DSOL-33 **He operations in metallic device**

|  |  |  |  |
| --- | --- | --- | --- |
| **TG priority:** High | **Start date:** 2015 | **Status:**  On-going | **Personnel exchange:**  Yes |
| **IO priority:** | **End date:** 2017 | **Motivation:** Plasma Operations | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Device /**  **Association** | **Contact**  **Person** | **2016 TG Request** | **Activity (from JEX/JA spreadsheet)** | | |
| **2015** | **2016** | **2017** |
| JET | S. Brezinsek | Desirable | Not doing |  |  |
| AUG | K. Krieger | Desirable | Committed |  |  |
| EAST | tbd | Desirable | Considering |  |  |
| WEST | J. Bucalossi | Desirable |  |  |  |
| ITER | G. De Temmerman | Desirable |  |  |  |

**This template is based on the 2014 report.**

**Purpose**

ITER will operate in the initial phase potentially with helium (He) plasma and full tungsten (W) divertor. Helium bombardment of metals is known to lead to the formation of nano-sized bubbles, blisters and nanostructures which can potentially modify the thermo-mechanical properties of the material and affect power handling, erosion, fuel retention. Such structural changes have been studied for tungsten as a function of plasma flux, plasma fluence, impact energy and material temperature. Initial studies in tokamaks (TEXTOR) with pre-produced W nano-structures – so-called W-fuzz – have shown erosion of grown structures by C impurities whereas experiments in C-MOD (in pure He) showed formation and growth of fuzz under high temperature operation. The question of nano-structures growth on metallic plasma-facing components (PFCs) under He impact and transient power loads (ELMs) is not clear- in particular ELMs could either accelerate fuzz formation or remove fuzz depending on the power flux and ELM-induced erosion. Laboratory experiments (Magnum-PSI) suggest that W-fuzz growth at high PFC surface temperature can be omitted, but dedicated experiments in tokamaks at high magnetic field and correct impurity composition are missing. Moreover, changes of the morphology may deteriorate the power handling of the W PFCs and hence reduce the operational window for the first ITER divertor. A recovery of the power handling with release of He from the W PFCs in deuterium operation, thus, the decay of He from W PFCs, has only be seen in W-coated PFCs, but not in bulk materials. Dedicated experiments under controlled plasma exposure conditions and at different power-loading and ELM energy are required.

These experiments will help to understand the He-induced material modification at the surface of bulk tungsten material and associated modifications of power handling, retention and erosion of the PFCs. The studies will provide vital input to predictions of lifetime and performance of bulk W divertor PFCs in ITER in the non-active phase and could provide schemes to avoid/recover the initial properties of tungsten.

**Plans for 2015**

AUG:

* Understand the He retention and release in W PFCs as function of plasma impact parameter (ion-flux, fluence, impact energy, density)
* Document the He-induced W-fuzz formation and destruction on W samples exposed at the outer target plate (by means of divertor manipulator) as function of Tsurf, ion flux and ELM size (~100kJ in He). The build-up of W-fuzz in L-mode will be measured by IR thermography (reflectivity change) and spectroscopy (change of W sputtering yield and He flux). The destruction of W-fuzz is supposed to take place in H-mode during ELM excursions. Structural and surface morphology modifications will be studied by post-mortem analysis of W PFCs used in the manipulator.
* Document the change in power handling of W PFC as function of He load and ELM size in order to provide input to first ITER divertor. Repeat of the same “reference He plasma in H-mode” over the He camping with outer-strike point away from the PFC tiles installed in the manipulator.
* Investigate if He and N show synergetic effects on the retention of N and He in W and, thus, on the above mentioned topics. Clarify if synergetic effects reduce the He and N content in WP PFCs and minimise the impact on the PFC. Comparison with Ne or Ar to compensate for local cooling effects.
* Document the global He decay time in full W device.

JET:

* Understand the He retention and release in W PFCs as function of plasma impact parameter (ion-flux, fluence, impact energy, density)
* Document the He-induced W fuzz formation and destruction on bulk W divertor module as function of Tsurf, ion flux and ELM size (~300kJ in He). The build-up of W-fuzz in L-mode will be measured by IR thermography (reflectivity change) and spectroscopy (change of W sputtering yield and He flux). The destruction of W-fuzz is supposed to take place in H-mode during ELM excursions. Post-mortem analysis of W PFCs used in the manipulator. Use of less-prominent stacks on bulk W divertor (lower part of stack A / upper part of stack B) shall ensure that post-experiment plasma exposure is minimised.
* Document the change in power handling of W PFC as function of He load and ELM size in order to provide input to first ITER divertor. Repeat of the same “reference He plasma in H-mode” over the He camping with outer-strike point away from the PFC tiles installed in the manipulator.
* Investigate if He and N show synergetic effect on the retention of N and He in W and, thus, on the above mentioned topics. Clarify if synergetic effects reduce the He and N content in WP PFCs and minimise the impact on the PFC. Comparison with Ne or Ar to compensate for local cooling effects.
* Document the global He decay time in Be/W device.

EAST:

* Complementary studies to AUG with usage of the W divertor in 2015 and midplane manipulator. Investigation of long He discharge operations.
* Details will develop if EAST will successfully operate in the new metallic environment in H-mode without Li evaporation.

Common:

* Post-mortem analysis of W PFCs exposed in 4He campaign. In JET also analysis of 3He at the end of the campaign prior to tile intervention in order to get 3He in Be and W for one particular configuration on vertical targets
* Dedicated modelling of the plasma background (SOLPS/EDGE2D-EIRENE) and plasma-wall interaction (WallDYN/ERO) and comparison with other involved tokamaks and extrapolation to ITER.
* Dedicated laboratory experiments in linear devices for complementary studies with W PFC exposure. Provides input on the retention of He in metallic PFCs, change of power handling in metallic PFCs with implantation of He, formation/destruction of W-fuzz under tokamak conditions, synergetic effects between He and seeding impurities.
* Complementary studies on linear plasma devices in EU/China studying in particular under controlled conditions the interplay of He and seeding gas on the change of the W PFC morphology.