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Investigation of an upgraded flowing liquid lithium limiter for higher performance plasmas in tungsten divertor in EAST

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Flowing liquid Li (FLiLi) used as plasma facing components (PFCs) promises to improve plasma performance due to reduced fuel recycling and impurity generation[1]. Various static and flowing liquid Li limiter have been tested in HT-7 and EAST, and significant progress has been achieved from the first FLiLi limiter based on the concept of a thin flowing film in the EAST device in 2014[2]. First it was confirmed that liquid Li could be driven by an innovative in-vessel DC EM pump to form a re-circulation loop. In addition exciting new results were also obtained during the FLiLi operation, including a controllable Li emission layer at the plasma edge due to the strong interaction between the liquid Li surface and plasma. This effectively reduced particle and heat flux onto the divertor plate, and mitigated ELMs with evidence of short (<150ms) ELM-free phases. However, it also encountered some issues, including clogged distributor before FLiLi experiment, non-uniformity Li distribution on limiter plate, and damaged limiter surface.
In order to enhance Li coverage uniformity and erosion resistance of limiter surface, two electromagnetic pumps were used to drive liquid Li on a copper plate with a stainless steel protection barrier. Hot isotatic pressing (HIP) technology was applied to improve the combination between SS thin layer and Cu heat sink, and the thickness of the SS surface layer was increased from 0.1mm to 0.5mm. Also, electric spark and successive wire-cutting was used to obtain a more uniform distributor design for improved Li flow uniformity. A set of high pressure He cooling system was designed to control the limiter temperature. By upgrading the FLiLi during 2016 FLiLi experiments, significant engineering improvements were demonstrated, resulting in improvement of liquid Li coverage uniformity >80%, as compared to about 30% in 2014 FLiLi campaign. In addition the present limiter surface was undamaged by PMI, in contrast to the 2014 results. It was also confirmed that high pressure(˜3MPa) He was more effective to cool limiter than N2 and Ar during plasma discharge. Moreover, improved plasma performance during full-field ohmic discharge and transient ELM-free H-modes with strong increase of WMHD and H98 were demonstrated for the first time with the new limiter. These promising results are encouraging for the use of flowing liquid lithium PFCs for future devices.

Reference
[1] Zakharov L. E. Phys. Rev. Lett. 90 (2003)045001
[2]J.S. Hu et al., Nucl. Fusion 56 (2016) 046011

Eligible for student paper award?

No

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