Annual Report of ITPA Topical Group on Scrape off Layer and Divertor

For the period July 2010 to December 2011

Prepared by B. Lipschultz, R. A. Pitts and E. Tsitrone for the SOL/Div Topical Group

Executive Summary

The SOL/Div Topical Group held two meetings during the reporting period, in Seoul, Korea, October 18-20, 2010 and Helsinki, Finland, 16-19 May 2011. It should be noted that the DivSOL TG did not hold a fall 2011 meeting, as the 16th meeting took place in early January 2012 instead, in connection with the selection committee for the International Conference on Plasma Surface Interactions (PSI).

Combined edge physics effects have been shown to impact the W erosion processes. For instance, in PWI simulators, additional arcing or melting under ELM events has been observed on samples pre loaded with He, preferential arcing has been noted on samples where W fuzz was grown, enhanced ELM erosion was measured on samples

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concern appears largest for toroidal asymmetries (of order 2) in terms of the total energy asymmetry, with the asymmetry lasting through the thermal quench. The data from ASDEX-Upgrade (AUG) implies that the toroidal asymmetry is higher for He than for higher Z gases. Runaway electrons are much more poorly characterized, which is in contrast to the importance of the threat on ITER of melting deep within PFCs. There are several models (e.g. NIMROD), which may be applicable to predicting load amounts and locations. Several mitigation techniques were discussed including injection of gas, reversal of the loop voltage and stochastic magnetic fields.

Fueling

Fueling of the plasma was the subject of a short joint session amongst Div/SOL, Pedestal, Integrated Operation Scenarios (IOS) and, Transport groups. A working group is being formed by A. Loarte (ITER), and he will solicit representatives from all relevant ITPA groups.

Fuel removal

the crack growth using the MEMOS code appears to do a reasonable job of matching the data. A new joint EU/Russian study using the Russian QSPA and e-beam facilities in TRINITI and Efremov to expose EU-supplied water cooled ITER W mono-block mock-ups to alternate transient (plasma ion) and steady state heat loads (electron beam) was reported at the meeting. Plasma-induced damage enhanced crack growth was obs

and educate us about more basic codes - ones that utilize molecular dynamics (MD) or density functional theory (DFT) approaches. The DFT calculations work at the smallest spatial and time scales to provide a basic modeling of the electrostatic lattice potentials for different situations (e.g., different kinds of traps in W and different atomic lattice potentials for He or H). The MD models can use the potential information to model the evolution of the traps – their diffusion, growth and annihilation. The drawbacks are their short timescales (ps) and spatial sizes (e.g.100s of atoms). For example, the size of the area modeled does not allow for grain boundaries. It is difficult (not possible yet) to derive the lattice potentials for high-Z materials. There is also no model for what happens to the lattice near the surface where the H implantation flux is so high that the local neutral density is much higher than the solute-allowable density. All of the above limitations appear to be under study at the many institutions worldwide but it is not clear how long it will take to address such limitations. On the other hand we were told that a more integrated approach of bringing models

raised surfaces which become leading edges, melting also leads to degraded bulk material characteristics such as grain structure, creation of voids, and general decrease in ductility (more cracking and potential for failure). It was also found that pre-exposure of materials to He ion fluences reduced the melting threshold in W and Mo.

1.3 IEA/ITPA multi-machine collaborations

A detailed DSOL report for 2011 and DSOL proposals for 2012 have been provided for the Coordinating Committee meeting in December 2011.

The status of the DSOL experiments is summarized below, in the 5 topical areas of the DivSOL TG. The color coding is the following : red : closed DSOL, blue : ongoing DSOL, green : new DSOL since last report.

Fuel retention and removal

DSOL-12 Reactive gas wall cleaning (P. Stangeby), closed

DSOL-23 Efficiency of ICRF Conditioning (D. Douai), ongoing

Proposal : JET, AUG, TEXTOR, KSTAR and TORE SUPRA

DSOL-27 Mitigation of fuel accumulation and impurity deposition in the gaps of castellated structures (A. Litnovsky), ongoing

Proposal : DIII-D, TEXTOR, ASDEX Upgrade, EAST, LHD, KSTAR, Tore Supra and Pilot PSI/Magnum PSI.

Dust

DSOL-21 Introduction of pre-characterized dust for dust transport studies (D. Rudakov), closed

Heat loads

DSOL-20 Transient divertor reattachment (R. Pitts), closed

DSOL-24 Disruption heat loads (E. Hollmann), ongoing

Proposal : ASDEX-U, C-MOD, DIII-D, JET, MAST, NSTX, TEXTOR, and Tore-Supra

Material migration

DSOL-2 Injection to quantify chemical erosion (S. Brezinsek), closed

DSOL-9 Tracer injection experiments to understand material migration (V. Philipps), closed

DSOL-26 Marker experiments to study material migration (S. Brezinsek), ongoing

Proposal : JET, ASDEX-Upgrade, DIII-D, TEXTOR, C-MOD

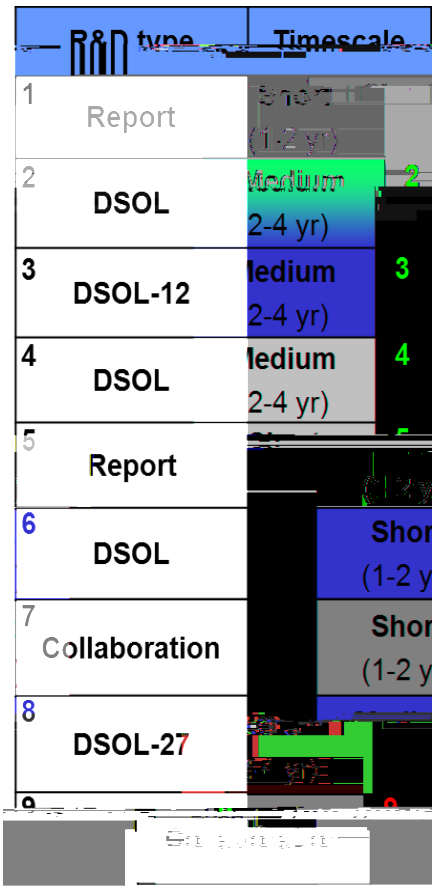
Tungsten

DSOL-25 Melt layer motion and disintegration, droplet propagation and resulting impact on plasma performance (J. Coenen), ongoing

