"Snowflake" divertor configuration in NSTX

V. A. Soukhanovskii[1], J.-W. Ahn[2], R. E. Bell[3], D. A. Gates[3], S. Gerhardt[3], R. Kaita[3], E. Kolemen[3], B. P. LeBlanc[3], R. Maingi[2], R. Maqueda[4], A. McLean[2], J. E. Menard[3], D. Mueller[3], S. F. Paul[3], R. Raman[5], A. L. Roquemore[3], D. D. Ryutov[1]

[1] *Lawrence Livermore National Laboratory, Livermore, CA, USA*

[2] *Oak Ridge National Laboratory, Oak Ridge, TN, USA*

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

[4] *Nova Photonics, Inc., Princeton, NJ, USA*

[5] *University of Washington, Seattle, WA, USA*

The studies of an innovative "snowflake" divertor (SFD) configuration in the National Spherical Torus Experiment (NSTX) provide support to this plasma-material interface concept as a viable candidate for future tokamaks and spherical tokamak based devices with high heat flux divertors. A number of theoretically predicted geometric and radiative properties of the SFD configuration [1-4] have been confirmed in experiments at NSTX. The obtained SFD showed evidence of impurity control and divertor heat flux mitigation. The SFD configuration was obtained in 1 MA 4-6 MW NBI-heated H-mode discharges with $P_{SOL} \simeq 3$ MW. Two divertor coils with 4 and 12 kA current waveforms controlled by the plasma control system were used to generate the SFD. A very high poloidal flux (area) expansion of the separatrix region in the SFD, a longer connection length and a larger divertor scrape-off layer (SOL) volume (as compared to standard NSTX divertor configurations) led to a partial detachment of the first several mm of the SOL width (as mapped to the midplane). Divertor heat flux profiles showed a significant reduction of the peak values, accompanied by an increase in divertor radiated power. A volume recombination zone with $T_e \simeq 1.5$ eV, $n_e \leq 3 \times 10^{20} m^{-3}$ developed in the X-point and strike point regions, suggesting an increase in volumetric momentum losses in the divertor. The core carbon density was reduced by up to 50 % in the SFD discharges with no degradation of H-mode stored energy and confinement. Work supported by US DOE in part under Contracts DE-AC02-09CH11466 and DE-AC52-07NA27344.

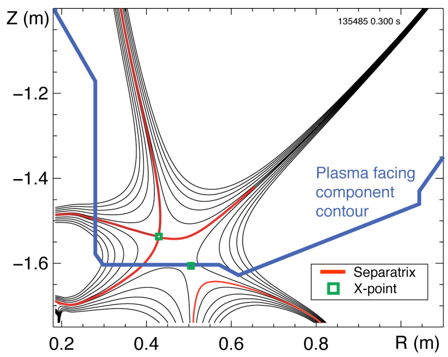

Figure 1: Magnetic equilibrium of the "snowflake" divertor configuration in NSTX. The flux surfaces are separated by 1 mm in the outer midplane.

References

[1] D. D. Ryutov, Phys. Plasmas 14, 64502 (2007)

[2] D. D. Ryutov et. al., Phys. Plasmas 15, 092501 (2008)

[3] D. D. Ryutov et al., Paper IC/P4-8, 22st IAEA FEC, Geneva, Switzerland, 10/2008

[4] M. V. Umansky et al., Nucl. Fusion 49, 075005 (2009)