Corrosion resistance and mechanism of CeN, TiN and CeN/TiN bilayer composite film deposited by dual ion beam sputtering

Wei Liang, Yunhan Ling, Kezhao Liu, Yin Hu, Anyi Yin, Fei Zhu, Limin Chen, Zhengjun Zhang

PII: S0257-8972(17)31256-2
DOI: https://doi.org/10.1016/j.surfcoat.2017.12.033
Reference: SCT 22951

To appear in: *Surface & Coatings Technology*

Received date: 4 September 2017
Revised date: 11 December 2017
Accepted date: 12 December 2017

Please cite this article as: Wei Liang, Yunhan Ling, Kezhao Liu, Yin Hu, Anyi Yin, Fei Zhu, Limin Chen, Zhengjun Zhang , Corrosion resistance and mechanism of CeN, TiN and CeN/TiN bilayer composite film deposited by dual ion beam sputtering. The address for the corresponding author was captured as affiliation for all authors. Please check if appropriate. Sct(2017), https://doi.org/10.1016/j.surfcoat.2017.12.033

Corrosion resistance and mechanism of CeN, TiN and CeN/TiN bilayer composite film deposited by dual ion beam sputtering

Wei Liang [a,b], Yunhan Ling[c], Kezhao Liu[d], Yin Hu[d], Anyi Yin[d], Fei Zhu[a], Limin Chen[a], Zhengjun Zhang[c,*]

a. The State Key Laboratory for New Ceramics and Fine Processing, School of Materials Science and Engineering, Tsinghua University, Beijing 100084, China

b. High-Tech Institute of Beijing, Beijing 100094,China

c. The Key Laboratory of Advanced Materials (MOE), School of Materials Science and Engineering, Collaborative Innovation Center of Advanced Nuclear Energy Technology, Tsinghua University, Beijing 100084, China

d. Science and Technology on Surface Physics and Chemistry Laboratory, Mianyang Sichuan, 621907, China

E-mail: zjzhang@tsinghua.edu.cn

Abstract: Uranium (U) is an important engineering material in nuclear energy industry. Its environmental instability, however, posed challenges on its applications. Due to the active property and similar electronic configuration, Cerium (Ce) can be used as a reference metal to simulate the protection of uranium from corrosion. In order to improve the corrosion resistance of Ce, ceramic CeN, and ceramic TiN and CeN/TiN bilayer composite film were prepared by dual ion beam sputtering deposition system (DIBD). The crystal structure of films was identified by X-ray diffraction (XRD) and the chemical states of CeN film were characterized by the X-ray photoelectron spectroscopy (XPS). The Surface morphology and structure changes in atmospheric environment were examined by scanning electron microscopy (SEM) and XRD, The corrosion behavior was studied by potentiodynamic polarization and electrochemical impedance spectroscopy (EIS). The experimental results indicate the single film of CeN or TiN shows poor corrosion resistance, but the CeN/TiN bilayer composite film has better corrosion resistance. Based on the XPS, SEM and impedance analysis, we supposed that the loose of integrity and passivity breakdown on as deposited coating may be the corrosion inducement.

Key Words: Cerium; CeN/TiN bilayer composite film; corrosion resistance; EIS; DIBD

1. Introduction

Uranium is an important strategic nuclear energy material widely used in national defense and nuclear energy fields. Uranium has a unique electronic structure ($-5f^3$-$6d^1$-$7s^2$) and very negative standard electrode potential (-1.50 v), thus it is highly active and prone to corrode easily with H_2, O_2 or H_2O in atmosphere, which reduces its lifetime, working efficiency and performance [1-9]. To address this issue, many methods such as alloying, electroplating coating, organic coating, chemical reaction layer, ion implantation, corrosion inhibitor were used to protect uranium from corrosion. Most methods and processes are complex and insufficient frequently, and uranium is still subject to corrosion. The coating will gradually fall off in long-term storage [10-18]. Due to its radioactive and harmful to the human body and environment, it's difficult to conduct experiments directly on uranium. It is more convenient and suitable to study corrosion