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Differentiating the role of lithium and oxygen in retaining deuterium on lithiated plasma-facing components[1]

CHASE TAYLOR, Idaho National Laboratory

Lithium wall conditioning has been implemented in nearly a dozen fusion devices, resulting in significantly improved plasma performance. Improvements are manifest as a reduction and eventual elimination of edge localized modes, reduced edge neutral density, reduced deuterium recycling, and some reduction in impurities. Initially, researchers assumed that lithium, via a direct lithium-deuterium bond, was directly responsible for these improvements. Our experiments and atomistic simulations have revealed that lithium coatings play a much more indirect role in improving plasma performance [1]. The presence of oxygen in tokamaks is ubiquitously viewed as unfavorable. However, recent results show that lithium reduces oxygen impurities and surprisingly uses the oxygen to retain deuterium. Experiments using X-ray photoelectron spectroscopy identify that oxygen immediately begins to accumulate on lithium conditioned surfaces [2]. Tight-binding density functional theory simulations tested various carbon matrices with and without lithium, oxygen, and hydrogen, and identified that oxygen plays the key role in retaining deuterium. In fact, a simulated PFC with 20% oxygen in carbon retains more deuterium than does 20% lithium in carbon. Recent experiments implanted oxygen in graphite to match simulations; however, we were unable to achieve the simulated results because all implanted oxygen was released upon deuterium bombardment. We therefore conclude that while oxygen retains deuterium, lithium plays an indispensible role in this process. Lithium attracts and retains oxygen, and then oxygen binds and retains deuterium.

[1] P. S. Krstic, J. P. Allain, C. N. Taylor, et al., Phys. Rev. Lett. 110, 105001 (2013).
[2] C. N. Taylor, B. Heim, and J. P. Allain, J. Appl. Phys. 109, 053306 (2011).

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