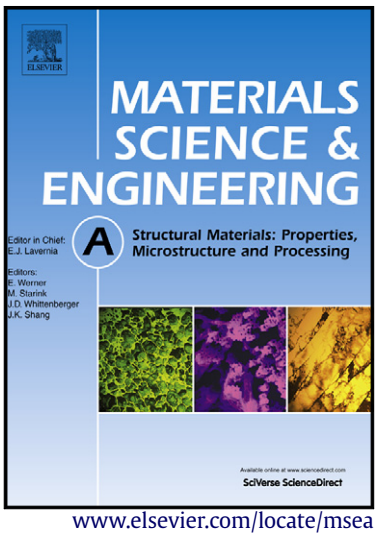

www.elsevier.com/locate/msea

Hardness and microstructure, of tungsten heavy alloy subjected to severe plastic deformation and post processing heat treatment

Zachary S. Levin, K. Ted Hartwig

PII: S0921-5093(15)00142-2
DOI: http://dx.doi.org/10.1016/j.msea.2015.02.025
Reference: MSA32044

To appear in: *Materials Science & Engineering A*

Received date: 8 December 2014
Revised date: 5 February 2015
Accepted date: 11 February 2015

Cite this article as: Zachary S. Levin, K. Ted Hartwig, Hardness and microstructure, of tungsten heavy alloy subjected to severe plastic deformation and post processing heat treatment, *Materials Science & Engineering A,* http://dx.doi.org/10.1016/j.msea.2015.02.025

Hardness and Microstructure, of Tungsten Heavy Alloy Subjected to Severe Plastic Deformation and Post Processing Heat Treatment.

Zachary S. Levin, and K. Ted Hartwig

For Materials Science and Engineering: A

Structural Materials: Properties, Microstructure and Processing

The contact information for the first author:

Texas A&M University Mechanical Engineering Department College Station, Texas 77843-3123

Phone 505 463-3898; Fax 979 845-3081; email zlevin1@tamu.edu

220 Reed McDonald Building, Materials Science and Engineering Department, Texas A&M University, College Station, Texas 77843-3003; telephone number 979 845-1585; Fax number 979 862-6835; email is thartwig@tamu.edu.

Abstract

The hardness and thermal stability of 90W 8Ni 2Fe tungsten heavy alloy (WHA) following severe plastic deformation by equal channel angular extrusion are reported. Square bars measuring, 25X 25 X150 mm^3, were processed at 300^{o}C to plastic strains of 2.68. The hardness of WHA increased with increased strain, from 29 Rockwell Hardness C (HRC) in the as-received condition, to ~50 HRC. ECAE refined the grain size of the tungsten particles from tens of microns to 270nm. This decrease in tungsten grain size correlates with the increase in hardness following a Hall-Petch relationship. Annealing results indicate the matrix phase recrystallizes at 500^{o}C, while the tungsten rich phase begins to recrystallizes at near ~800^{o}C. The morphology of the tungsten rich particles changes from near-spherical to elongated platelets or ellipsoids, depending on processing strain path. The results suggest ECAE is an effective technique for manipulating the microstructure, phase morphology, and mechanical properties of WHA.

Keywords

Tungsten heavy alloy, equal channel angular extrusion, ECAE, severe plastic deformation, microstructure; hardness

Corresponding author Tel.: 1+979.845.1585, Fax: 1+979.862.6835, Email: thartwig@tamu.edu

Introduction

Tungsten heavy alloys (WHAs) are a group of metal alloys used for their strength, density, and thermal stability. Creating a WHA requires the use of powder metallurgy techniques, such as sintering, due to the high melting temperature of tungsten (3422^{o}C). Common metals used for this alloying include iron, nickel, cobalt, and copper [1-3]. WHA microstructures normally consist of a nearly a pure spherical tungsten phase, comprising more than 85% of the volume, surrounded by a ductile metal matrix [4-7]. This approach to alloying yields a composite two-phase material with some of tungsten's exceptional properties including high density and strength, with an improved ductility and workability. While these