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Development of a Compact Molecular Hydrogen Ion Source for Low Energy Surface Scattering Experiment

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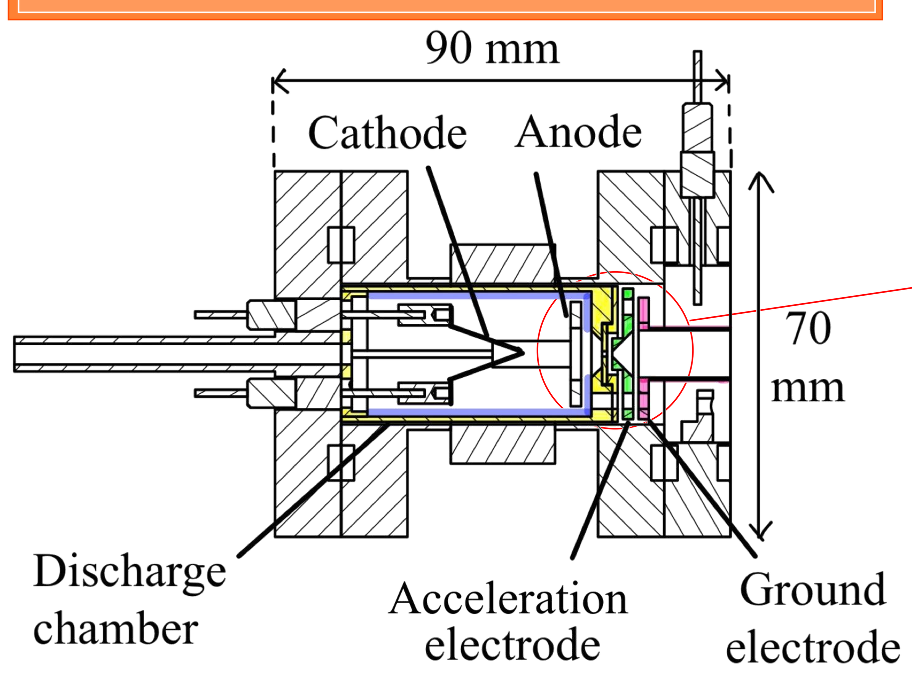
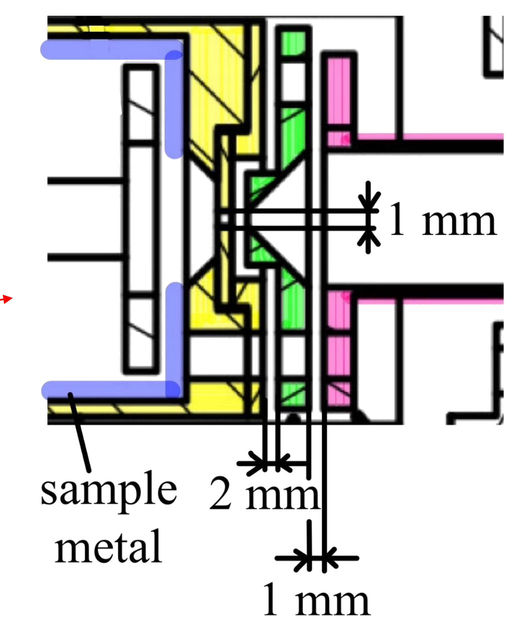
INTRODUCTION

Fundamental data on surface processes are necessary for understanding which factor is the most influential upon the edge plasma parameters in a future fusion reactor. The hydrogen particle reflection at metal surface is being investigated using an apparatus to study angle resolved energy distribution functions of positive/negative ions emitted from the surface. The data on low energy ion beam reflection are still insufficient because of low intensity. The compact ion source was developed so as to shorten the flight distance for mitigating beam divergence due to space-charge. Molecular ions delivers more hydrogen atoms at lower beam energy, and the source operation condition suitable to produce H_3^+ ions can realize enough signal intensity for low energy hydrogen atom reflection. The ion source wall material alters species composition of molecular ions; molecules like hydrogen is adsorbed on the surface of the ion source wall. The adsorbed hydrogen causes recombination and produces hydrogen triatomic molecules upon incidence of hydrogen atoms. The recombination coefficients differ from a metal to another. In this paper, study of difference in production rates of hydrogen molecular ions among stainless steel, Ti, Ni, and Mo using a new compact ion source are reported.

