TOPIC: EX-D

Snowflake Divertor as Plasma-Material Interface for Future High Power Density Fusion Devices

Soukhanovskii, V. A

Lawrence Livermore National Laboratory, Livermore, CA, USA

vlad@llnl.gov

Recent NSTX results demonstrate that the snowflake divertor (SFD) configuration may provide a promising solution for mitigating steady-state and transient divertor heat loads and target plate erosion, and project favorably to future fusion devices. In NSTX, a medium-size spherical tokamak with high divertor heat flux ($q_{pk} \leq 15$ MW/m^2, $q_{||} \leq 200$ MW/m^2), steady-state SFD configurations were obtained for up to 600 ms in 4 MW NBI-heated H-mode discharges of 1.0-1.2 s duration. In agreement with theory, the SFD geometry increased the plasma-wetted area, the X-point connection length, and the divertor volume, thus reducing the deposited heat flux and increasing divertor volumetric losses. The SFD formation led to a stable partial detachment of the outer strike point otherwise inaccessible in the standard divertor at P_{SOL}=3 MW in NSTX. Peak divertor heat flux was reduced from 3-7 MW/m^2 to 0.5-1 MW/m^2. Additional seeding of deuterated methane increased divertor radiation further. Heat fluxes from Type I ELMs (ΔW/W=7-10 %) were also significantly dissipated: peak target temperatures measured at peak ELM times reached 1000-1200 ^{o}C in the standard divertor phase and only 300-500 ^{o}C in the SFD phase. H-mode core confinement was maintained albeit the radiative detachment, while core carbon concentration was reduced by up to 50 %. To project SFD properties to future devices, a two-dimensional multi-fluid edge transport model based on the UEDGE code is developed, and initial simulations indicate large reductions in T_e , T_i, particle and heat fluxes due to the SFD geometry effects. In the planned NSTX Upgrade, two up-down symmetric sets of four divertor coils will be used to test SFD for handling the projected steady-state 20-30 MW/m^2 peak divertor heat fluxes in 2 MA discharges up to 5 s long with up to 12 MW NBI heating. This work was performed under the auspices of the U.S. Department of Energy in part under Contract DE-AC52-07NA27344.