Contribution ID: **91** Type: **Oral**

Helium bubbles growth in tungsten by in-operando GISAXS

Wednesday, 17 July 2024 17:00 (20 minutes)

In nuclear fusion reactors, the divertor is the most stressed part of the physical barrier facing the plasma. The divertor extracts the heat and particles as helium (He), deuterium and tritium from the plasma. In recent reactors like WEST, ASDEX-upgrade, EAST or ITER, tungsten (W) has been chosen as material of the divertor. In the case of ITER, the most powerful fusion reactor currently under construction, the divertor has to resist to high particles fluxes up to 1022 m-2.s-1 and high heat load between 10 MW.m-2 in normal operation and up to 20 MW.m-2 in case of plasma instabilities. In particular, He bombardment leads to the formation of nano-sized bubbles in the first dozen of nm below the surface of the W components. The W microstructure is hence modified, and the material properties are altered. A major concern is the increase of the radioactive tritium retention in the divertor due to helium bubbles, which could present a risk for the nuclear safety. Thus, the evolution of W under irradiation and especially the He bubbles growth processes must be understood for nuclear fusion exploitation.

In that perspective we have characterized the growth of He bubbles by Grazing Incidence Small Angle X-ray Scattering (GISAXS). The GISAXS experiments have been performed in operando, in real time during He bombardment using the INS2 setup [1] of the BM32 beamline (ESRF). He implantations have been done on W single crystals using 400 eV or 2 keV ions to address the effect of implantation damage on He bubbles formation. In addition, the temperature dependence during implantation has been investigated between RT and 1200℃. Finally post-implantation annealing up to 1500℃ has been performed to mimic the heating of the divertor during a plasma instability. Below 1000℃ bubbles appear rounded, while for higher temperature, bubbles are facetted and show {100} and {110} facets [2]. The shape of the facetted bubbles (truncated rhombic dodecahedron) has been implemented in the IsGISAXS software [3] in order to fit the experimental data and simulate the bubbles growth during the implantation and annealing steps. We show that the bubbles size increases by migration and coalescence of bubbles [4]. The Brownian kinetics of bubbles is attributed to a migration process hindered by the nucleation of a new ledge on the bubble facets [5]. These results are supported by post-mortem transmission electron microscopy analysis. We hope these results obtained on model samples are a basis for theoretical work and further experiments on real plasma facing components.

[1] G. Renaud, R. Lazzari, and F. Leroy, Surf. Sci. Rep. 64, 255 (2009).
[2] L. Corso et al., Nucl. Mater. Energy 37, 101533 (2023).
[3] R. Lazzari, J. Appl. Crystallogr. 35, 406 (2002).
[4] L. Corso et al., In preparation.
[5] S. Curiotto et al., Appl. Phys. Lett. 123, 241603 (2023).

Please select the related topic from the list below

Dynamics of surfaces, interfaces, and nanostructures

Primary authors: CORSO, Loic (CEA, IRFM, F-13108 Saint Paul-lez-Durance, France); Dr CURIOTTO, Stefano (Aix Marseille Université, CNRS, CINAM, Marseille, France); Dr CABIE, Martiane (Aix Marseille Univ., CNRS, Centrale Marseille, FSCM (FR1739), CP2M, Marseille, France); Prof. MARTIN, Céline (Aix Marseille Univ., CNRS, PIIM, UMR 7345, Marseille, France); Dr BERNARD, Elodie (CEA, IRFM, F-13108 Saint Paul-lez-Durance, France); Prof. LEROY, Frédéric (Aix Marseille Université, CNRS, CINAM, Marseille, France)

Presenter: CORSO, Loic (CEA, IRFM, F-13108 Saint Paul-lez-Durance, France)

Session Classification: Sunil Sinha Session