Plasma-Wall Interactions Studies in support of the new ITER baseline

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The ITER project is currently undergoing a major revision to accelerate the construction and to operate the tokamak as soon as possible with reactor- relevant actively cooled first wall armor material (tungsten) in the activated operational phase. A new baseline research plan has been recently developed [1] covering essentially a two-stage approach: (i) inertial cooled tungsten components in the main chamber during the scientific research operation (SRO) phase in predominantly hydrogen plasmas, and (ii) deuterium-tritium operation (DT1) aiming in early Q=10 demonstration with all tungsten (W) components actively cooled.

The initially foreseen first wall material beryllium (Be) has been replaced in the new plan by W from day one, bringing ITER from the point of view of plasma-wall interaction and exhaust (PWIE) as well as integrated core-edge plasma operation closer to the regime of a future fusion reactor. The usage of W shall enhance the power handling capabilities of main chamber components during critical transients like vertical displacement events and reduce the steady-state first wall erosion and long-term fuel retention during long pulse operation in DT at high Q values. Lessons learned from JET operation with Be/W material mix [2], from e.g. ASDEX Upgrade operation with W walls [3], and enhanced modelling capabilities for PWI and impurity transport simulations during steady-state operation [4] and better understanding and modelling of transient events [5] paved the way towards the full-W ITER option from point of view of PWIE.

However, boronization, a glow-discharge with diborane inducing a boron (B) layer of about 50nm, will be applied to getter oxygen, reduce the W first wall source and influx, and ensure a wide operational window for ITER operation as well as permit fast progress in scenario development towards H-mode operation. As consequence fuel retention by co-deposition in B layers is expected to appear and needs to be measured, controlled, and removed by wall conditioning techniques to minimize the fuel content in the vessel and stay within nuclear licensing safety limits. The retention in B layers is according to current knowledge higher than in beryllium, but the amount of B is limited to the number of boronisations applied in contrast to the infinite source of Be as first wall armor.

In close collaboration with the ITER organization and the ITPA, the EUROfusion program was refocused to address critical issues for operation and safety from day one in the areas of PWIE with W armor, i.e. W sources and influxes, and boronization, i.e. B layer lifetime and fuel retention in B layers.

An overview of the currently running supporting experimental and numerical studies within the EUROfusion program on PWIE physics and beyond will be present. This spans e.g. in the area of boron-related physics: fundamental molecular dynamics simulations of chemical erosion, validation erosion and retention experiments in linear plasmas, experiments in tokamaks with material samples, ex-situ and in-operando measurement of retention in B-layers, fuel removal experiments, modelling predictions of B migration etc. Complementary, studies regarding the W first wall focus on W source and influx estimates, W re-deposition quantifications W layer stabilities and support in W coating selection and qualification. W studies related to transients (melting, damage) are already part of the initial research in support of the W divertor in ITER

References

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