Real-time wall conditioning by controlled injection of boron and boron-nitride powder in full tungsten wall ASDEX-Upgrade

A. Bortolon[1], V. Rohde[2], R. Dux[2], R. Maingi[1], E. Wolfrum[2], A. Nagy[1], A. Herrmann[2], R. Lunsford[1], R. McDermott[2], A. Kallenbach[2], R. Neu[2], D. Mansfield[1], R. Nazikian[1] and the ASDEX-Upgrade team

[1] *Princeton Plasma Physics Laboratory, 100 Stellarator Rd, Princeton, NJ 08543 USA*
[2] *Max-Planck-Institut für Plasmaphysik, EURATOM Association, 85748 Garching, Germany*

abortolon@pppl.gov

We report results from ASDEX-Upgrade (AUG) in which injection of boron nitride and pure boron powders in plasma discharges improved wall conditions in subsequent H-mode plasmas, using a newly developed powder injector designed to handle a variety of materials. Specifically, pure boron injection appeared to improve wall conditions qualitatively similar to boronization, while boron nitride injection was dominated by the effects of nitrogen, including confinement improvement as observed with nitrogen gas puffing.

In the full tungsten wall AUG, boronization, typically performed by injection of B_2D_6 gas in He glow discharges [1], has proven effective for control of W influx and access to low density and collisionality. The beneficial effect of boronization lasts for a few days up to two weeks of operation, after which a new boronization cycle is required for access to low collisionality. Here we attempted to improve wall conditions with injection of boron-rich compounds during plasma discharges. The experiments were enabled by a newly deployed powder injection system [2], specifically designed to handle a variety of materials, including viscous powders that naturally form conglomerates and obstruct flow. Powders were delivered gravitationally into lower single null, H-mode plasmas (I_p=800 kA, P_{NBI}=10 MW, n_e=6x10^{19} m^{-3}) through a vertical guide tube installed on the top of AUG, at approximately constant rates for intervals of 1-4 s. The plasma shape was optimized with small but poloidally constant outer gap to favor redeposition of ablated powder onto the W limiters.

Ablation of powder particles occurred mostly at the injection location, as indicated in wide-angle discharge imaging. A fraction of particles was observed to migrate on approximately field-aligned trajectories. Core impurity line emission from charge exchange recombination spectroscopy increased with impurity injection rate, as expected. During B powder injection, radiative losses increased by up to 50%, with only a minor effect on plasma characteristics. Visible spectroscopy indicated an increase of B emission at the limiters and in the divertor, during B (and also BN) injection, suggesting deposition at these locations. Increased W emission was also observed in certain cases. An increase of energy confinement of 10-20% was also observed with BN injection, which is attributed to the improved pedestal stability associated with N injection [3]. These preliminary results suggest that injection of B and/or BN powder in dedicated wall-conditioning plasmas can be used to partially restore and possibly extend the beneficial effects of a boronization in AUG.

Supported in part by U.S. Dept. of Energy under contract DE-AC02-09CH11466.

[1] V. Rohde et al., J.Nucl.Mat., 363-365,(2007), 1369.
[2] A. Nagy et al., to be submitted to Rev. Sci. Instrum.
[3] M.G. Dunne et al., Plasma Phys. Control. Fusion 59 (2017) 014017.