Impact of divertor target material on recycling and discharge fueling during the full ELM cycle*

I. Bykov, E.M. Hollmann, D.L. Rudakov, J. Guterl[a], J. Boedo, M. Groth[b], A. Jaervinen[c], A. Pigarov, R.A. Moyer, E. Unterberg[f], T. Osborne[d], C.S. Lasnier[c], H.Q. Wang[a], J.G. Watkins[e], T. Abrams[d], A. McLean[c], A. Briesemeister[f]

University of California San Diego, La Jolla, CA, USA
[a]Oak Ridge Associated Universities, 1299 Bethel Valley Rd, Oak Ridge, TN 37830, USA
[b]Aalto University, P.O. Box 11000, FI-00076 AALTO, Finland
[c]Lawrence Livermore National Laboratory, Livermore, CA, 94550, USA
[d]General Atomics, 3550 General Atomics Ct, San Diego, CA 92121, USA
[e]Sandia National Laboratories, Albuquerque, NM and Livermore, CA, USA
[f]Oak Ridge National Laboratory, 1 Bethel Valley Rd, Oak Ridge, TN 37830, US

ibykov@ucsd.edu

Simultaneous ELM-resolved measurements of Balmer-α and Fulcher-band radiation from both D atoms and D_2 molecules, respectively, recycling at the outer strike point (OSP) were conducted in DIII-D during Metal Rings Campaign (MRC). The MRC involved operation with two toroidally continuous rings of W-covered TZM (Mo alloy with 0.5% titanium and 0.08% zirconium) inserts in the lower divertor. It was found that the relative fraction F of D atoms originating from D_2 molecules in the total recycling D flux changes during ELMs. Between ELMs, F on carbon and on tungsten is F_C~60% and F_W~85%, respectively, consistent with expectations if all atomic recycling is due to reflections. During ELMs, F dropped to F_C~40% and F_W~60%.

This effect has been studied with a variety of samples (C, Mo, uncoated and W-coated TZM, W, W fuzz, and Ti) exposed using Divertor Material Evaluation System (DiMES) manipulator in the lower divertor near an attached outer strike point in L-mode discharges. External voltage bias of square waveform between +10 V and -150 V with frequency 10 Hz was applied to the sample to investigate the dependence of atomic and molecular recycling on the D^+ ion impact energy (E_i). It was found that an increase of E_i by ~160 eV due to the bias leads to a transient increase of the recycling fraction above unity, similar to [1]. The flux of D_2 in contrast to D only showed a transient increase on C where ion induced D_2 desorption is an important channel of D_2 re emission [2]. Thus, the surface material and the ion impact energy as well as the surface temperature [3] are important factors in controlling the fraction of recycling molecules. This result has implications for both divertor detachment and pedestal fueling, as reflecting D atoms have longer ionization length and contribute to density pedestal recovery after an ELM. D_2 molecules, on the other hand, aid detachment and produce cold Frank-Condon atoms upon dissociation. During the MRC, with the total fraction of the W-covered area on each metal ring ~0.6% of the total wall area, the effect of W in the divertor could be seen in a ~10% increase of the line averaged density when OSP was placed on the W ring. This is qualitatively similar to what was seen on ASDEX upon a complete change from C to W PFCs [4]. We also present results of EDGE2D-EIRENE simulation assessing the effect of adding W in the divertor on divertor fueling and modification of the temperature and density profiles.

[1] S. Wiesen et al., Contrib. Plasma Phys. 56, No. 6-8(2016)754-759
[2] W. Möller et al. *Nucl. Instr. Meth. B* 19/20(1987)826-831
[3] Ph. Mertens et al., *Plasma Phys. Contr. Fusion*, 43(2001)A349-A373
[4] T. Lunt et al., 2017 *Plasma Phys. Control. Fusion* **59** 055016

*Work supported by the US DOE under DE-FG02-07ER54917[a], DE-FC02-04ER54698[b], DE-AC04-94-AL85000[c], DE-AC05-00OR22725[g], DE-AC05-07NA27344[d].