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Plasma Electrode Shape Suitable for Negative Hydrogen Ion Production

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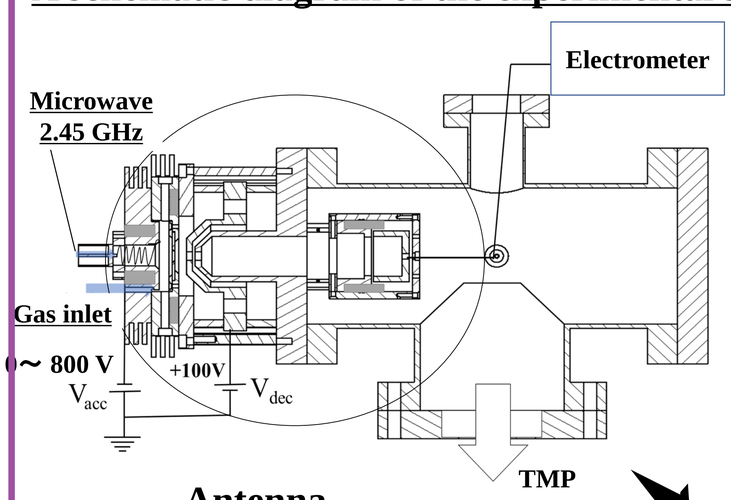
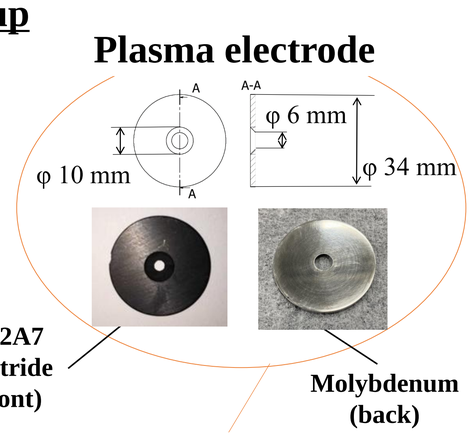
INTRODUCTION

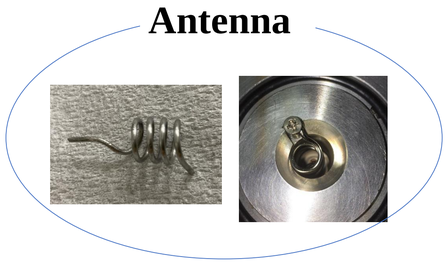
We have been investigating the amount of H^- current and the amount of co-extracted electron current when C12A7 electride or molybdenum (Mo) were used for the Plasma electrode (PE) in a compact ECR ion source with an exchangeable PE. The C12A7 electride has a low work function, and it is expected to increase the amount of H^- ion current and suppress the co-extracted electron current when used as the PE material. In this study, we focus on the H^- ion extraction and electron coextraction due to the shape of the PE of a H^- ion source. Two materials: Mo and C12A7 electride are examined for a search of extraction structure suitable for a Cs-free ion source.

