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LITHIUM GETTERING ON T-10 TOKAMAK

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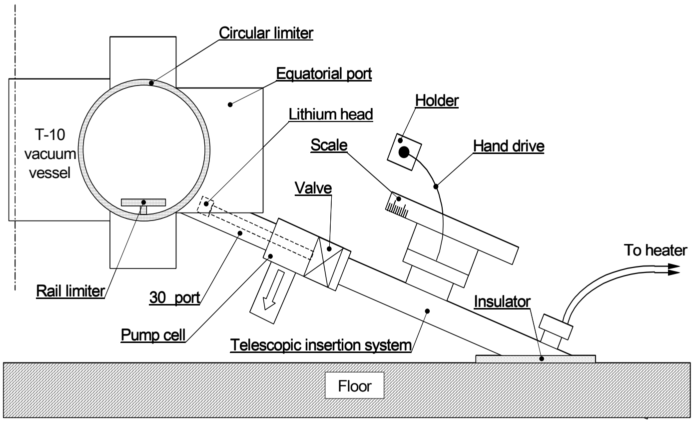
Several tokamaks use now lithium as the wall getter, or the limiter material [1-4], since the successful TFTR experiment [5]. It was shown that lithium can reduce the recycling and impurities level and provide clean plasma with density control. As T-10 is the tokamak with the graphite limiters and high deuterium recycling, its reduction and impurities level decrease will be very useful for the OH and ECRH discharges with high power heating. That was first goal of lithium experiment in T-10. But apart of the advantages of the Li - gettering, it caused alarm of the quartz and gyrotrons windows covering by lithium. The test of the Li-gettering compatibility with the high power ECRH was next goal of experiment. Taken this into account, only the moderate Li gettering was used. The Li amount, introduced to the chamber per one experiment, was 20-100mg according to our estimation.

The Li-element used for gettering was made by "Red Star" on the base of the capillary porous (10-100μm) system (CPS), which have been already successfully used in T-11M and FTU experiments in Troitsk [1] and Frascati [2]. The Li was sustained in the bottom of the Li-element and forced by capillary tension to the plasma facing surface along CPS. The Li-element was placed in the T-10 port together with the ECRH windows, graphite rail and circular limiters, as it is shown in the Fig.1. The Li-element was positioned in the special pump cell and transported to the plasma boundary by means of the telescopic mechanism. The electrical heater permitted to increase the Li-element temperature up to 550° C. It was measured by the thermocouples.

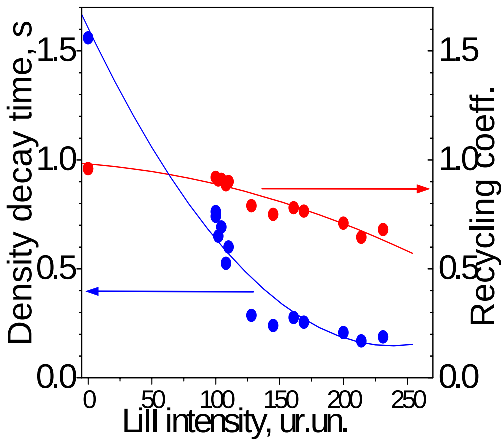
The T-10 experiments were carried out in OH and ECRH discharges with the current Jp=300 kA, toroidal magnetic field Bt=2.4 T and average density <Ne>= $3\times10^{19}m^{-3}$.



Two techniques of Li gettering were used. In the first one the Li-element was positioned in T-10 chamber before plasma experiments and heated up to the 450° C during two hours. The Li deposition to the chamber was about 20mg.

Figure 1. Experimental setup of T-10 Li experiment

Such technique was sufficient to reduce the time of density decay (w/o gas puffing) from 2-1.5 s to 0.5 s. But the most pronounced effect was obtained when the Li-element was positioned close to the chamber wall and evaporation occurred continuously during the all operational day. The lithium behavior monitored by the brightness of the LiII line in limiter cross-section, showed the gradual decrease of the Li amount in the first technique and accumulation in the latter one. The evolution of some discharge characteristics in a series



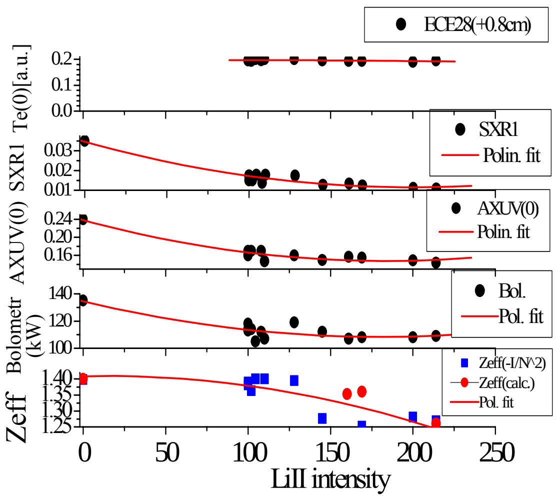


Figure 2. Recycling versus Li line intensity Figure 3. Discharge parameters versus Li deposit

