8th International Conference on Physical and Numerical Simulation of Materials Processing (ICPNS)

14–17 October 2016

Seattle, Washington | Hosted by Purdue University

SESSION 8: POSTER, GRAND PACIFIC BALLROOM
SUNDAY, OCTOBER 15, 2016

(alpha + gamma) Ultrafine duplex structure formation in two-phase stainless steel by high-pressure torsion and annealing

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ABSTRACT

High-pressure torsion (HPT) was applied to an (alpha + gamma) two-phase stainless steel (Fe–21%Cr–5%Ni–1.5%Mo) powder at room temperature, and the HPT powder compacts were annealed at various temperatures. The received powder had a fully alpha single phase due to the rapid cooling by gas atomizing process. X-ray diffraction (XRD) analysis revealed that decomposition of alpha phase to gamma phase took place during the annealing at 1173 K for 3.6 ks. Detailed microstructure observation showed that an equiaxed (alpha + gamma) micro-duplex structure was developed, and its average grain size was approximately 3.2 μm. The same heat treatment given to the material without HPT resulted in a coarse two phase microstructure; therefore, it is considered that an ultrafine grained microstructure was caused by increasing of nucleation sites for gamma phase due to severe plastic deformation (SPD) of HPT process. Electron backscatter diffraction patterns (EBSD) analysis indicated that alpha phase has a {110}/<001> strong texture, that is, the alpha phase seems to have single orientated coarse grain structure. The gamma precipitates indicated a {111}/<001> strong texture, and the crystallographic orientation relationship of Kurdjumov–Sachs was observed. Noteworthy is that only a single variant was observed. In other words, there exists a severe variant selection rule for choosing a single variant from 24 variants. Such a variant selection rule was probably attributed to the limitation of nucleation sites for gamma precipitates in alpha phase.

KEYWORDS: nanocrystalline structure, severe plastic deformation, precipitation, texture, Kurdjumov–Sachs crystallographic relationship