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ACCEPTED MANUSCRIPT

SPUTTERING EFFECTS ON MIRRORS MADE OF DIFFERENT TUNGSTEN GRADES

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Abstract

Because tungsten (W) is used in present fusion devices and is a reference material for ITER divertor and possible plasma-facing material for DEMO, we strive to understand the response of different W grades to ion bombardment. In this study, we investigated the behavior of mirrors made of four polycrystalline W grades under long-term ion sputtering. Argon (Ar) and deuterium (D) ions extracted from a plasma were used to investigate the effect of projectile mass on surface modification. Depending on the ion fluence, the reflectance measured at normal incidence was very different for different W grades. The lowest degradation rate of the reflectance was measured for the mirror made of recrystallized W. The highest degradation rate was found for one of the ITER-grade W samples. Pre-irradiation of a mirror with 20-MeV W^{6+} ions, as simulation of neutron irradiation in ITER, had no noticeable influence on reflectance degradation under sputtering with either Ar or D ions.

Keywords: ITER, tungsten, sputtering, simulation of neutron irradiation, surface modification

1. Introduction

The high melting temperature, low retention of hydrogen isotopes, and low erosion yield of tungsten (W) have made it the reference plasma-facing material in high heat-flux divertor areas in the experimental fusion reactor ITER [1, 2], with a total area of W tiles ≈150 m^2. The authors of paper [3] also considered the case where beryllium, which is a reference material for the first wall in ITER, may be replaced by tungsten. Two "full-W-wall" tokamaks are already under operation (ASDEX-Up [4] and WEST [5]), and one more (JT-60SA) is planned to be operated in the future [6]. Moreover, W is considered one of the candidate materials for the first mirrors of optical diagnostic systems if the sputtering rate of the mirror with charge exchange atoms is too high for other materials such as molybdenum. Under the impact of harsh ITER environments, some important characteristics of W can deteriorate over time under ITER operation, such as the sorption capacity of deuterium and tritium, rate of sputtering by charge exchange atoms, development of surface roughness, and ability to reflect and absorb electromagnetic radiation emanating from a plasma.

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