of OH discharges with continuous Li gettering as the function of the LiII line brightness are shown in the Fig. 2 and 3. The reduction of the plasma density decay time from 1.5 s to 0.17 s and recycling coefficient from 0.97 up to 0.7 are seen in Fig. 2. Figure 3 showed that the electron temperature was not changed, while even low Li coverage significantly reduces the total bolometric losses up to 20%, the central radiation losses in factor of 1.7 and SXR intensity up to 3 times. The value of Z_{eff}, measured with the visible continuum is influenced only at the highest Li amounts and decreased from 1.4 up to 1.25. As the temperature was unchanged the decrease of the SXR may be due to the decrease of the high Z and oxygen impurities, while the concentration of the main carbon impurity and Z_{eff} was changed not so significantly due to the low Li deposition in plasma. The spectroscopic observations of the impurities lines showed oxygen OII decrease in 7 times, while CIII decrease only 30%. The comparison of the characteristics of the ECRH discharges with and without lithium is presented in Fig. 4. It is clearly seen: the electron temperatures are equal again, while all radiation losses are decreased. The energy confinement times are also almost the same with and without Li in OH and ECRH discharges. The T-10 Li-experiment didn't show some problems for ECRH system (the full power 1.7 MW). The decrease of the quartz windows transmission were not observed too.

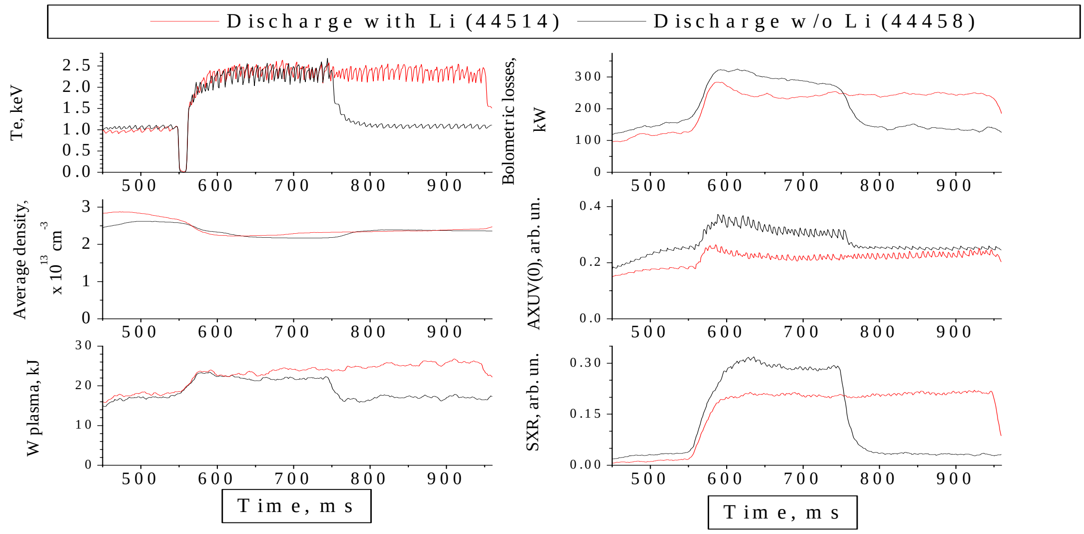


Figure 4. ECRH discharges characteristics with and without Li (short pulse-200 ms)

The evaluation of the density decay time after single Li gettering in a series of the OH and ECRH discharges showed that after total discharges duration of 12 seconds the decay time was still lower in 2.5 times with respect 1.5 s. without Li deposit. The increase of Li deposit caused the rise of the required gas puffing in discharge regimes with fixed N_e. If in discharge without Li the gas valve was open partly during density buildup and was closed at the flattop, with Li deposits the valve was opened fully at the density rise and partly at flattop. The 50% increase N_e in the SOL was measured at the highest Li deposit. It may point out the high screening of Li by SOL due to its low ionization potential. This feature may be very important for the future reactor Li perspective, because it may radiate significant power in the SOL region with low Li confinement.

Some interesting chemical transformations were observed after the vacuum chamber opening to atmosphere. The dark blue color of the lithium element and the port walls was observed after 10 minutes. The X-ray spectrum (EPMA), showed the dominant oxygen line. Carbon was 10 times less and nitrogen was absent. We may conclude that at this stage lithium oxide is formed. After two weeks the color became white. The X-ray spectrum, showed also the dominant oxygen line, but the carbon concentration increased and reached 1/3 of the oxygen one. The nitrogen was not observed again. As the ratio of 1/3 is characteristic for $Li_2(CO_3)$ we can suppose its formation as the final substance. The inspection of the T-10 chamber with the TV camera revealed the high number of the small white grains at the rail limiter and at the walls. The dimensions of the grains were from 0.1 to 1 mm. They were observed only in the limiter port. They can appear during the evaporation, or formed at the limiter. As the Li-element was placed in the limiter port it is impossible to make unambiguous conclusion about the mechanism of their formation.

It is possible to conclude that the T-10 experiments support the results of previous experiments with respect to decrease of recycling and plasma purification. But the change of these parameters was not too high due to the low deposit level. The total duration of the recycling decrease as result of single Li gettering was about 12 seconds, which corresponds to 15 T-10 discharges. Nevertheless the recycling didn't return to the value without lithium even for longer period. This is consistent with FTU observation [2]. The T-10 experiment showed that lithium gettering is compatible with the high power ECR heating. The mechanism of the white grains formation near the limiter should be investigated in future experiments.

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