In-operando GISAXS study of helium bubbles growth in tungsten

M Loïc CORSO (CEA-IRFM, IRFM - CEA Cadarache Bât. 507, , 13108 Saint-Paul-lez-Durance (France))

Abstract

In the next fusion reactor ITER, tungsten (W) has been chosen as the most stressed material facing the plasma and must resist to intense helium (He) bombardment. He irradiation generates nano-sized bubbles modifying the W microstructure and jeopardize physical properties. A major concern is the increase of the radioactive tritium retention, which presents a risk for the nuclear safety. Thus, understanding the He bubbles formation and growth is crucial for nuclear fusion exploitation.

In that perspective we have characterized in real time during He bombardment, the growth of He bubbles by in-operando Grazing Incidence Small Angle X-ray Scattering (GISAXS) using the INS2 setup [1] (ESRF-BM32 beamline). W single crystals have been implanted with 400 eV or 2 keV ions to address the effect of implantation damage on bubbles formation. In addition, the temperature dependence has been investigated between RT and 1200°C during implantation and up to 1500°C by post-implantation annealing. Below 1000°C bubbles appear rounded, while for higher temperatures, bubbles are facetted and show {100} and {110} facets [2] forming a truncated rhombic dodecahedron. The facetted shape has been implemented in the IsGISAXS software [3] to fit the experimental data and simulate the bubbles growth during the implantation and annealing steps. We show that the bubbles size increases by Brownian migration and coalescence of bubbles [4]. The limiting step is attributed to the 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.

[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).