CPMI Center for Plasma-Material Interactions http://cpmi.uiuc.edu

ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Laboratory Investigation of an Effect of Lithium on ICRF Antenna in DEVeX

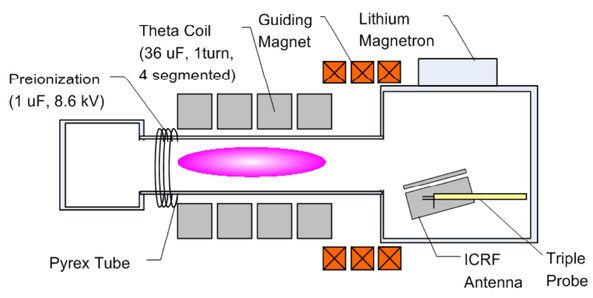
S. Jung, D. Andruczyk, V. Surla and D. N. Ruzic*

[a]*Center for Plasma-Material Interactions ◆ Department of Nuclear. Plasma and Radiological Engineering*
University of Illinois, Urbana-Champaign, Urbana, IL 61801 USA

Objective

Impurity production from Ion Cyclotron Resonance Frequency (ICRF) antennas has been studied for years to understand the associated problem of impurity radiation and the antenna power-handling limits. [1-2]

A theta pinch device called the Divertor Erosion and Vapor Shielding eXperiment (DEVeX) facility was built in order to study erosion of ICRF antenna and material-plasma interaction for fusion plasma conditions.



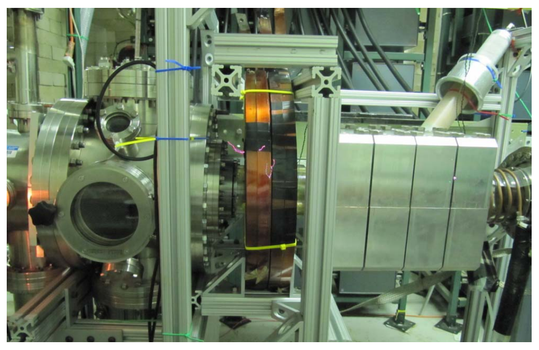
Previous experiments showed that a plasma can be sustained for approximately 80 μs per pulse, with a $(10)^{21}$ - $(10)^{22}$ /m^3 plasma density and 10 – 100 eV electron temperature near the theta coil. [3-4]

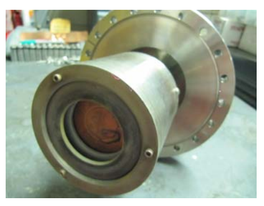
To study an effect of lithium, one of the promising material for fusion, on an ICRF antenna, a small ICRF antenna is inserted in the chamber. Triple Probe diagnostics are carried out to measure plasma parameters inside the antenna.

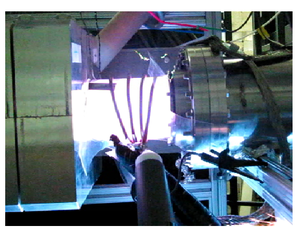
Experimental Setup

Device Description:

- Rail-gap switch for main bank.
- Currently 36 μF, charged up 30 kV (fixed at 20 kV in this experiment)
- Theta coil – capacitors are discharged through single-turn theta coil .
- RG-19/U coaxial cable for the power transmission .
- Pulsed (1 μF, 8.5 kV) preionization source triggered by a spark gap switch
- Hydrogen at 1 - 2 mTorr
- Guiding magnet: 65 A, B field > 1100 G at the center
- Triple Langmuir probe installed in the ICRF antenna





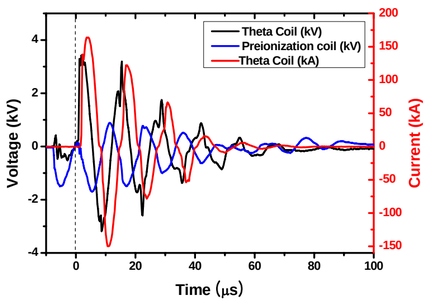


Antenna & Magnetron:

- 3 ‘’ x 4 ‘’ x 5 ‘’ Al antenna box
- Stainless rods for faraday shield (transparency: ~55 %)
- Multi-turn copper antenna placed in the box
- Antenna faraday shield aligned with axis magnetic field
- Lithium sputtering by Magnetron
- Lithium deposition on the ICRF antenna
- RF power: Variable frequency RF amplifier (0.3 – 35 MHz, fixed at 15.5 MHz for this experiment) up to 500 V
- Lithium Magnetron: TORUS magnetron (K. J. Lesker) with 5cm diameter Lithium target

