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Proposed Liquid Metal PFC Development Program in NSTX-U

Projected divertor heat flux footprints from Eich1 and Goldston2 scalings for next step devices is in the range of 1-2 mm, with unmitigated peak heat fluxes of several hundred MW/m2. However there may be meaningful deviations from these scalings for spherical tokamaks, e.g. NSTX3. At full plasma current and heating power, nonetheless, H-mode discharges in NSTX-U4 are projected to have midplane heat flux widths of 2-3mm, with resulting unmitigated peak heat fluxes of 30 MW/m2. Coupled with the scientific need to confirm and understand these scalings, especially the possible role of turbulence to increase SOL heat flux footprints5, the NSTX-U divertor physics program will both measure the scalings at full parameters, as well as embark on a liquid lithium PFC development program both as a power exhaust strategy and a method to increase energy confinement toward compact reactor designs.

The long-term goal of this liquid Li PFC program is to deploy full toroidal coverage flowing liquid Li PFCs by the latter part of the 2020's, using full high-Z Mo-based (TZM) tiles as substrates. Li coatings and other technologies would be used to cover/coat the Mo tiles outside of the divertor. Experience with static liquid Li PFC technology at modest inventory levels would be obtained by implementation of pre-filled Li tiles, which were designed for NSTX-U and tested in MAGNUM-PSI6, 7. Experience with flowing liquid Li PFCs would be obtained by installation of a flowing liquid Li midplane limiter, building on three generations of collaborative design and experimentation on the EAST device8. This proposed plan would mesh seamlessly with the nascent US liquid metal PFC development program aimed at developing concepts for a fusion nuclear science facility or a compact pilot plant. *Work supported by U.S. DoE contract DE-AC02-09CH11466 with PPPL.

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