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EX/P5-21: Snowflake Divertor as Plasma-Material Interface for Future High Power Density Fusion Devices

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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 ($q_{peak} \leq 15$ MW/m^2, $q_{||} \leq 200$ MW/m^2), steady-state SFD configurations lasting up to 0.6 s ($\leq$10 τ_E) in 4 MW NBI-heated H-mode discharges. In agreement with theory, the SFD geometry increased the plasma-wetted area, the X-point connection length, and the divertor volume. The SFD formation led to a stable partial detachment of the outer strike point otherwise inaccessible in the standard divertor at P_{SOL}=3 MW in NSTX. Peak divertor heat flux was reduced from 3-7 MW/m^2 to 0.5-1 MW/m^2, while radiated power and recombination rate increased. Additional seeding of deuterated methane increased divertor radiation further. Heat fluxes from Type I ELMs ($\Delta W/W$=7-10 %) were also significantly dissipated: peak target temperatures measured at peak ELM times reached 1000-1200 deg. C in the standard divertor phase and only 300-500 deg. 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 the 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. Supported by the U.S. DOE under Contracts DE-AC52-07NA27344, DE-AC02-09CH11466, DE-AC05-00OR22725, and DEFG02-99ER54519.

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