Sputtering of W-Pd Bimetallic System under Nitrogen Plasma Impact

G.D. Glebov1, A.A. Andersen1, D.I. Bacon1, E.D. Volokov2, A.P. Dolgov2, R.M. Kitaev3, A.L. Kootsoppyk3, and A.B. Hasimov3

1 Institute of Plasma Physics of National Science Center "Kharkiv Institute of Physics and Technology", 61168 Kharkov, Ukraine
2 Argonne National Laboratory, 60439 Argonne, IL, USA

It was suggested earlier [1] to use a two-layer (bimetallic) diffusion system, which consists of another thick palladium substrate and erosion resistant coating, e.g., tungsten on the plasma facing surface, for active control of hydrogen recycling process in intermediate fusion devices. In order to choose the optimal performance of tungsten-palladium bimetallic system, it is needed to carry out thorough investigations of its properties under plasma impact, in particular, the erosion behavior as hydrogen saturated or non-saturated state. Such researches could be useful not only for fusion focus, but for numerous plasma applications (hydrogen power engineering, plasma chemistry, biomedical applications, etc.). When mentioned diffusion system could be used for hydrogen isotopes puffing through cathodes directly in reaction zone. Tungsten protective coatings on palladium substrate were produced by vacuum arc method and by epitaxing in magnetron-type discharge (so-called "soft" configuration) in argon atmosphere. So the different W-films structures and morphologies were realized. For a comparison also investigated were virgin samples made of pure W. The experimental setup for plasma impact studies was devoted with mirror Penning discharge, which was ignited at magnetic field 88T in ranges at pressures 5⋅10⁻⁴ to 1 Torr. The ion energy values were 0.8 eV - 1.6 keV, irradiation dose were 10⁻⁴-10⁻⁵ n/cm². Stress coefficient values were measured by weight loss method. Before sputtering experiments under nitrogen plasma impact, the current-voltage characteristics were measured with and without small hydrogen admixture. It was shown that there is no significant influence of hydrogen admixture in the working gas on plasma performance. Such behavior is explained by the fact that plasma column in mirror Penning discharge has no contact with the wall surface, so surface reactions, influencing Recombination rate, do not play an essential role. It was shown that stress coefficient weakly depends on ion energy for both Pd and W-Pd system and its value (2.3 atm/cm for Pd and 0.3 atm/cm for W) is in a good agreement with literature data on sputtering by monoelectric 34 keV ions. But practical independence of sputtering rate on hydrogen saturation of Pd up to concentrations about 34% did not unexpected result. The point is that in more recent works, e.g., [2] it was shown the possibility to decrease material erosion for hydrogen/deuterium saturation to high concentration. Possible mechanisms discussed to understand the reason of such differences in erosion behavior. For hydrogen saturated W-Pd system the new kind of radiation damages were observed caused by not homogeneous distribution of relatively thick W-films and the change of sample form from flat to convex. The discussed dose dependencies are different for coatings made by different methods: For W-films made by vacuum-arc sputtering, the erosion coefficient value is near to that for bulk tungsten, and it does not change to dose about 4⋅10⁵ n/cm². At the further dose increase, sputtering rate increases extremely up to typical values for bare palladium due to full film disruption. In the case of W-films made in magnetorhoe-type discharge, erosion coefficient significantly increase as dosage time. Mechanisms are suggested and discussed to explain such erosion behavior.


Diffusion of Cathodic Arc Plasma in a Magnetic Filter

Tao Zhang1, Paul K. Chu1, and Ian G. Brown2

1 Institute of Low Energy Nuclear Physics, Beijing Normal University, Beijing 100875, China
2 Dept. of Physics & Materials Science, City University of Hong Kong, Kowloon, Hong Kong
3 Lawrence Berkeley National Laboratory, University of California, Berkeley CA 94720, USA

A model based on Bohm diffusion is developed to investigate the optimal bias of a magnetic filter used in conjunction with a cathodic arc plasma source. Details regarding the derivation of the model as well as experimental results to corroborate the model are presented. According to the model, the optimal bias at which the magnetic duct produces the maximum plasma output is related to the ion spin, ion mass, ion charge state, and plasma density in the filter. Even though the magnetic field is taken into account, it is not a variable in the final equation. Our experimental results confirm that the magnetic field has almost no influence on the optimal bias when the magnetic field is above 40G. The presented work enriches our understanding on the mechanism of plasma transport through the magnetic duct.