Results

Theta coil discharge characteristics

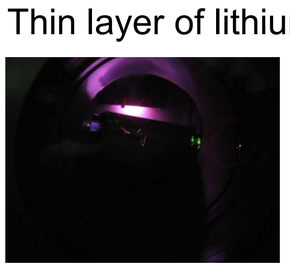


Preionization cap: 8.6 kV
Capacitor bank: 19.5 kV

- Preionization: ~10 μs
- Theta coil pulse duration : 70 - 80 μs
- Theta coil voltage: ~ 3 kV
- Theta coil current: max. 160 kA
- B max at the coil: ~ 0.4 T
- Oscillatory current waveform: periodic plasma compression and decompression

Lithium Deposition with Sputtering

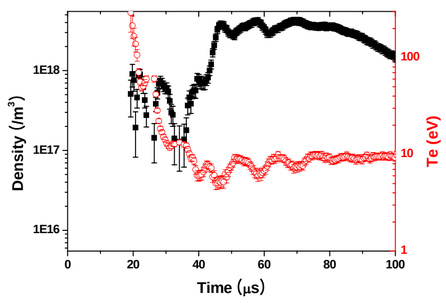
DC Magnetron with lithium target sputtered by Argon
1 hr deposition on the ICRF @ 250 mA, ~25 mTorr
Thin layer of lithium on faraday shield is observed



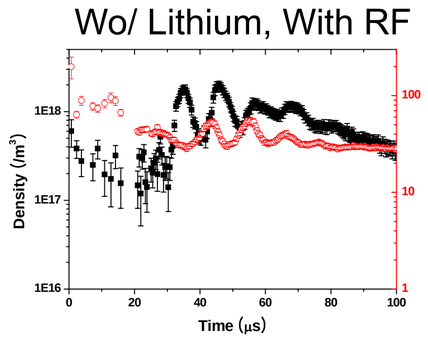
Plasma Parameter measurement near ICRF Antenna

- Triple Langmuir Probe with 0.5 V and 10% area error propagation for n_e, T_e
- Thin and collisionless sheath approximation & non-saturation equation solver
- RF power fixed at 15.5 MHz, 90 W, magnetic field at target chamber: ~150 G
- Experimental conditions: No Li – No RF, No Li – RF, Li – No RF, Li – RF

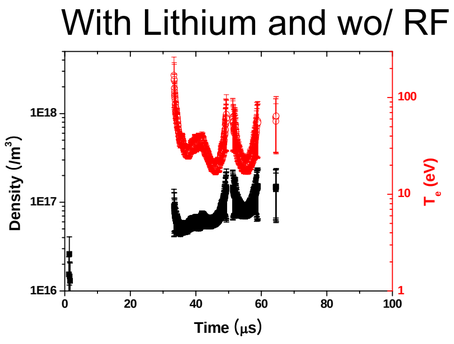
Wo/ Lithium and RF



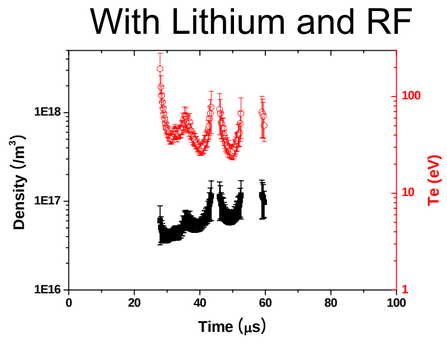
Wo/ Lithium, With RF



With Lithium and wo/ RF



With Lithium and RF



- For non-Lithium experiment, peak plasma density is around 10^{18} /m^3 while density for lithium-coated antenna stays around 10^{17} /m^3.
- Temperature change is not as conspicuous as density change.
- Magnetic field and antenna power is too low to observe heating effect.

Conclusion & Future Works

- Comparison of plasma parameters for lithium-coated antenna and non lithium-coated antenna shows that plasma density inside the lithium coated antenna is significantly lower than non-lithium antenna.
- Power to the antenna and magnetic field in the target region needs to be much higher to observe a strong ICR heating effect in our experiment.
- Better physical understanding of the interaction between lithium, antenna fields, and the shield material is needed to interpret this phenomenon.

Reference

[1] J. R. Myra, and et al., Nucl. Fusion 30 (1990) 845-858
[2] F. W. Perkins, Nucl. Fusion 29 (1989) 583-592
[3] T. Gray, Ph. D dissertation, University of Illinois at Urbana Chamapaign (2009)
[4] S. Jung and et al., characterization of a theta-pinch plasma using triple probe diagnostic, published online in JNM (2011)

Support

OAK RIDGE National Laboratory
U.S. DEPARTMENT OF ENERGY