

Using 3D-printed tungsten to optimize liquid metal divertor targets for flow and thermal stresses (Article)

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Abstract

[View references \(27\)](#)

Liquid metal divertors aim to provide a more robust alternative to conventional tungsten divertors. However, they still require a solid substrate to confine the liquid metal. This work proposes a novel design philosophy for liquid metal divertor targets, which allows for a two orders of magnitude reduction of thermal stresses compared to the state-of-the-art monoblock designs. The main principle is based on a 3D-printed tungsten structure, which has low connectedness in the direction perpendicular to the thermal gradient, and as a result also short length scales. This allows for thermal expansion. Voids in the structure are filled with liquid lithium which can conduct heat and reduce the surface temperature via vapor shielding, further suppressing thermal stresses. To demonstrate the effectiveness of this design strategy, an existing liquid metal concept is re-designed, fabricated, and tested on the linear plasma device Magnum-PSI. The thermo-mechanical finite element method analysis of the improved design matches the temperature response during the experiments, and indicates that thermal stresses are two orders of magnitude lower than in the conventional monoblock designs. The relaxation of the strength requirement allows for much larger failure margins and consequently for many new design possibilities. © EURATOM 2019.

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