Improvement of the STOR-M Tokamak Plasma Discharges by Lithium Coating of the Inner Wall

A. Rohollahi[1], S. Elgriw[1], J. Adegun[1], A. Mossman[2], M. Patterson[1], J. Zhang[1], C. Xiao[1], A. Hirose[1]

[1]Plasma Physics Laboratory, University of Saskatchewan, Saskatoon, Canada

[2]General Fusion Inc., Burnaby, British Columbia, Canada

Summary

This research focused on the experimental observations of the Improvement of plasma parameters after lithium (Li) coating of the tokamak inner wall. Reduction of impurity contents of the tokamak plasma and the wall hydrogen recycling have been observed after Li coating. The plasma density has been reduced due to the particle pumping effects of Li coating.

Motivations

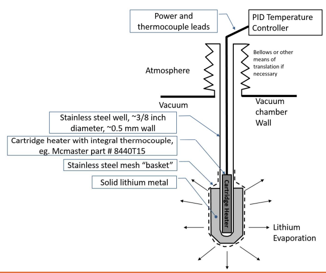
- In a tokamak, increased fuel recycling may lead to loss of control of the plasma density, and high-Z impurity release from the first wall to tokamak discharges will increase radiation loss. These two adverse effects can be reduced by coating the tokamak wall.
- Boronization, siliconization and lithium coating of the tokamak first wall can be utilized to reduce the fuel recycling and the high-Z impurities release from the tokamak wall.
- Li coating of the plasma facing components (PFC) increases the plasma current and energy confinement time.

Introduction

- Lithium (Li) is one of the most chemically active metallic elements with a low charge number and low melting temperature.
- Lithium can be employed as an active getter for low-mass impurities inside the tokamak chamber such as oxygen, carbon and water.
- It has been reported previously that Li coating of the inner tokamak wall reduces low-Z impurities (oxygen and carbon) in the tokamak plasma.
- Coating of the inner wall of a tokamak with Li reduces the hydrogen recycling from the tokamak wall and thus reduces the plasma density.
- To compensate for the reduction of the plasma density, additional fueling using different techniques such as supersonic gas puffing, molecular cluster injection and neutral beam injection (NBI) are necessary.

Experimental Setup

- **The STOR-M tokamak (R/a = 0.46/0.12 cm, B_t =0.65 T, I_p =22 kA) is a small research tokamak at the University of Saskatchewan equipped with the University of Saskatchewan Compact Torus Injector (USCTI). The tokamak chamber is made of stainless-steel (304L alloy).**
- **General Fusion has developed a modular lithium plasma vacuum deposition (PVD) system which can safely and conveniently deposit lithium coatings on relatively large vacuum vessels in situ.**



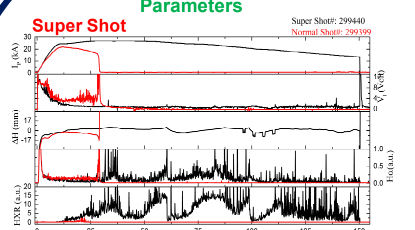
2 grams Li rod placed inside a basket which is covered by a mesh to prevent Li from splashing during the evaporation and boiling process. A closed end stainless steel (SS) pipe is inserted into the basket and a heater cartridge integrated by a thermocouple is inserted into the pipe to heat the Li rod. The inside of the SS pipe is isolated from the vacuum. The heater, which is controlled by a PID controller, can heat up the Li rod to 600 °C which is higher than the melting point of Li (180 °C)

- **The STOR-M tokamak is equipped with a residual gas analyzer (RGA) which can monitor contamination in the chamber with molecular mass up to 100 amu.**
- **A spectrometer attached to a high resolution ICCD camera is used to record line emissions of plasma impurities. The spectrometer is a 0.3-meter triple grating monochromator (Spectrapro 300i) with a 0.1 nm resolution. An 8-channel fiber optic cable is connected to the spectrometer to collect line emissions of impurities from the tokamak plasma at 8 different radial locations. Three bright ion species (C_{III}, O_V and C_{VI}) have been chosen to study plasma impurities due to their bright line emissions.**

Experimental Results

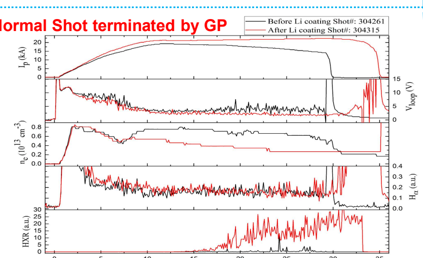
Effects of Li Coating on Plasma Parameters

Super Shot



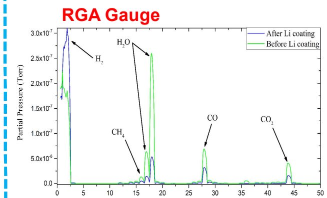
	Pre- Li Coating	Post- Li coating
I_P	20 kA	28 kA
Discharge Duration	30 ms	150 ms
V_{loop}	4 V	2 V
HXR	low	Very High

Normal Shot terminated by GP



	Pre- Li Coating	Post- Li coating
n_e	8×10^{12} cm^{-3}	4×10^{12} cm^{-3}

RGA Gauge

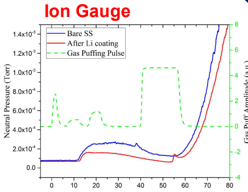


Reduction of Impurity gasses of Vacuum

- H_2O, CO_2, CH_4 and CO

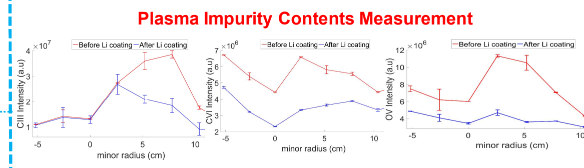
Increase of H_2

Ion Gauge



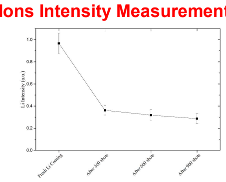
Reduction of Wall Recycling

Plasma Impurity Contents Measurement



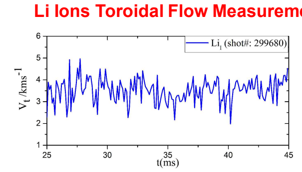
Reduction of Impurity Ions C_{III}, O_V and C_{VI}

Li Ions Intensity Measurement



60% of Li Coating Is Brushed off After 300 Shots

Li Ions Toroidal Flow Measurement



The Rotational flow velocity Of Li Ions is ~ 3.5 km/s

Conclusion

- Reduction of Impurity Gasses of Vacuum
- Reduction of Plasma Impurities
- Reduction of Plasma Density and Hydrogen Wall Recycling

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