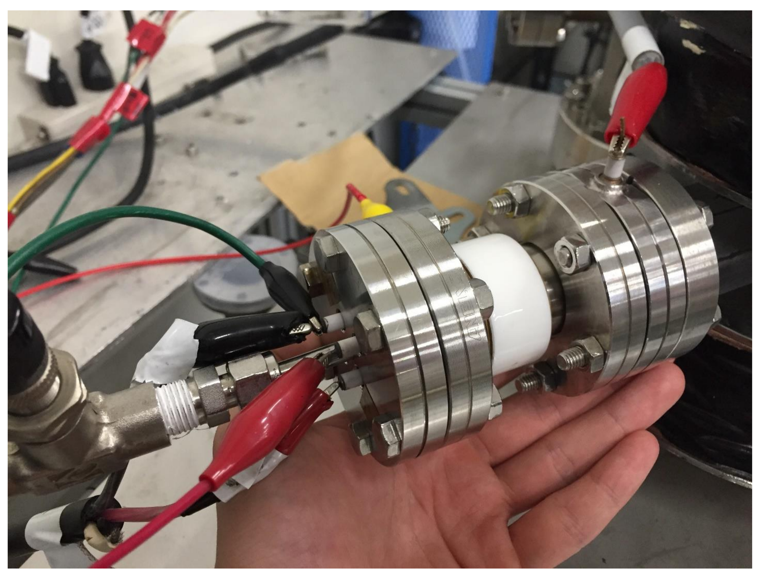
EXPERIMENTAL SETUP



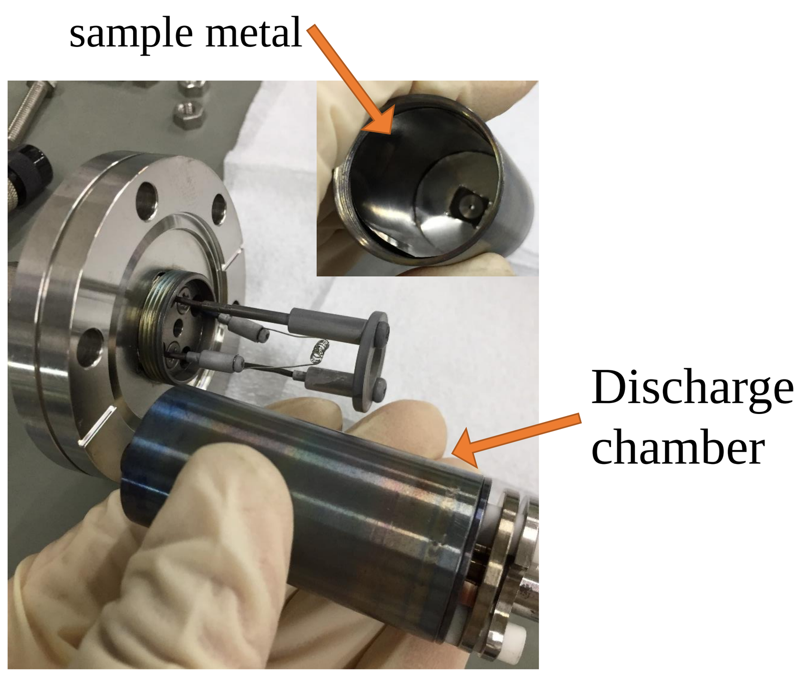
The developed compact ion source

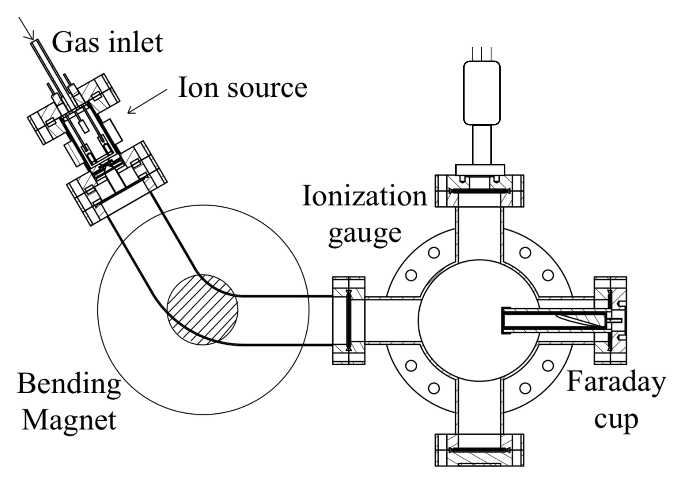


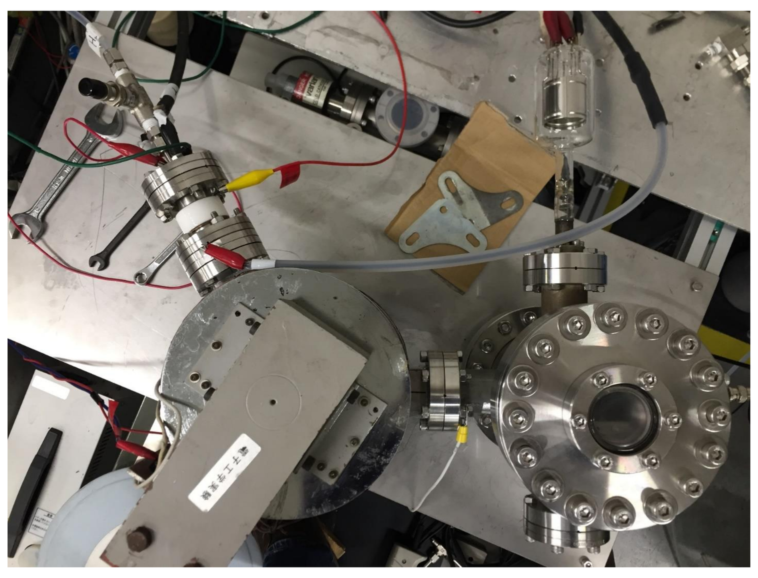
The extraction electrodes



Palm-sized ion source





