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FTP/3-5: Lithium-Metal Infused Trenches: A New Way to Remove Divertor Heat Flux

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As we come closer to realizing fusion as a viable power source, many machines which have made significant progress in plasma heating and power find that removing heat from the divertor region has become a challenging problem. Peak heat fluxes up to 20 MWm-2 are typical these days for machines and if there is an ELM event or disruption then it can be even higher. Solid plasma facing components (PFC) materials such as carbon and tungsten suffer from permanent damage due to huge thermal stresses. The alternative is to use a liquid PFC where the surface is replenished. Liquid Lithium offers such an alternative and has the added advantages that it offers a low recycling surface allowing for density control and higher confinement times.
At the University of Illinois at Urbana-Champaign (UIUC), such a system has been developed. The Lithium-Metal Infused Trenches (LiMIT) concept uses the self-driven flow of liquid lithium to cool the divertor surface. At UIUC's CPMI labs a proof-of-principle experiment has been done and it is scheduled to be used in the Chinese HT-7 tokamak in April of 2012. LiMIT uses many narrow, parallel trenches with millimeter thick gaps between them to flow the liquid lithium. The tile with the trenches runs perpendicular to the toroidal magnetic field direction. Once a temperature gradient is established between the top and bottom of the trench from the plasma hitting the lithium surface, a thermoelectric current is generated in the direction of the temperature gradient. The lithium flow is driven along the trenches in the radial direction across the plasma strike point removing heat.
Self driven flow velocities have been measured to be 0.22 ± 0.03 ms-1 and IR camera measurements showed clear temperature increases after the lithium had passed the area. The tile is heated via a linear electron beam which has a peak heat flux of 10.0 ± 1.1 MWm-2 and the temperature increase showed no significant evaporation of the lithium. The heating of the surface as well as the magnetic field strength can have an effect on the velocity and heat transport. Analytical solutions reveal that in the presence of a strong magnetic field the surface temperature and flow velocity are proportional to the square root of the surface heat flux. This has large heat transfer potential for future applications in fusion devices.

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Collaboration (if applicable, e.g., International Tokamak Physics Activities)

NSTX

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