STUDY OF HELIUM ION IMPLANTATION IN TUNGSTEN CRYSTAL AT LOW INCIDENT ENERGY

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Tungsten was selected as a plasma facing material for the ITER reactor. It will be exposed to severe plasma conditions such as particles bombardment. High fluxes of light ions on tungsten surface generate defects in the crystal. Helium ion flux interaction with tungsten surface leads to vacancy defects generation and eventually larger defects like helium/vacancy clusters [1]. These lead to a deterioration of the mechanical properties of tungsten and impact the yield and safety of the reactor. The objective of this study is to observe the first steps of the implantation process at low ion flux and kinetic energy, i.e. induced defect formation without sputtering.

For this study an ICP-RF plasma source was developed at the GREMI in Orleans, France. Various plasma diagnostics are used to qualify the implantation conditions, such as Langmuir Probe, Heat Flux Microsensor and an adapted grid system (RFA type). Polished and annealed tungsten substrates are exposed to a $^3$He plasma in a temperature range from 80 to 875 K. $^3$He is used in order to carry out Nuclear Reaction Analyses.

The ion flux accessible with the ICP source varies between $10^{11}$ to $10^{14}$ at.cm$^{-2}$.s$^{-1}$. Comparing Debye length to the mean free path of the He$^+$ showed that the sheath is non-collisional in these implantation conditions. The kinetic energy of the ions is thus determined by the substrate bias voltage and can typically be varied between 50 eV to 500 eV. Below –100 V substrate bias, it appears that the main part of the global energy flux is delivered to the surface by He$^+$ ions.

Surface characterizations with NRA technique showed low He retention rates (below $10^{21}$ at/m$^2$) similar to the ones presented by P.E. Lhuillier[2]. Positron Annihilation Spectroscopy and Thermal Desorption Spectroscopy are used to observe the defect formation in tungsten substrates and the He retention as a function of the implantation conditions. Molecular Dynamics modeling of the implantation process is carried out for comparison with these experimental results.


Keywords
Ion implantation, Plasma Diagnostics, Surface defects characterizations