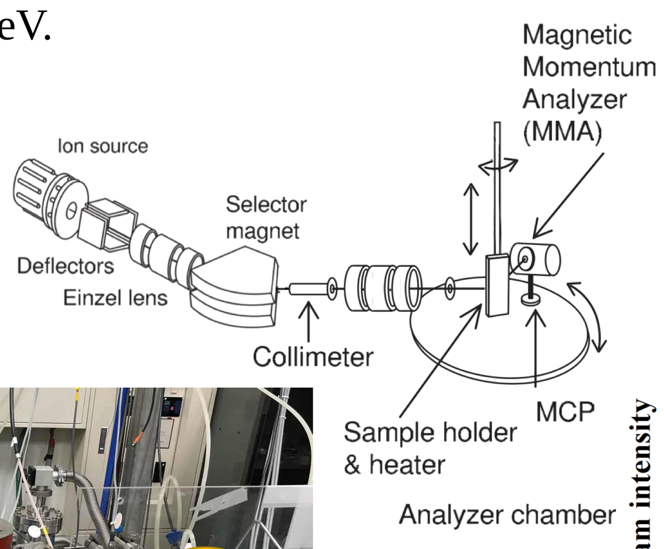


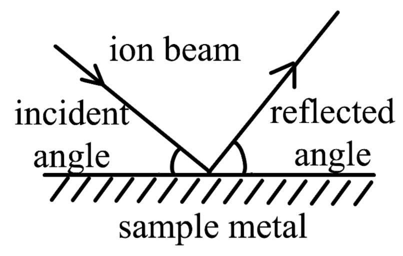
The experimental apparatus

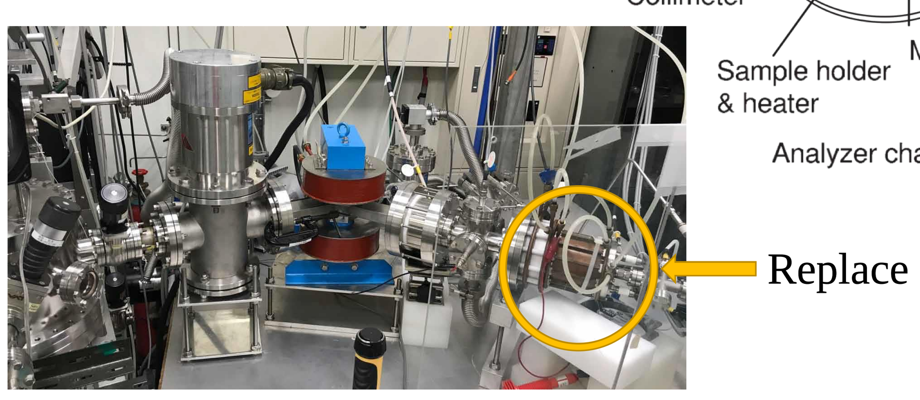
MOTIVATION OF THE STUDY

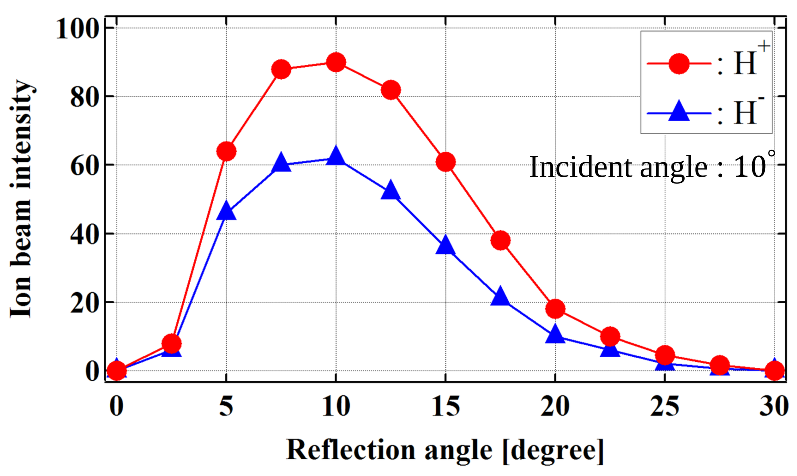
The scattering experiment

The ion beam reflects at a rotating target and is detected by MCP. The experiment focuses the scattering beam that become H^+ and H^- ions at impact to the target. The new ion source is expected for low energy ion beam since the intensity of ion beam from present ion source is weak at several hundreds eV.