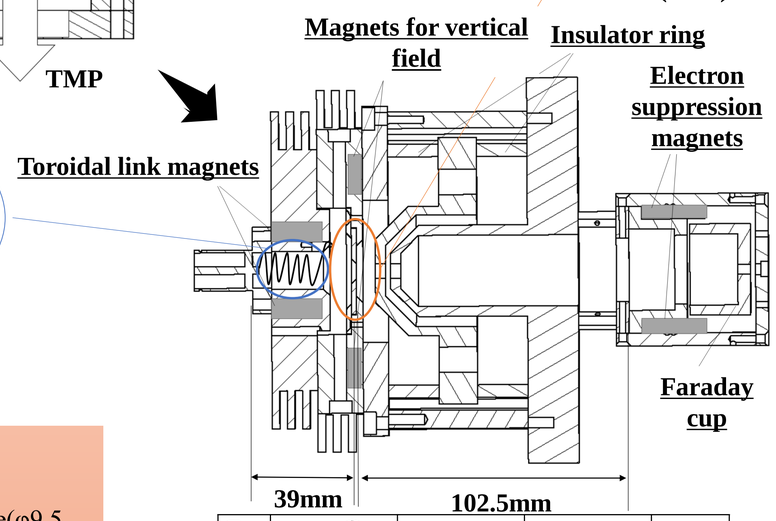
EXPERIMENTAL SETUP

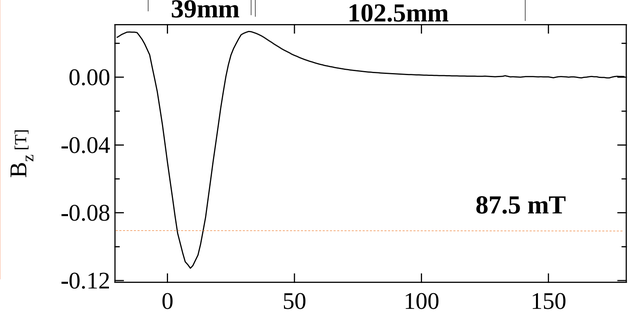
A schematic diagram of the experimental setup











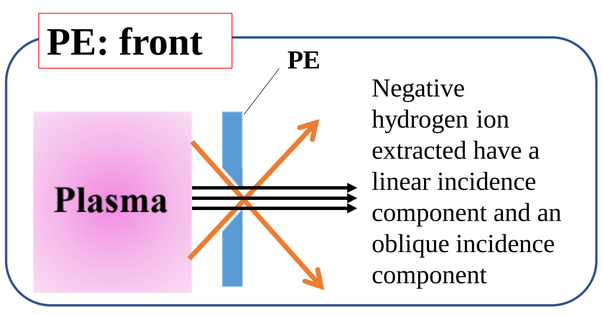
Ion source design

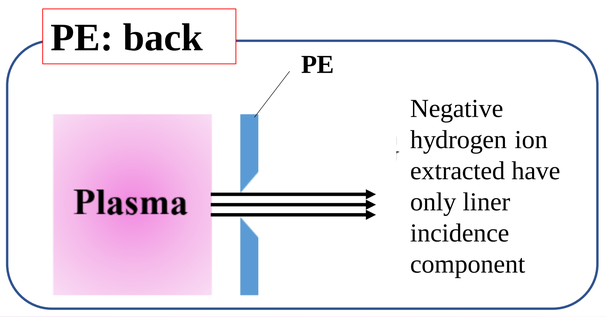
- ECR discharge with toroidal link magnet field (2.45 GHz cylindrical space(φ9.5 mm) microwave and 87.5 mT)
- Spiral Antenna in 15 mm diameter
- 39mm distance from feedthrough to PE

Plasma electrode (PE)

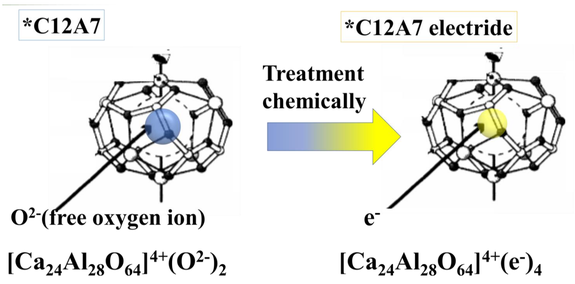
- 34mm diameter
- 6mm hole diameter
- Materials : C12A7 electride and Mo

