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 degredation of plasma-facing components forcing regular replacement. One novel approach to solving the erosion issue 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.

Experiments have been conducted using a toroidal Liquid Lithium Divertor (LLD) module in the outer region of the lower divertor[1]. Liquid lithium in particular is expected to provide a low-Z target material and potentially absorb and retain incident particle flux through chemical bonding.

A high-density Langmuir probe (HDLP) array was implemented in the divertor to better understand the demonstrated capabilities of the LLD as operated in the NSTX divertor[2,3]. Kinetic interpretation of the Langmuir probes allows the determination of the entire electron distribution function of the plasma and non-Maxwellian distributions are found[4]. The non-Maxwellian distribution temperatures can be reproduced with non-local electron transport models[5] that indicate the short electron thermal gradients give rise to energetic tail populations, even in detached plasmas[6]. Such non-Maxwellian effects lead to concern that simple reduction of a bulk-population temperature (e.g. by gas puffing and/or impurity radiation near the target) may not be sufficient for reducing the actual ion impact energy.

Erosion rates of order the lithium deposition rate are found using impact energies obtained with the HDLP. The surface of the LLD may be composed of a *mixed-material* due to lithium gettering of background gases. Impurity layers could reduce the implantation depth of incident ions hindering deuterium uptake as observed[7]. On the other hand non-zero retention may still be possible Li-C-O compounds are found together[8]. In these experiments carbon is still the majority PFC in NSTX and discharges with the LLD were found to obtain similar performance improvements and require similar fueling as previous campaigns with lithium wall-conditioning. New liquid metal divertor concepts are described.

References

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