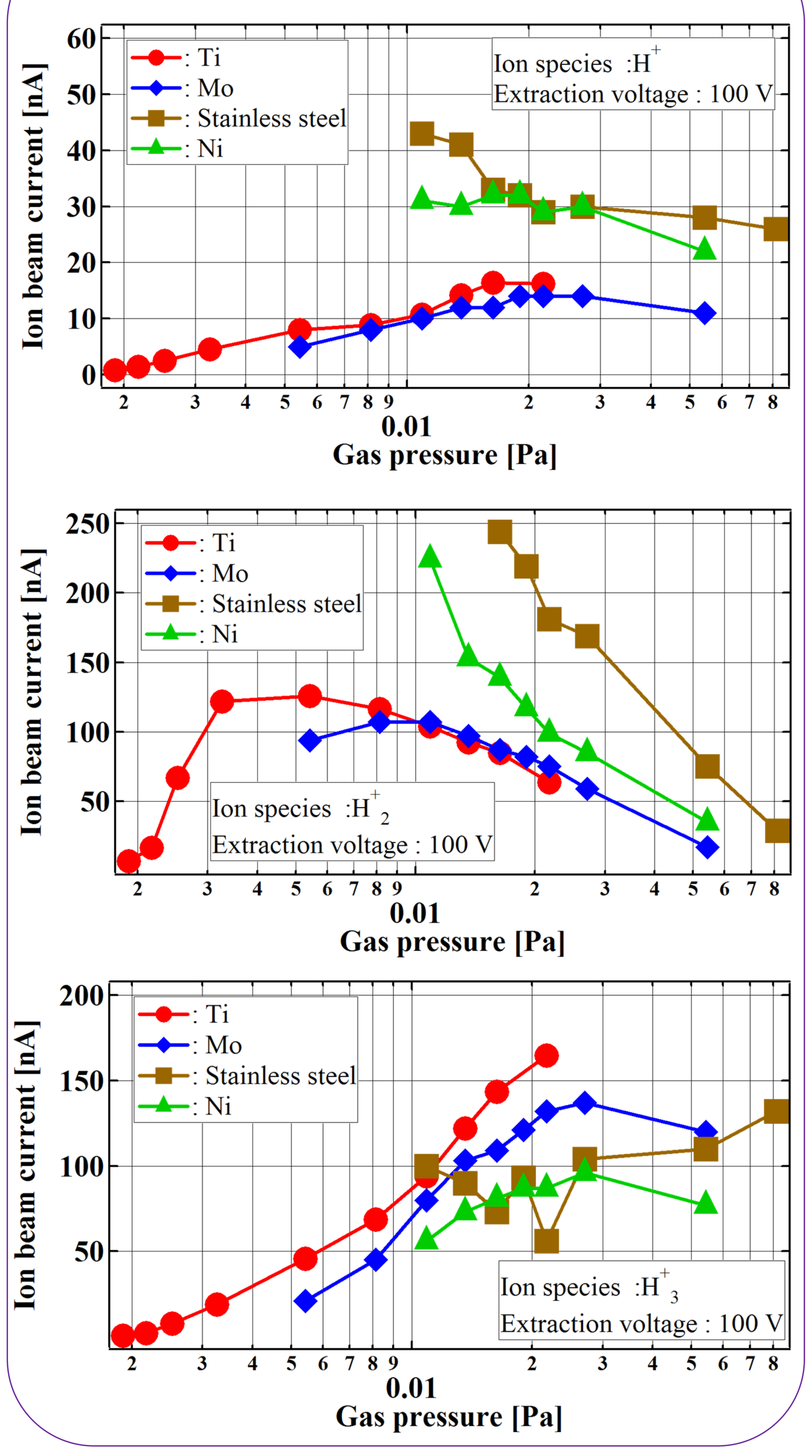




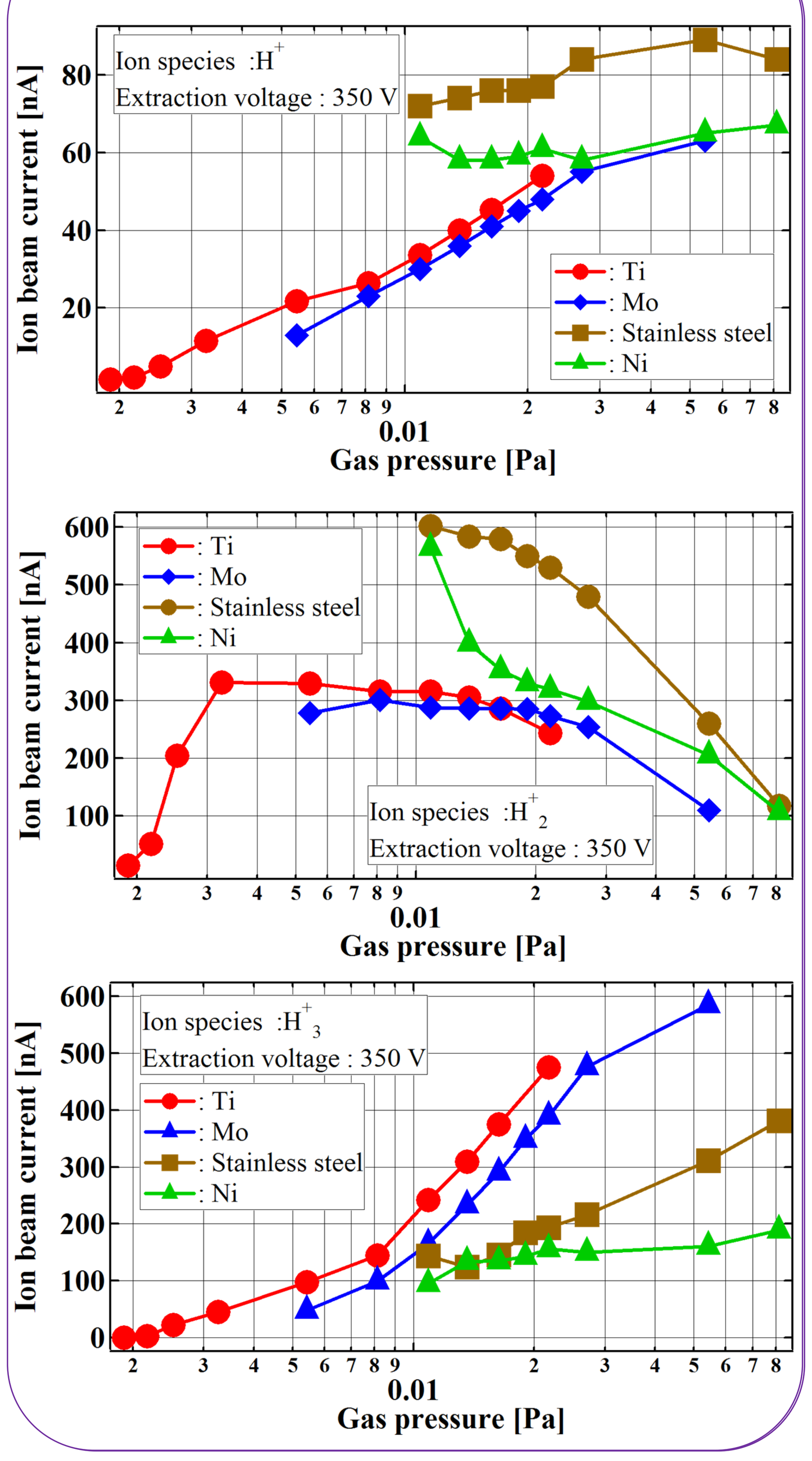
RESULTS

The new developed ion source was evaluated by measuring hydrogen molecular ion beams. The H^+, H_2^+, H_3^+ ion beams with changing the plasma surface of the discharge chamber to Ti, Ni, and Mo ware extracted up to 350 V with increments of 50 V. The results of 100 eV, 350 eV, and 100 eV/atom are shown as follows.

