Reduction of Low-Z Impurities During Plasma Start-up Through The Application Of Large Surface Area Biased Electrode Discharges*

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Reduction of low-Z impurities is essential during initial plasma generation in tokamaks. This was well recognized during the early days of tokamak research [1] and led to vessel conditioning methods such as glow discharge cleaning and boronization techniques, as well as the recognition that gas pre-fill in a vary narrow range is required for successful inductive plasma start-up at low values of the applied loop voltage. Recently during the development of a novel way for plasma startup using the method of Coaxial Helicity Injection (CHI), the importance of controlling the influx of low-Z impurities during the early phase of plasma start-up has become even more apparent. Conventional methods alone have been inadequate to generate a sufficiently clean plasma discharge. Results from both the concept exploration HIT-II experiment at the University of Washington and recently from the NSTX device at PPPL, show that running long pulse CHI discharges [2] on the lower divertor surfaces can liberate significant amounts of oxygen impurities from the divertor surfaces. In this method, the lower divertor coils are used to generate poloidal flux that connects the lower divertor plates, which are insulated from each other. Then in the presence of a toroidal field, gas is injected in the divertor region and current is driven on the field lines connecting the plates. The current pulse is DC in nature so that it could be maintained for as long as needed as long as gas continues to be injected in the region of the electrode discharge. Spectroscopic data show the liberation of oxygen, which dramatically increases with the injected current magnitude. The path of the current is determined by controlling the intensity and shaping of the poloidal flux. In principle, as long as a single divertor plate on a tokamak is bisable, one could preprogram the poloidal field coils to bias this toroidally symmetric large surface area divertor plate with respect to other parts of the vacuum vessel to run a moderate to high-current (several kA) discharge to ablate surface contaminants and gases trapped near the surface. The technique also has the potential for tritium removal from the vessel walls. Using this vessel pre-conditiong method, both HIT-II and NSTX have been able to improve plasmas produced using the CHI process to be sufficiently clean of low-Z impurities so that they can then be successfully ramped up in current when induction is applied, demonstrating that the input power from induction, which is typically 300 kW during the start-up phase considerably exceeds low-Z line radiation losses. Results from HIT-II and NSTX using this method as well the capability of further modifying the initial poloidal field structure to either produce a field null or to provide a buffer flux to limit plasma contact with the walls will be presented.

[1] J. Sheffield, 1986, in *Tokamak Start-up*, edited by H. Knoepfel (Plenum, New York).
[2] R. Raman, T.R. Jarboe, D. Mueller, et al, Nuclear Fusion **41**, 1081 (2001)

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