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EX/P5-31: Liquid Lithium Divertor Characteristics and Plasma-Material Interactions in NSTX High-Performance Plasmas

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ITER and future fusion experiments are hampered by erosion and degradation of plasma-facing components, forcing regular replacement. The conventional approach has been the use of high-Z walls (e.g. W) which can undergo permanent modification due to erosion and melting. One novel approach to solving these issues in the tokamak edge is the usage of liquid metal plasma facing components.
The National Spherical Torus Experiments (NSTX) is the only US confinement device operating a liquid metal divertor target to examine the technological and scientific aspects of this innovative approach. The Liquid Lithium Divertor (LLD) module formed a nearly toroidally continuous surface in the outer, lower divertor. NSTX H-mode discharges were repeatedly run with the outer strike-point directly on the LLD plates. Peak heat fluxes of ˜5MW/m2 were regularly applied to the LLD surfaces alongside significant ion fluxes. No molybdenum line radiation was observed in these plasma[3] indicating protection of the substrate material.
During these experiments, no macroscopic ejection was observed from the LLD contrary to experiments conducted in the DIII-D tokamak, where lithium ejection exposed the substrate[4]. Quiescent scrape-off layer current (SOLC) densities were ˜10 kA/m2, with peak SOLCs >100 kA/m2. Stability analyses for the liquid metal layers show that despite the large current densities, capillary and viscous forces are effective at reducing motion demonstrating stable operation of the liquid metal PFC.
The strong chemical reactivity of lithium results in the steady accumulation of impurities in the PFC material, mitigating the low-Z benefits of the lithium. Eroded material from the carbon PFCs in NSTX can redeposit onto the LLD, and background vacuum gases are also gettered onto the surface. Flowing systems are under study and are designed to allow one to obtain a low-Z, replenishable PFC by removing gettered materials and eliminating the accumulation effect.

References

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