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Temperature impact on the morphologic µstructural changes at the surface of W exposed in LHD He plasma

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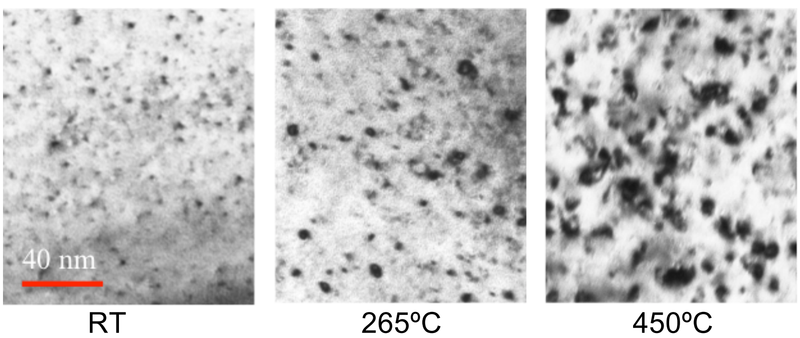
In order to understand the micro structural changes induced in tungsten at the surface by charge-exchange particles from the plasma, a new temperature controlled material probe was designed for the exposure of tungsten samples to He plasma in the LHD. Samples were then studied by TEM (Transmission Electron Microscope), giving an insight of the irradiation damages. We could observe that dislocation loops appear from relatively low fluences and temperatures, their number quickly saturating while size increases with temperature as shown in Figure. Bubbles formed only at high fluence and temperature above 350 ºC, with constant density and increase of size as the temperature gets higher. Final aim of this study will be to investigate the effect of these microstructural damages on hydrogen recycling in tungsten.

Choice of plasma-facing materials for next generation fusion machines, such as ITER and DEMO, has to take into consideration the intensive fluxes of light elements, such as He and H isotopes, which the first wall materials will be subjected to. This irradiation can let to important damages at the surface, affecting the properties and life span of the materials, hence the efficiency of the reactor. In the case of tungsten, one of the most promising candidates, incident ions and charge-exchange particles from the plasma have been proven to drastically affect the surface, with the observed formation of dislocation loops, bubbles or W-fuzz in the crystal. These changes at the material surface can increase hydrogen retention in the structure, one of the major concerns for next generation devices; the understanding and characterization of the µstructure changes and their impact is thus of prime importance.

One key parameter to examine when considering the various damages created is material temperature: indeed, first wall in fusion device can reach up to high temperatures beyond 500ºC. Moreover, temperature rise can affect vacancy and interstitial mobility in the material, with a direct impact on the µstructure obtained after irradiation. Preliminary studies led in laboratory devices will be presented, confirming the need to define evolution of the phenomenon in correlation with the material temperature surface.

In order to understand the µstructural changes induced in tungsten at the surface by incident ions and charge-exchange particles from the plasma, a new temperature controlled head probe was designed for the exposition of several tunsgten samples to the LHD He plasma. Once irradiated, samples are studied by TEM, giving an insight of the irradiation damages such as dislocation loops or bubbles. The study allows an insight of the impact of two irradiation parameters on the damages: temperature and irradiation fluence.

After displaying our original setup, we will present results obtained during two experiments led during the beginning of the LHD 17th campaign: 3 sets of tungsten samples exposed to 1, 5 and 20 discharges of He short-pulse plasma, each set being composed of 5 samples exposed at temperatures ranging from room temperature to 450ºC; and 2 sets of 6 tungsten samples exposed to He plasma for 100 to 200 discharges, within a temperature range of 230 to 800 ºC. Additional FIB cross-sections will complete the surface TEM images obtained.



TEM images of tungsten exposed to 20 short-pulse plasma discharges at various temperatures.