100 eV

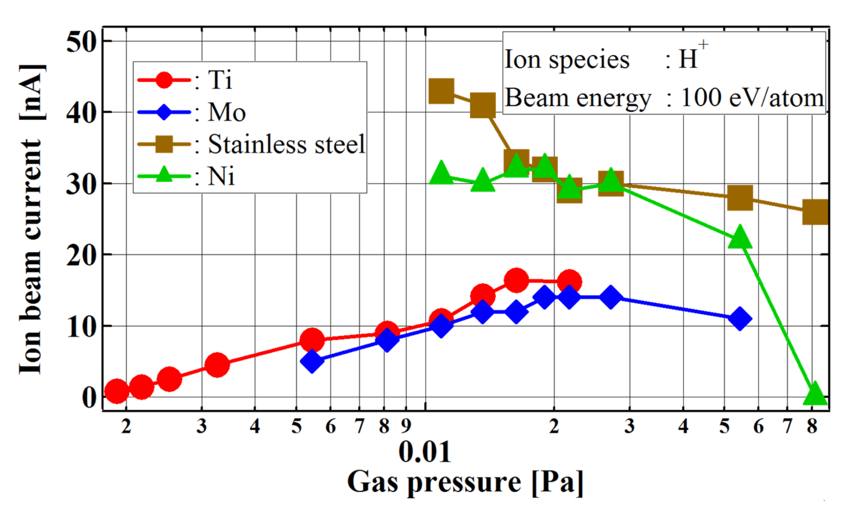


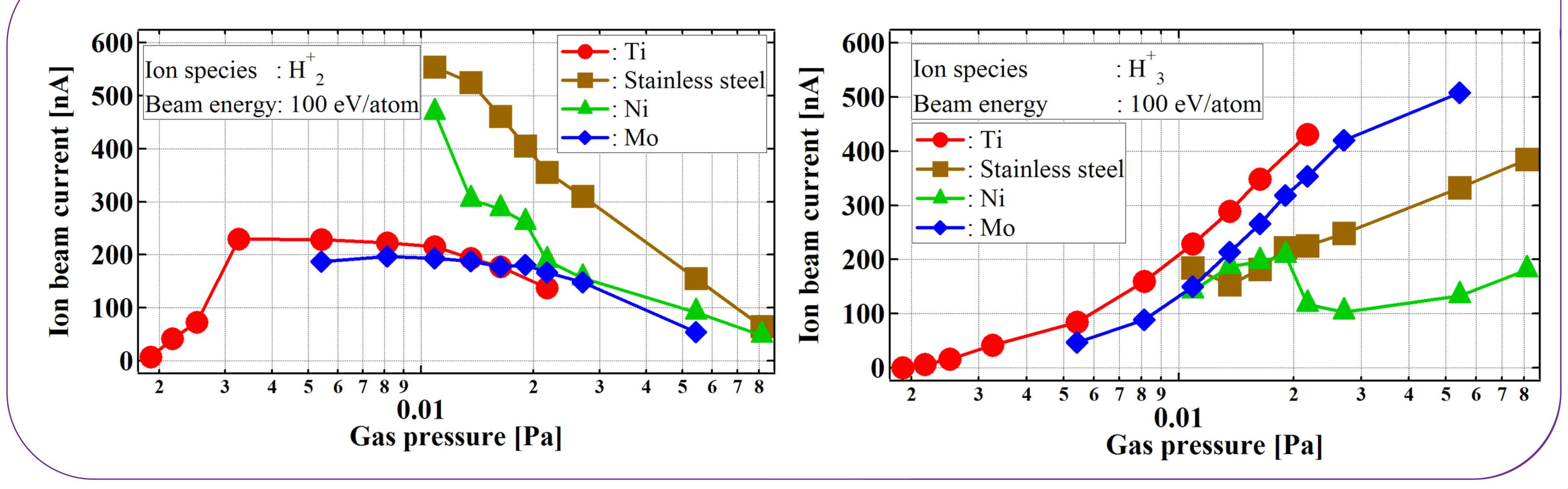
350 eV



Condition
Filament : W Ø0.30 mm, ℓ = 110 mm
Filament to anode : 8 mm
Filament to plasma grid : 14 mm
Discharge voltage : 80.0 V
Discharge current : 0.10 A
Beam line : 370 mm

100 eV/atom





CONCLUSION

The compact ion source for low energy surface scattering experiment was developed and evaluated by measuring H^+, H_2^+, and H_3^+ ion beams. The experimental results indicate that characteristics of stainless steel are similar to those of Ni. The characteristics of Ti are differ from those of stainless steel but similar to the ones characteristics of Mo. The stainless steel and Ni surface produced higher H^+, H_2^+ ion beams than Ti and Mo surface at any energy. The Ti and Mo surface showed advantage on H_3^+ ion beam production as compared with stainless steel and Ni. The H^+ and H_3^+ ion beams current at Ti and Mo surface rise more steeply than at stainless steel and Ni. While the reduction of H_2^+ ion beam current at Ti and Mo surface is not pronounced as compared with those of stainless and Ni surface stainless steel and Ni surface. Comparing the particle flux intensity at 100 eV/H atom, the 200 eV H_2^+ ion beam current at stemless steel surface produces the largest at low pressure. On the other hand, Ti surface can produce H_3^+ beam of the particle flux intensity at high pressure; thirty times the H atom intensity compared to H^+.