Experiments of continuously and stably flowing lithium limiter in EAST towards a solution for the power exhaust of future fusion devices

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Liquid lithium (Li) has effects to partly ameliorate lifetime and power-exhaust issues of plasma facing components (PFCs) by allowing for a self-healing, self-replenishing surface with no susceptibility to neutron damage in future fusion devices. Such a system is beneficial for the improvement of plasma performance, and therefore be attractive for future fusion devices. In this contribution, in order to allow for stable operation under tokamak conditions as well as its heat-exhaust capabilities, a flowing continuously flowing Li limiter on the concept of a thin flowing Li film on an actively cooling heat sink is designed and tested in high performance discharges in EAST [1,2]. In addition, experiments related to material compatibility, wetting, flowing as well as plasma impact were studied. A circulating Li layer with a thickness of <0.1 mm and a flow rate ~2 cm^3s^{-1} was achieved. Novel in-vessel electro-magnetic pumps (EMPs), working with the toroidal magnetic field of the EAST device, were reliable to control the Li flow speed. Some new ideals and techniques, i.e. increase the thickness of stain steel layer, using hot isotatic pressing (HIP) technology to braze stain steel layer and Cu heat sink, new design of distributor and a new set of high pressure He cooling system, were successfully explored to enhance Li coverage uniformity, erosion resistance of limiter surface and heat removal, and also plasma performances [3]. It was found the flowing liquid limiter is fully compatible with various plasma scenarios, including high confinement mode plasmas heated by lower hybrid waves or by neutral beam injection. The controllable Li emission from the limiter was beneficial for the reduction of recycling and impurities, for the reduction of divertor heat flux and the mitigation of ELMs (~150ms ELM-free phase), and in certain cases, for the improvement of plasma stored energy, which bodes well application for the use of the renewal of circulation of Li flows on targets of divertor in future fusion devices. The results shows that the flowing lithium PFC is an possible and alternative choice for the design divertor with high heat flux in future reactors by allowing for a self-healing, self-replenishing surface with no susceptibility to neutron damage to partly ameliorate lifetime and power-exhaust issues of PFCs. To further increase the flowing uniformity due to well wetting capacity between Li and Mo, new FLiLi upgraded using Mo instead of SS as support surface for Li is expected to be tested in HIDRA in Illinois and EAST in the end of 2017.

[1] J.S. Hu, et. al., Nucl. Fusion 56 (2016) 046011
[2] G.Z. Zuo, et. al., Nucl. Fusion 57 (2017) 046017
[3] G.Z. Zuo, et. al., Upgraded flowing liquid lithium limiter for improving Li coverage uniformity and erosion resistance in EAST device, Submitted to Rev. Instrum. Sci.