Contribution ID: **602**

Type: **Poster**

FTP/P1-14: Recent Progress in the NSTX/NSTX-U Lithium Program and Prospects for Reactor-relevant Liquid-lithium Based Divertor Development

Tuesday, 9 October 2012 08:30 (4 hours)

Developing a reactor compatible divertor has been identified as a particularly challenging technology problem for magnetic confinement fusion. While tungsten has been identified as the most attractive solid divertor material, the NSTX/NSTX-U lithium (li) program is investigating the viability of liquid lithium (LL) as a potential reactor compatible divertor plasma facing component (PFC). In the near term, operation in NSTX-U is projected to provide reactor-like divertor heat loads ≤ 40 MW/m^2 for 5 s. During the most recent NSTX campaign, ~ 0.85 kg (1.5 liter) of li was evaporated onto the NSTX PFCs where a ~50% reduction in heat load on the LLD was observed, attributable to enhanced divertor bolometric radiation signal. This reduced divertor heat flux through radiation observed in the NSTX LLD experiment is consistent with the results from other li experiments and calculations. These results motivate an LL-based closed radiative divertor concept proposed here for NSTX-U and fusion reactors. With an LL coating, the li is evaporated from the divertor strike point surface due to the intense heat. The evaporated li is readily ionized by the plasma due to its low ionization energies, and the ionized li ions can radiate strongly, resulting in a significant reduction in the divertor heat flux. Due to the rapid plasma transport in divertor plasma, the radiation values can be significantly enhanced up to ~ 11 MJ/cc of LL. This radiative process has the desired function of spreading the focused divertor heat load to the entire divertor chamber, which facilitates the divertor heat removal. The LL divertor surface can also provide a "sacrificial"surface to protect the substrate solid material from transient high heat flux such as the ones caused by the ELMs. The closed radiative LLD concept has the advantages of providing some degree of partition in terms of plasma disruption forces on the LL, li particle divertor retention, and strong divertor pumping action from the li-coated divertor chamber wall. By operating at a lower temperature than the first wall, the LLD can serve to purify the entire reactor chamber, as impurities generally migrate toward lower temperature li-condensed surfaces. To maintain the LL purity, a closed LL loop system with a modest capacity (e.g., ~ 1 liter/sec for ~ 1% level "impurities") is envisioned for a steady-state reactor.

Country or International Organization of Primary Author

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

NSTX Program

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Session Classification: Poster: P1

Track Classification: FTP - Fusion Technology and Power Plant Design