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First stages of surface modification by low kinetic energy helium ions produced in a dedicated ICP-RF plasma source

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In the frame of nuclear fusion studies, it has been found that fiberform nanostructured tungsten (W), so-called “tungsten fuzz,” is formed on W surface by helium (He) plasma irradiation. This nano-structure has been observed to form at kinetic energy below the atomic displacement threshold, and exhibits a high porosity (90%), which could be of great interest for various applications (light absorption, catalysis etc.). Further investigations have evidenced the formation of such porous structures on molybdenum, nickel and iron surfaces. Even if largely studied, the first stages of the interaction between low energy He ions and metals still requires investigation in order to precisely control the features of the porous surface.
An ICP-RF plasma source has been developed at the GREMI to perform implantations at low ions fluxes, i.e. in a low electron density plasma. The interaction conditions have been precisely characterized using a Langmuir probe (plasma parameters), homemade retarding field analyzer (ion energy flux distribution), and energy flux diagnostic. Surface characterization by Nuclear Reaction Analysis technique with 3He isotope allowed to determine the He retention rates and Positron Annihilation Spectroscopy was used to investigate vacancy defect formation inside the W lattice due to helium accumulation.
Molecular Dynamics modeling of the implantation process has been carried out. In previous studies we have shown that comparison with experimental results give interesting insight into the mechanisms involved in the modification of W under He+ implantation: He atom interstitial diffusion, aggregation, formation of W vacancies etc. In the present work, He implantation depth and concentration profiles, bubble formation close to the surface and W rupture phenomenon have been investigated in function of the He ion kinetic energy and W lattice temperature.

Keywords
low pressure plasma/surface interaction
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ion implantation
molecular dynamics simulations