EX/P5-28

Comparison and advantages of various combinations of emitters and collectors of the tokamak T-11M lithium circuit

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ABSTRACT

• In the conditions of the plasma experiment at T-11M tokamak, the elements of the closed circuit of lithium circulation - emitters and collectors were tested. Four combinations of their location were analyzed;

• It was found that the most optimal is the "double symmetric" configuration, when the collectors are located symmetrically along the torus through 180 ° and are immersed in the SOL to an equal depth. Deviation from it leads to the magnetic islands formation, and losses of lithium to the walls, which has been demonstrated experimentally.

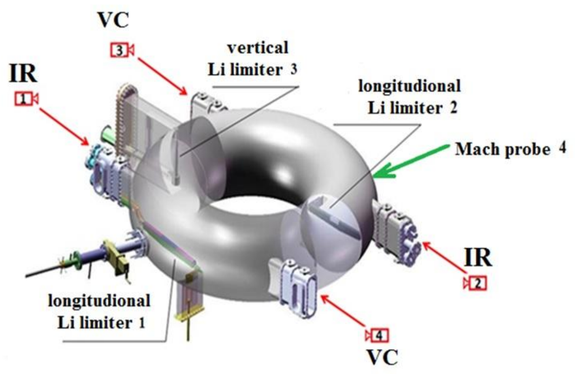
BACKGROUND

• The main goal of future tokamaks is operation in the steady-state regime. This requirement will be fulfilled only in the case of permanent self-healing of its first wall (PFC) and removal of its erosion products.

• These functions could be performed by a lithium flow circulating between the vacuum chamber of the fusion reactor and the hot plasma. In addition, lithium PFC remove erosion products, and could reduce the direct effect of aggressive hydrogen isotope plasma irradiation by re-emitting thermal energy falling on it.

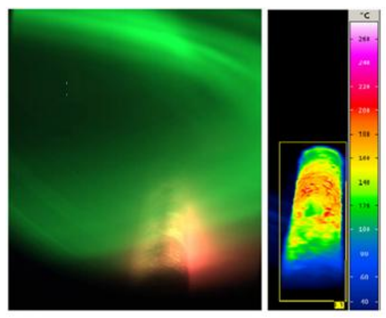
• The creation of the lithium flow requires the placement of lithium emitters and collectors (limiter system) in the vacuum chamber. One of the task performed on the T-11M is a test of them.

T-11M TOKAMAK AND DIAGNOSTICS



T-11M parameters

R/a	0.7m/0.2m
B_T	1-1.5 T
I_p	70-90 kA
Δt	≈250 ms



• Three movable CPS-based lithium limiters

• Two high-speed video cameras

• Two IR cameras

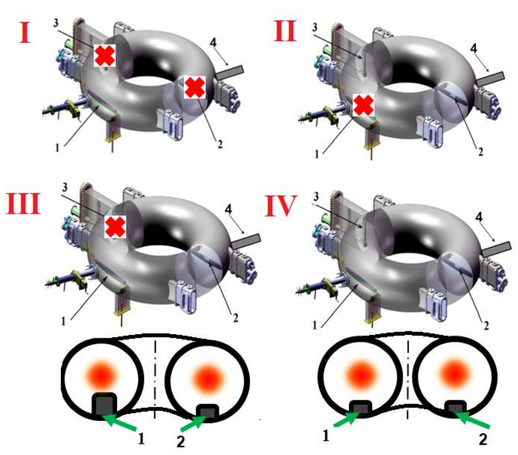
• Movable Mach probe

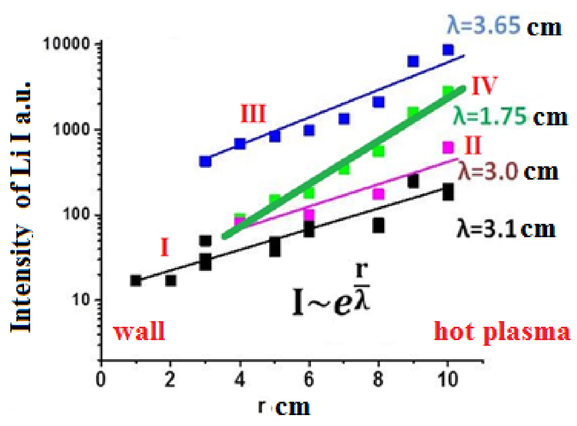
RESULTS AND DISCUSSION

Lithium penetration in SOL by LiI intensity measurements

• Four various combinations of three lithium limiters at T-11M tokamak were analyzed;

• LiI intensity measurements on the Mach probe plate revealed that scheme IV is characterized by the steepest decay λ of the lithium distribution in the SOL, which demonstrates a decrease in the radial transport of lithium in this region.



