

#### §4. Development of a Small Penning-Type Ion Source for Measurements of Charge Transfer Cross Sections in Slow Metallic Ion - Atom and Molecule Collisions Relevant to Fusion Edge Plasmas

Kusakabe, T. (Dept. Nucl. Eng. Kinki Univ.)  
 Nakai, Y. (At. Energy Res. Inst. Kinki Univ.)  
 Tawara, H., Sasao, M.

The low-temperature edge plasmas play a pivotal role in isolating the high-temperature core plasmas from the vacuum vessel. In edge plasma regions, there are many different low charge state ions, neutrals and molecules. The cross section data of charge transfer of metallic impurity ions generated near vessel walls, limiters and divertor plates are also important for plasma modelling and diagnostics, but are relatively scarce.<sup>1)</sup> We therefore plan to measure the charge transfer cross sections of various metallic ions with high melting point. For the production of various metallic ions, we have tried to construct a cold cathode Penning-type (PIG) ion source with a permanent magnet.<sup>2)</sup>

Figure 1 shows the cross sectional drawing of the present PIG ion source consisting of two cathodes, an anode and magnetic circuit, and associated electric circuit for generating and extracting ions. The anode made of stainless steel was a ring of 16 mm inner diameter and 4 mm thickness in size. The magnetic flux density by a cylindrical Sm-Co magnet of 20 mm outer diameter and 10 mm thickness with a 1.5 mm $\phi$  pin-hole was about 0.2 T at the discharge region. The lower cathode made of aluminum was a 16 mm diameter and 3 mm thickness disc with 2 mm $\phi$  ion extraction-hole. The upper cathode was the same size as the lower cathode and prepared by aluminum, tantalum, copper tungsten alloy and Hastelloy C-276. High purity argon, krypton or xenon gases as a working gas for creating the Penning discharge were introduced through the pin-hole of magnet and the upper cathode with a variable leak valve.

The extracted ion beam was analyzed according to its charge  $q$  and mass  $m$  by a 60° sector magnet. The selected ion beam was detected with a Faraday cup and its current was measured with an electrometer (Keithley, 617). Two vacuum chambers, which contain the PIG ion source and the Faraday cup, respectively, were evacuated with 4" and 6" oil diffusion pumps having cold traps. The vacuum pressure in the vessel was monitored with two ionization gauges. The residual gas pressure was about  $1 \times 10^{-4}$  Pa.

Figure 2 shows typical ion mass spectrum extracted from the present PIG ion source by using krypton as a working gas and a tantalum cathode. The anode and ion accelerating voltage,  $V_a$  and  $V_{acc}$ , were 1.7 and 1.0 kV, respectively. The net Kr gas pressure was about

$2 \times 10^{-4}$  Pa at outer region of the PIG ion source. The singly charged Ta<sup>+</sup> ions were about 0.3 pA together with intense Kr<sup>+</sup>, Kr<sup>2+</sup>, Al<sup>+</sup> and various ions of residual gas species. By using Kr or Xe as the working gas, Cu<sup>+</sup> and W<sup>+</sup> ions from Cu-W cathode and Mo<sup>+</sup>, Ni<sup>+</sup> and Cr<sup>+</sup> ions from Hastelloy cathode are observed, respectively.

Therefore, the present small PIG ion source with a permanent magnet can be applicable to slow metallic ion collision experiments.

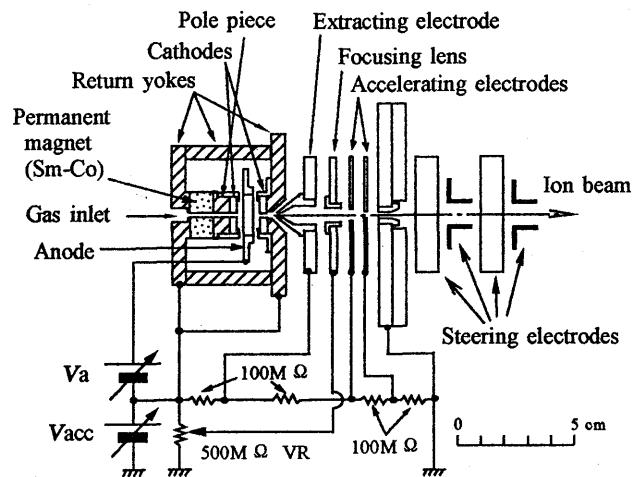


Fig. 1. Cross sectional drawing of the present PIG ion source with a Sm-Co magnet and associated electric circuit for generating and extracting ions.

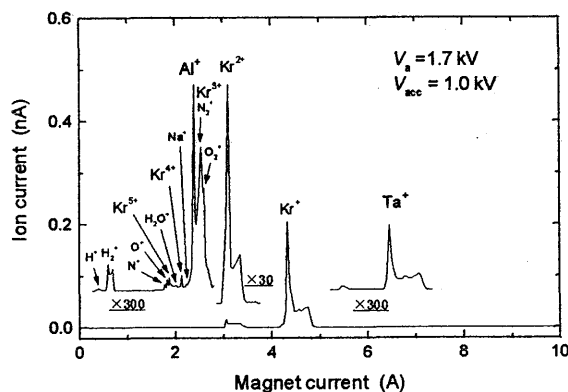


Fig. 2. Typical ion mass spectrum extracted from the present PIG ion source. The working gas was krypton and the upper cathode was made of tantalum.

#### References

- 1) Janev, R. K., "Atomic and Molecular Processes in Fusion Edge Plasmas", Plenum Press, (1995) p. 1
- 2) Son, Z., Yu, J., Yuan, Z. and Li, R., Rev. Sci. Instrum. **61**, (1990) 463