Lithium and Liquid Metal Studies at PPPL

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Strategic planning studies have identified control of the plasma-material interface as a critical area for realization of power production. Solid plasma-facing components (PFCs) are the leading candidates for future devices, predominantly serving as PFCs for present devices. ITER is relying on metallic PFCs, namely W in the divertor and Be on the first wall. While ITER has been designed to work with these materials, there is little safety margin on heat flux removal capability. The power exhaust challenge for reactors the size of ITER is even harder, requiring higher amounts of core and divertor radiation\(^1\). Moreover, very recent studies have shown that both the steady heat exhaust and transient exhaust, during e.g. edge-localized modes (ELMs), is more challenging, owing in part to the narrowness of the scrape-off layer power flux footprint with increasing midplane poloidal field\(^2\).\(^3\).

Liquid metal (LM) PFCs have some attractive features that could remove some of the restrictions of solid PFCs. The typical erosion and PFC performance degradation of solid PFCs can be obviated with self-healing surfaces; the challenge shifts to controlling core impurity content, and managing tritium retention. Similarly LM PFCs are also tolerant to neutron damage, and can, under the right conditions, exhaust very high steady and transient heat flux. Finally lithium PFCs can provide access to low recycling, high confinement regimes\(^4\), e.g. at \(\sim\)2x H-mode scalings, enabling attractive core and edge plasma scenarios. Outstanding issues include acceptable temperature operating windows, LM chemistry control, and free-surface MHD issues for unrestrained flowing LM systems.

This paper focuses on research and development of liquid metal and lithium PFCs at PPPL, including NSTX\(^5\) and coming studies in NSTX-U\(^6\), along with studies in smaller devices, e.g. LTX\(^7\), as well as collaborative studies on other US and international devices; a related paper at this workshop discusses the vapor box divertor concept\(^8\). The use of lithium often increased the energy confinement in these devices, and modified the edge characteristics. An overview of experimental results and R&D directions will be presented.

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