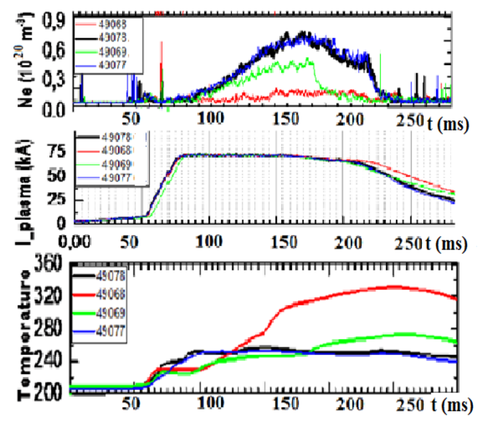


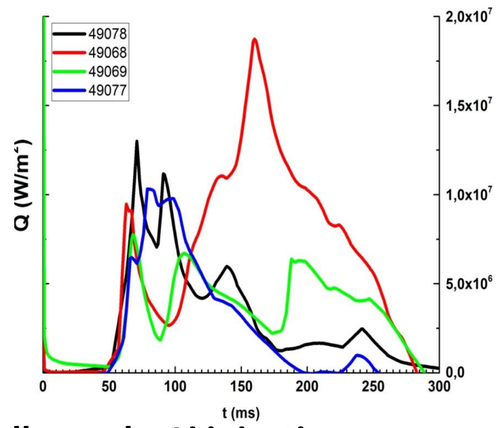
The radial distributions of lithium from the wall to the edge of the hot plasma for all emitter-collector combinations

Results and discussion

Re-radiation of the heat load on the collector by the density increasing

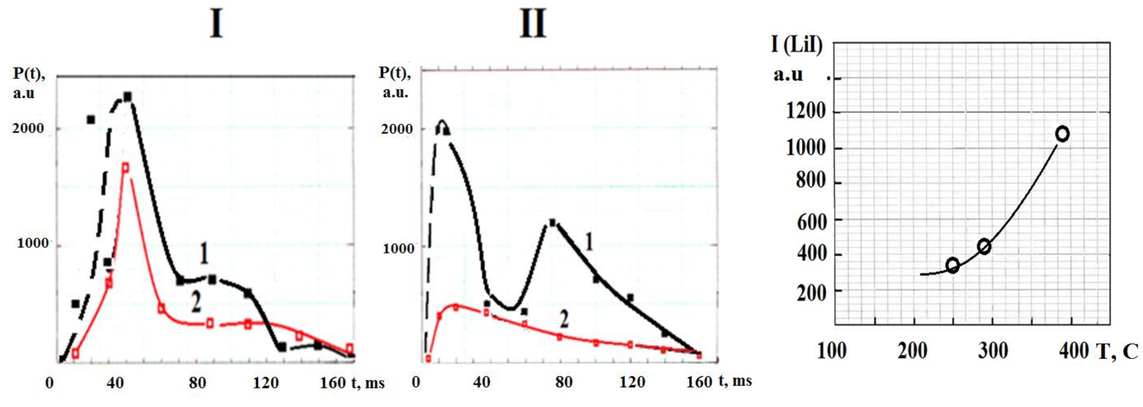
• The increment of the surface temperature during the discharge decreases to more than 2 times with decreasing density of 5 (from 5 x 10^{19} to 1 x 10^{19} m^{-3}) while reducing the power ohmic heating from 90 to 60 kW





Re-radiation of the heat load on the collector by Li injection

•The increase of lithium injection led to decreasing of the heat flux to the collector 2 in 2 - 3 times at the beginning of the discharge (40 ms) and in 2 times at the middle phase (100-120 ms)

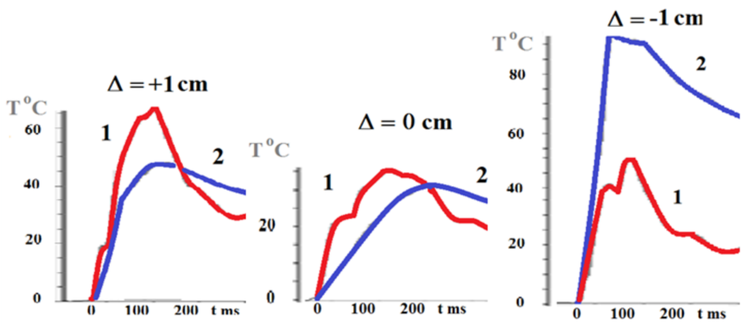


Reduction of heat flux to collector 2 with an increase in Li-emission by 3 times

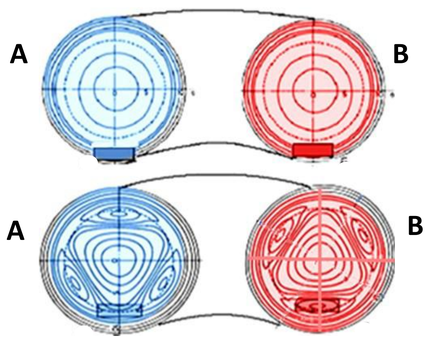
Experiments in violation of the "symmetry" of collectors by vertical displacement of the plasma column

• When the initial vertical shift reached 2cm, the ratio between the IR signals changed dramatically - the heat flux to the "slave" limiter 2 times exceeded the flux to the "leading" one;

• Such transition have been expected when a magnetic island with isolated O-point and an open X-point (180° along the torus) concentrating heat flux into this zone formed at the edge plasma.



The heat flux to the first and the second longitudinal limiters as immersion to the edge plasma



Two alternative schemes for the influence of limiters immersed in a plasma: a — without crossing the resonant magnetic surface, q(rs) = 3 (- - -) , b – with crossing

CONCLUSION

• An increase of the plasma density and lithium emission lead to screening of the heat flux to the second limiter,;

• Four different combinations of lithium limiters were investigated at T-11M tokamak;

•A practical recommendation that can be made on this basis is all lithium emitters and collectors of tokamaks, where it is assumed to use: the emitter-collector circuit, should be installed symmetrically and in pairs, thereby suppressing the possibility of magnetic islands formation.

ACKNOWLEDGEMENTS

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