Accepted Manuscript

The Effects of Tungsten's Pre-Irradiation Surface Condition on Helium-Irradiated Morphology

Lauren M. Garrison, Gerald L. Kulcinski

PII: S0022-3115(15)30111-2

DOI: 10.1016/j.jnucmat.2015.07.025

Reference: NUMA 49225

To appear in: *Journal of Nuclear Materials*

Received Date: 17 April 2015

Revised Date: 14 July 2015

Accepted Date: 16 July 2015

Please cite this article as: L.M. Garrison, G.L. Kulcinski, The Effects of Tungsten's Pre-Irradiation Surface Condition on Helium-Irradiated Morphology, *Journal of Nuclear Materials* (2015), doi: 10.1016/j.jnucmat.2015.07.025.

The Effects of Tungsten's Pre-Irradiation Surface Condition on Helium-Irradiated Morphology

Lauren M. Garrison[a,b]* and Gerald L. Kulcinski[a]

[a]University of Wisconsin, 1500 Engineering Drive, Madison, WI 53706-1609, USA
[b]Present address: Oak Ridge National Laboratory, One Bethel Valley Road, Oak Ridge, TN 37831-6133, USA
*Corresponding author: garrisonlm@ornl.gov

Abstract

Erosion is a serious concern associated with the use of tungsten as a plasma-facing component in fusion reactors. To compare the damage progression, polycrystalline tungsten (PCW) and (110) single crystal tungsten (SCW) samples were prepared with (1) a mechanical polish (MP) with roughness values in the range of 0.018–0.020 μm and (2) an MP and electropolish (MPEP) resulting in roughness values of 0.010–0.020 μm for PCW and 0.003–0.005 μm for SCW samples. Samples were irradiated with 30 keV He^+ at 1173 K to fluences between 3×10^{21} and 6×10^{22} He/m^2. The morphologies that developed after low-fluence bombardment were different for each type of sample—SCW MP, SCW MPEP, PCW MP, and PCW MPEP. At the highest fluence, the SCW MPEP sample lost significantly more mass and developed a different morphology than the SCW MP sample. The PCW samples developed a similar morphology and had similar mass loss at the highest fluence. Surface preparation can have a significant effect on post-irradiation morphology that should be considered for the design of future fusion reactors such as ITER and DEMO.

Keywords: plasma-material interaction; plasma-facing material; fusion materials; sample polishing; tungsten; helium ion irradiation

1. Introduction

Although tungsten has been selected as the divertor material for ITER [1, 2], was the choice for the first wall of the High Average Power Laser (HAPL) reactor design project [3], and will likely be a plasma-facing material for future fusion DEMO reactors, there are several variables to be decided for producing tungsten components. Different methods of manufacturing, different crystallographic textures, and different tungsten geometries can each lead to varied responses of tungsten to fusion conditions. In addition, the surface preparation of tungsten can play an important role, but it is often not the focus of experiments simulating fusion conditions. Reviewing recent papers on plasma-material interactions reveals a variety of different sample preparation techniques have been used. Ueda et al. prepared tungsten samples by mechanically polishing them to a mirror finish with 10 nm roughness before annealing them at 1173 K for 30 minutes for stress relief [4]. Baldwin and Doerner mechanically polished tungsten samples to below 50 nm roughness but did not heat-treat them [5]. Ryazanov et al. specifies only that the tungsten samples were "polished and cleaned" [6]. Zenobia et al. used a mechanical polish to unspecified roughness followed by electropolishing with 2 wt % KOH and a 15 minute anneal at 1173 K [7]. Each of these treatments alters the material's near-surface microstructure in different