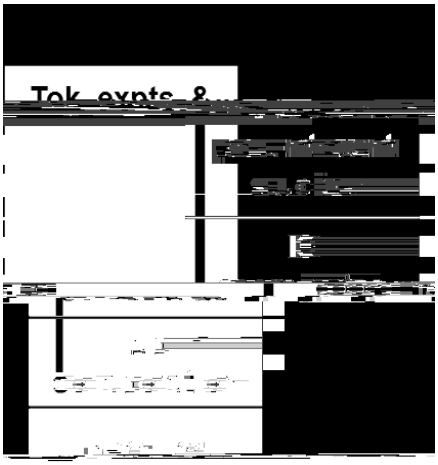
2. High Priority Research Areas

As in the previous report, the DivSOL group has maintained a core activity in the current period along the same five priority areas identified at the beginning three-year plan leading up to the end of 2011. These are Fuel Retention, Heat Fluxes, Tungsten, Dust and Migration. Special Working Group Leaders were appointed at the beginning of this period, to follow through on a series of sub-tasks selected on the basis of the IO Research Plan priorities set out in 2009. The tables below have been selected from the report delivered to the ITPA CC in Dec. 2011 (on IDM at: https://portal.iter.org/departments/POP/ITPA/CC/CCCTP/Documents/2/Presentations/03-01-Lipschultz.pdf) which provided a review of the progress made over the reporting period in the five priority areas. The colour coding follows the same convention as that adopted from the beginning of this system within the Topical Group. Namely green cell colours correspond to areas where significant progress has been achieved since the Task Groups were established, orange to areas in need of re-energising or re-orientation and grey to subtasks whose objectives have been reached and the task is proposed for closure. As before, the priority indicator in the final column remains unchanged from the 2009 report and is derived from the priorities set in the IO PWI research plan on which the R&D tasks are based. The comments accompanying each column give more detail of the specific topics nt progres0ire 538.63 TBT1ven

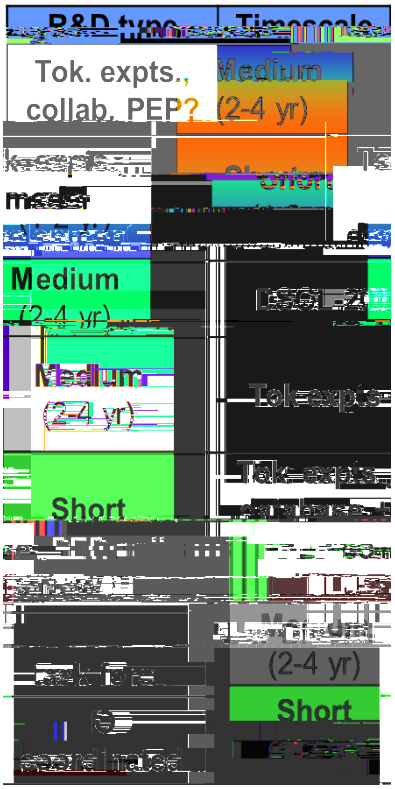
Tritium retention and removal



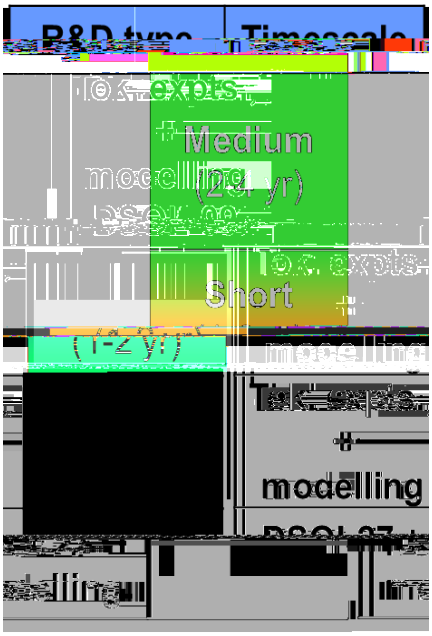
Dust



Heat fluxes



Material migration



Tungsten

3. Future meetings

The 16th DivSOL meeting took place in Juelich, Germany, in January 2012. The next meeting of the

Publication list of ITPA DivSOL Topical Group from June 2008 to Dec. 2011

----------19 th PSI papers----------

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Performance of deformed tungsten under ELM-like plasma exposures in QSPA Kh-50
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Exposure of tungsten nano-structure to TEXTOR edge plasma
Journal of Nuclear Materials, Volume 415, Issue 1, Supplement, 1 August 2011, Pages S92-S95

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Controlled tungsten melting and droplet ejection studies in ASDEX upgrade
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Bazylev et al., B. (2011), 'Numerical Simulation of Tungsten Melt Layer Erosion caused by JxB force at TEXTOR', Physica Scripta (2011) 014054.

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of pulsed and quasi-stationary heat loads relevant to expected transient events at ITER *Phys. Scr.* 2011 014064 doi:10.1088/0031-8949/2011/T145/014064

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