Effect of PE structure



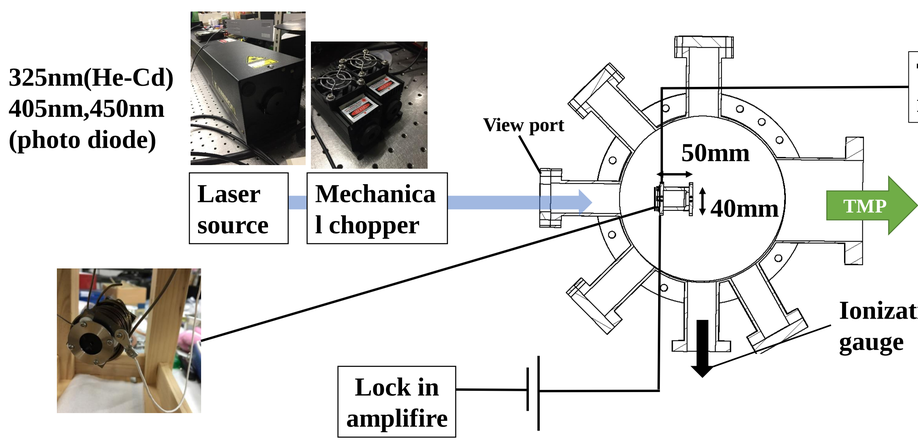


C12A7 electride



- Replacement free oxygen ion by reduction to electron results in C12A7 electride.
- High electric conductivity
- Low work function (2.4 eV)
- Chemical stability and high heat resistance

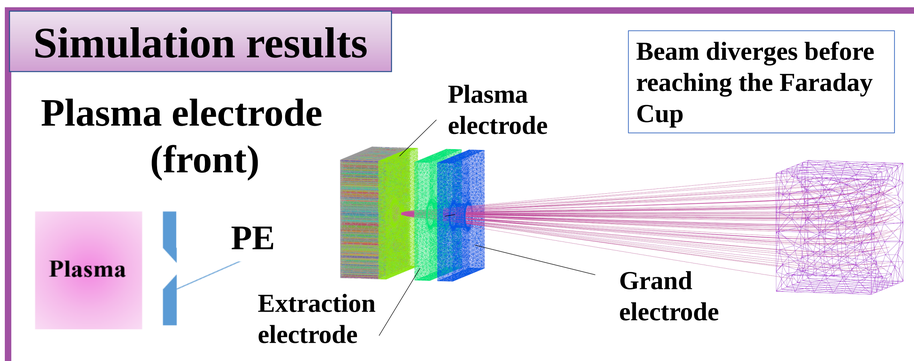
Heating system for electride



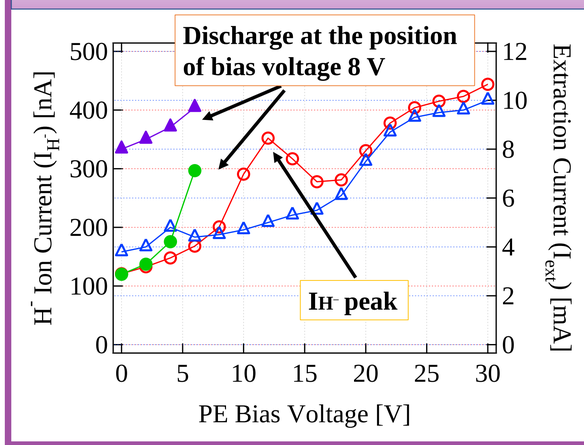
After increasing the temperature to 800 ℃ over 1 hour, heat for 15 minutes. Repeat this process twice

