Real-Time Wall Conditioning in LHD with Boron and Boron Nitride Powder Injection

E. P. Gilson[1], N. Ashikawa[2,3], R. Lunsford[1], S. Masuzaki[2,3], A. Nagy[1], F. Nespoli[1], T. Oishi[2,3], M. Shoji[2], C. Suzuki[2], D. A. Gates[1], T. Morisaki[2,3], and the LHD experiment group

[1] *Princeton Plasma Physics Laboratory, Princeton, NJ, USA*

[2] *National Institute for Fusion Science, Gifu, Japan*

[3] *The Graduate University for Advanced Studies, SOKENDAI, Gifu, Japan*

The first gravitational injection of 150-micron-diamter boron and 60-micron-diamter boron nitride powders into long-pulse LHD discharges was shown to improve wall conditioning in real-time, offering both a possible alternative to gas-based boronization schemes and a useful tool for steady-state operation. An Impurity Powder Dropper (IPD) [1] was installed atop LHD at a location chosen to optimize powder penetration into the discharge [2]. Powder dose rate studies were conducted in four-second-long, 10^{19} m^{-3} density plasmas heated by up to 8 MW of NBI and up to 3 MW of ECH in order to select the optimum dose rate for long-pulse experiments. Dose rates up to several hundred mg/s were used. In the initial short-pulse experiments, for which the background oxygen level was high, the powder was observed to reduce the oxygen impurity level in the discharge. In subsequent short-pulse experiments, the powder did not reduce the oxygen level below the already-low level created by a recent boronization using a glow discharge with diborane. In long-pulse experiments, 10-second bursts of powder were injected into plasmas lasting between 37 s and 9 minutes. Visible camera imaging and spectroscopy of boron and nitrogen showed the successful penetration of the powders into the plasma. Between several 40-second-long shots, the gas fuelling system behavior was changed. While powder was injected, the gas flow rate was held fixed, shut off, or used with feedback. Collectively, the data showed that the powder acted to reduce the wall recycling and decrease the plasma density after the initial transient increase in plasma density, stored energy, and electron temperature caused by the powder. This result suggests that the IPD may be a useful tool for wall conditioning and plasma density control for steady-state LHD discharges. Comparisons of experimental results to EMC3-EIRENE edge simulations will also be presented.

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

[1] A. Nagy et al., 2018 Review of Scientific Instruments 89 (10):10K121

[2] M. Shoji et al., 2019 Contributions to Plasma Physics