Seminar

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Institute for Plasma Research

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Title: Synthesis and Studies on Some Surface Conditioning Materials and Techniques for Tokamak and Laboratory Vacuum Systems

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Date: 27th February 2024 (Tuesday)

Time: 10:30 AM

Venue: Seminar Hall, IPR

Abstract

Effective control of impurities, fuel recycling and precise regulation of the fuelling gas are extreme prerequisites for optimal operation in any tokamak device. Conventional wall conditioning methods fall short in achieving extremely better wall conditioning. The conventional wall conditioning methods like vessel baking and H_2 (D_2) fuelled glow discharge cleaning (GDC) are required preliminary to remove impurity in bulk after vessel venting. The excess amount of hydrogen, injected during H_2-GDC can be reduced by helium fuelled GDC. But, helium removing from the vessel is more challenging due to its low mass, inert nature and hard to trap by cryo pump. It is more challenging to achieve the optimal wall conditioning of plasma facing components (PFCs) and vessel wall using conventional methods of H_2/He GDC, operated for extended hours/days.

The H_2 (D_2) fuel retention and recovery is the prime issue in any tokamak device. In ADITYA-U tokamak, the carbon PFCs retain the high amount of H_2 due to the porosity of graphite tiles, covered large surface area of different limiters and diverter components. A novel method has been developed as pulsed fueling GDC (P-GDC) for ADITYA-U to study the control of the H_2 retention. The experimental studies of P-GDC have been compared with conventional GDC. The H_2 retention and behavior of impurities like, H_2O, CO, CO_2, CH_4, hydro carbons are studied in these experiments. The removal of H_2 using pulsed fueling He-GDC is also compared with and conventional He-GDC.

Low-Z lithium coating on PFCs and vessel wall is performed for suppressing the high Z and oxygen impurities plus increasing the PFCs life in various tokamaks using different methods. A major drawback of the lithiumization, the effect is disappeared immediately in few plasma discharges due to the removal of lithium coating from the PFCs/wall during plasma wall interaction. In ADITYA-U, two methods of lithiumization have been developed to synthesize the Li-coating on the PFCs and vessel wall using Li-rod and Li-evaporator with H_2 glow discharge plasma. The formation of lithium hydride (LiH) and its effect of Li coating are studied here. The experiments of different types of surface conditioning with Li-coating contribute the improvement in the tokamak plasma discharges. The long retention of Li on wall is observed in plasma discharges. The carbon, oxygen impurities and hydrogen recycling are reduced, thus the plasma performance is improved in term of impurity radiation loss and plasma temperature. The

material characterization studies of graphite PFC sample is also performed and compared with standard graphite sample.

The limitation of H_2-GDC in term of the removal of carbon and oxygen contained impurities is observed in ADITYA-U due to the large surface area of graphite PFCs. A mixture gases as argon and hydrogen fuelled GDC has been developed for ADITYA-U tokamak. In this wall conditioning technique, the long lived and sufficient amount of ArH^+ ions are formed and reacted with the wall impurities. The high momentum of ArH^+ supports to break the high energy bonds of impurities in PFCs and vessel wall. The hard bonded impurities cannot be removed due to low mass H^+, H_2^+, H_3^+ ions, formed in H_2-GDC. The experimental study of proper mixture percentage of Ar with H_2 has been carried out to avoid the disturbance of the tokamak plasma discharges due to the excess fuelling of high-Z argon. The carbon and oxygen contained impurities are reduced beyond the limit of H_2-GDC. The relative low pressure of dominant impurities like CO, CH_4, and H_2O are obtained during Ar-H_2 GDC compare to routinely operated H_2-GDC. A comparison study of H_2-GDC and developed Ar-H_2 GDC are performed in term of wall conditioning and tokamak plasma operation. The encouraging results of the Ar-H_2 GDC have been obtained in both scenario of surface cleaning and tokamak plasma operation. The development of wall conditioning techniques and related studies are useful for tokamak devices and any lab scale plasma experimental setups.