Dependences of the divertor and midplane heat flux widths in NSTX

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Here we report on the dependencies of National Spherical Torus Experiment (NSTX) lower divertor heat flux profiles, measured using ELM-averaged infrared thermography, on a wide range of discharge and plasma shapes. Of special interest for future higher power machines is how the heat flux and its associated figures of merit scale as plasma current and beam power are increased. For example, the proposed upgrade to NSTX is predicted to have equal or greater divertor heat flux than in ITER.

Previously it was found[1] that the SOL heat flux widths, λ_q^{mid} decreased with increasing I_p, and was relatively independent of P_{NBI} at high P_{NBI}. However, all of the previous results were limited to lower divertor triangularity $\delta \sim 0.5$. Here we have extended the studies to higher triangularity of $\delta \sim 0.7$, confirming and extending the previous trends up to 1.2 MA. At higher triangularity, the same relative trend is observed with a ~50% contraction in λ_q^{mid} when the plasma current is increased from 1 to 1.2 MA. For high triangularity discharges, a trend of increasing heat flux profile is shown when δ_r^{sep} is decreasing between -5 to -15 mm. While for low triangularity discharges λ_q^{mid} is observed to be relatively constant at ~ 10 mm over a wide range of δ_r^{sep}. This results in increased heat flux as δ_r^{sep} increases at high triangularity. λ_q^{div} shows as strong increase as the magnetic flux expansion, f_{exp} increased over a range of f_{exp} = 10-40. This leads to a strong reduction of the peak heat flux, where the peak heat flux is reduced from 8 to 2 MW/m^2 as the magnetic flux is expanded from $10 \leq f_{exp} \leq 40$. Finally, NSTX utilizes unique lithium conditioning to condition its graphite PFCs[2]. This results in ELM-free discharges[3] leading to a further contraction of the heat flux profile. While uncertainty in the surface emissivity for lithium coated graphite plasma facing surfaces limits a direct comparison of the magnitude of the heat flux profiles, the relative change in radial profile shape from pure graphite to a lithium coated surface is still applicable. This assumes that the emissivity of the lithium coated graphite surface is spatially and temporally uniform, with in reason, during the discharge. The reduced edge collisionality due to the lithium coating appears to lead to an increase in transport of thermal energy onto the divertor. The experimental details will be presented as well as the impact on the performance of future spherical tokamaks.

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