at TAKUMI beamline in Materials and Life Science Experimental Facilities at J-PARC, Japan. The in-situ neutron-diffraction low-cycle fatigue test was conducted at room temperature with the maximum tensile strain of 1% and the maximum compressive strain of -1%. The cyclic frequency was 1 Hz.

Results

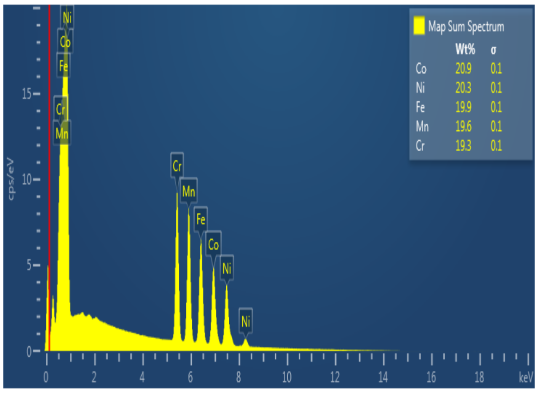
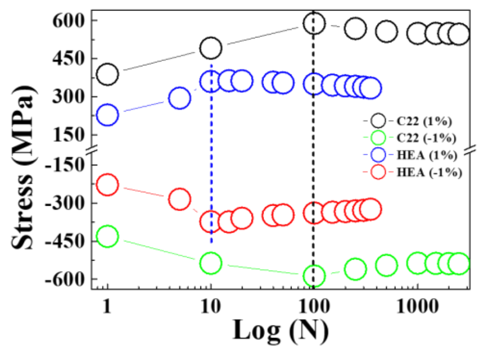


Figure 1. EDX spectrum of the CoCrFeMnNi



HEA

Figure 2. The stress evolution at the maximum tension (1%) and compression (-1%) as a function of fatigue cycle for the C22™ and HEA.

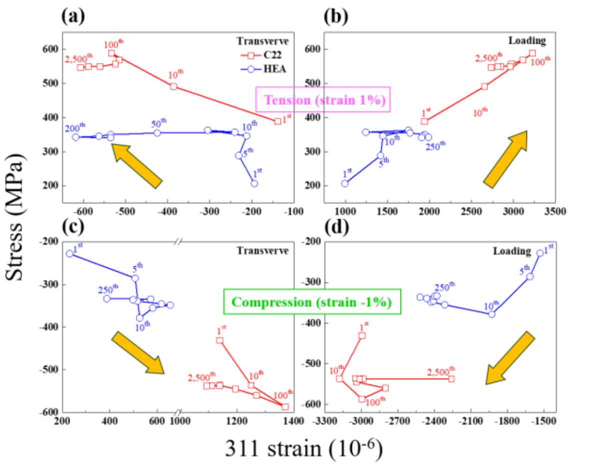


Figure 3. The {311} lattice strain-stress relationship at the maximum tensile strain of 1% in (a) transverse and (b) loading; and that at the maximum compressive strain of -1% in (c) transverse and (d) loading directions for the C22™ and HEA.

Acknowledgments

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