Study of carbon influxes from lithium-coated graphite plasma facing components in NSTX H-mode discharges

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In this work we report an analysis on carbon influxes in NBI-heated H-mode discharges on the National Spherical Torus Experiment (NSTX). A particular emphasis will be given to lithium-coated graphite plasma facing components (PFCs) and to the behavior of outer strike point (OSP) divertor carbon influxes. Lithium coatings are routinely applied on the lower divertor PFCs of NSTX as a wall conditioning technique by means of two lithium evaporators (LITERs) [1]. This results in coatings with a toroidally non uniform thickness potentially leading to large spatial scale toroidal asymmetries in lithium influxes, deuterium recycling and carbon sputtering. H-mode NSTX discharges with lithium evaporative coatings are generally affected by core carbon accumulation, with core Z_{eff} increasing up to 4. This appears to be a consequence of both ELMs suppression and increased inward neoclassical pinch due to changes in main ion T_i and n_i profiles at the plasma edge [2]. In NSTX, divertor and main wall carbon influxes are derived, using the S/XB method, from the photon fluxes of visible transitions (CII, CIII) measured by filtered fast cameras with a full toroidal coverage of the divertor and high resolution spectrometers. This analysis is aimed at estimating divertor influxes and, at this stage, no attempt will be done to distinguish chemical and physical sputtering contributions.

A clearer picture of how lithium coatings affect divertor carbon influxes in NSTX is emerging. In particular, the reduction in carbon sputtering expected from the coverage of graphite tiles with lithium coatings can be counteracted by both the limited lifetime of the coating itself (degrading under the OSP particle and heat fluxes) and the change in divertor plasma parameters (due to the transition of the SOL to a sheath-limited regime). In a series of discharges, the application of lithium coatings in increasing amounts on boronized graphite PFCs (up to 400 mg) does not result in an obvious reduction of the carbon sputtering rate at the OSP. A moderate reduction in the total OSP sputtered carbon is however observed due to the reduced divertor ion fluxes, with the uncertainties in the S/XB coefficients limiting a more quantitative estimate. In a series of discharges from a NBI power scan (1-6 MW) with a constant amount of lithium coatings (300mg), a large increase (>4x) in the OSP carbon source is observed with the increase in NBI power. The increase in divertor ion fluxes is not sufficient to account for the increased sputtered carbon ions, indicating a higher carbon sputtering rate at the OSP. This is consistent with both an increase in physical sputtering (due to increase in divertor T_e) and in chemical sputtering (due to increase of divertor surface T, from ~100C to ~350C from IR thermography). Furthermore, the lifetime of the applied lithium coatings at the strike point is expected to be reduced with the increased particle and heat fluxes and this would result in increased carbon physically available for an incoming ion to sputter.

[1] M.G. Bell, PPCF 51(12), 2009.

[2] F. Scotti, in preparation, 2011.