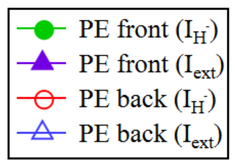
RESULTS

Simulation results



Influence of electride PE Bias Voltage

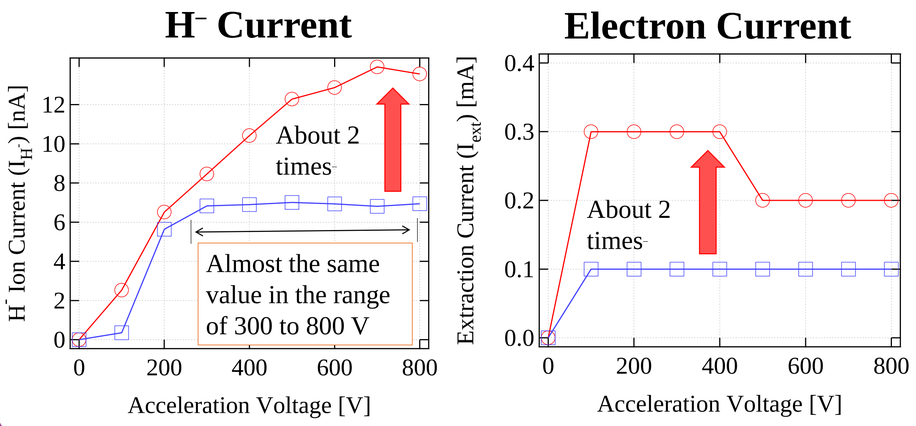


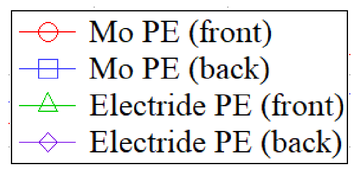


- **I_{H^-} peak was observed under the condition of a PE(back) bias voltage of 12 V was applied.**
- **Applying a bias voltage of 8 V to the PE(front) caused a discharge between the antenna and the PE.**

Influence of Acceleration Voltage

PE material: Molybdenum

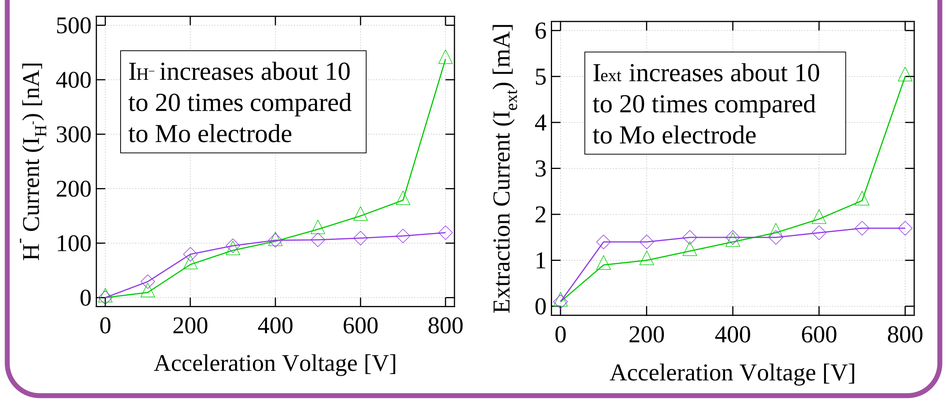




Experimental Condition

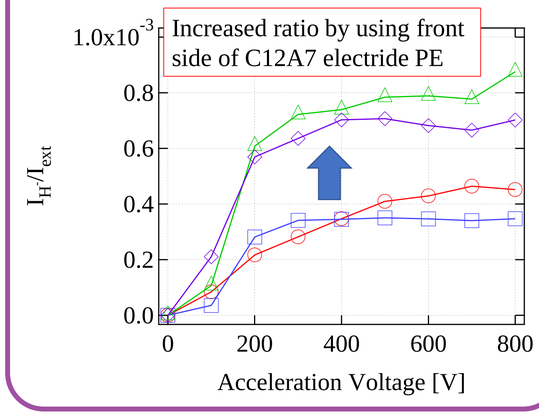
Input Power (Micro wave) : 25 W
Gas pressure : 0.15 Pa
PE Bias Voltage : 5.0 V
PE materials: Mo or C12A7 electride

PE material: C12A7 electride



The ratio of I_{H^-}/I_{ext}

- Electride increased the ratio of I_{H^-}/I_{ext}
- Small change between the front and back of the Mo electrode



SUMMARY

◆In the simulation, the increase in beam convergence was observed when the conical opening is facing the back side of the electrode.
◆When the Plasma Electrode was changed from the back to the front side, the negative hydrogen ion current(I_{H^-}) and co-extracted electron current(I_{ext}) increased, when the PE Bias was 6 V. This is due to the oblique incident component of I_{H^-} and I_{ext} passing through the extraction hole.
◆Plasma electrode material is changed from Mo to C12A7 electride, I_{H^-} and I_{ext} were about 10 to 20 times higher.
◆For the molybdenum electrode, the ratio of I_H/I_{ext} changed little by flipping the surface of the plasma electrode. However, using C12A7 electride it improved by facing the conical opening to the plasma. This shape side suitable for surface production of negative hydrogen ion.
◆The change of plasma parameters by PE Bias Voltage and the effect to I_{H^-} and I_{ext} will be studied in future.