Importance of Lithium Wall Conditioning in ADITYA-U Tokamak

- In fusion devices, various techniques of low-2 material coating like Lithium, Boron, and Silicon are performed to generate better plasma discharges.
- In ADITYA-Upgrade tokamak, different techniques of Lithium wall conditioning are developed to get uniform and sustainable coating of Lithium on Plasma facing components (PFCs) and vessel wall.
- In current study, two techniques are used to generate Li from source, first Li-rod sputtering by H ion and atoms in H-glow discharge cleaning (H-GDC) and second vaporization from high temperature Li-Evaporator.
- With Li-evaporator operation, H-glow discharge is also carried out to uniform distribution of Li-vapour in toroidal chamber.
- Additionally, the Lithium is highly reactive with H ions and atoms compare to H2 gas, thus in H-GDC with Li vapour creates more Lithium Hydroxide (LiOH) molecules on vessel wall and PFCs.
- The melting temperature of Li-H is very high 688.7° C compare to Lithium melting temperature 180.5° C. As result, the Li-H retained, Li wall conditioning effect sustains for long period of plasma operation compared to physically deposited Li atoms.
- In ADITYA-U, due to high surface area of Graphite PFCs, the major concerns for plasma performance are carbon impurity and Hydrogen recycling.
- The combination of Li sputtering, Li evaporation, H-GDC, He-GDC, Ar-H mixture GDC are used to get better plasma discharges.

Effect of Li Evaporation rate increased by Temperature Ramp-Up

- Flashes shown in fig. The C4 and C11 impurity are reduced in factor more than Li compare to shot 34159.
- The temperature was increased 300-650 eV in shot 34159 as 300 eV.

Development of Lithium Wall Conditioning Techniques

(A) Heated Lithium rod (120° C) sputtering by Hydrogen glow discharge
- Location: Installed on B-3 Blad of Mid-plane on ADITYA-U Vessel
- Parameters: Lithium Rod Baking max. 120° C using Silicon Insulated Heater; Fresh Rod Size: 12.5 Dia. 6 cm Long
- ADITYA-U Glow Discharge Cleaning System: 0.5 to 2 A, 400-800 V, H2 Gas Pressure: 2 - 5 x 10⁻⁵ Torr, n20= 5 x 10⁻⁵ Torr /cm², S = 1 x 3 m

(B) Lithium vaporization by developed Li-Evaporator (600° C)
- Location: Installed on 8 External Mid-plane in ADITYA-U Vessel
- Parameters: Lithium Evaporator Storage capacity: 10 grams of Li
- Baking Capacity: Up to 600° C using SS Clamp Heaters (3 Nos.); Sensor: n-type Thermocouple
- ADITYA-U Glow Discharge Cleaning System: As above mentioned parameter

Using these two Li Generation systems; various Lithium wall conditioning techniques

- Studied with following Combinations:
  1. Heated lithium rod with Li-GDC
  2. Lithium coating by developed Li evaporator system
  3. Combination of Lithium Evaporator operation of different temperature under H-GDC
  4. Effect of Helium GDC with Lithium coating
  5. Combination of Ar-H mixture GDC then Lithium coating with H-GDC

Li - Evaporator Performance

- Plasma discharge shots as 34146, No Li-Coating, 34145B - Only Li evaporator operation at 600° C for 2 Hrs, 34158 - Li evaporator operation at temperature 600° C under Hydrogen glow discharge cleaning (H-GDC) in shot 34154
- The C4 and D-1 impurity line radiation and visible continuum in 34145B and 34145B are reduced 30-50% compared to no-Lithium coating shot 34144
- Plasma current, duration, softness, ion impurity with no recycling has been observed in 34145B as effect of Li evaporator with H-GDC. While in 34145B has marginal improvement compared to 34144
- The evidence of Hα is observed in visible line radiation spectrometry at simultaneously detection of Li ion intensity with its line intensity is different plasma states.
- The C4 and D-1 impurity line radiation and visible continuum in 34158 and 34158B are reduced 30-50% compared to no-Lithium coating shot 34154

Effect of Helium Pulsed Glow discharge on Lithium coating

- The developed Li wall conditioning techniques are implemented successfully in ADITYA-U tokamak.
- The Fresh Lithium rod sputtering in H-GDC is more effective for better wall conditioning compared to old Li-rod.
- The comparison of Li-rod and Li-evaporation in H-GDC techniques, there is marginally better performance has been observed in Li-evaporation techniques due to more Lithium consumption in evaporation.
- The evidence of Li on PFCs and vessel wall has been observed in the relation of Hα and Li particles influx to plasma spectroscopic study.
- With reduction of neutral Hydrogen from wall using pulsed He-GDC, the ratio Hα/Li reduction indicates more Li-H concentration. As result, the plasma performance was improved in short He-HDC + Li-GDC on InP Coated wall.
- First time we have operated full D2 plasma in tokamak. With support of high temperature Li-Evaporator operation (600° C), the high temperature 290 eV and long duration D2 plasma discharges were generated.
- The control of Carbon influx and Hydrogen recycling has been observed in term of core temperature rise, density, and control of various wall conditioning techniques.
- The initial study of Ar-H mixture GDC before Li wall conditioning is carried out. Further study of this technique will be carried out to control more impurities.