§11. Development of a Sputtered Ion Source for Measurements of Charge Transfer Cross Sections in Slow Metallic Ion - Atom and - Molecule Collisions Relevant to Fusion Edge Plasmas

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In low temperature edge plasma regions near the vacuum vessel walls, limiter and divertor plates in fusion plasma devices, many different low charge state ions as well as neutral particles are present. Though the cross section data of charge transfer of such metallic "impurity" ions have been realized to play an important role in plasma modelling and diagnostics, they are still scarce.1) Therefore we have been working to measure the charge transfer cross sections of various metallic ions with high temperature melting materials. In order to produce these metallic ions, we had previously constructed and tested a cold cathode discharge Penning-type (PIG) ion source with a permanent magnet.2) By using argon, krypton or xenon as the working gas, the Ta^+ ions from Ta cathode, Cu^+ and W^+ ions from Cu-W cathode and Ni^+, Cr^+, Mo^+ and W^+ ions from Hastelloy cathode have been observed. However, this PIG ion source has been found to have some serious intrinsic problems for our cross section measurements: (1) short life-time due to contamination of the inner surfaces, (2) broad energy distributions of ions produced and (3) the presence of significant fractions of the metastable state ions.

Thus, we are trying to develop a new electron impact ion source, combining with sputtered neutral atom source, similar to the sputtered secondary neutral particle mass spectrometry (electron beam-SNMS)3). Figure 1 schematically shows the present sputtered ion source consisting of two electron impact ion sources (EIIS1 and EIIS2) and a metallic target to be sputtered. Singly charged Ar^+ ions, which were produced under impact 80 eV electrons emitted from a Th-W filament and accelerated up to 5 keV in the EIIS1, were impinged on the metallic target. The sputtered neutral metallic atoms effused into the EIIS2 were ionized by another electron beam whose energy was chosen to produce only the ground state ions (or some metastable state ions). The focused and accelerated metallic ions were analyzed with a 60° sector magnet and detected with a channel electron multiplier (CEM). Two vacuum chambers containing the ion sources and the CEM ion detector were separately evacuated with 4" and 6" oil diffusion pumps with cold traps. The residual gas pressure was about 1×10^{-4} Pa.

Figure 2 shows a block diagram of the present ion mass-charge analyzing system. Signal from the CEM was amplified, pulse-shaped and sent into a rate meter. Its analog output was sent into a personal computer (PC) through an ADC board (Interface, AD12P8D-79), together with that of a constant current regulator for the sector magnet. Through sweeping the magnet current in saw-tooth wave forms, the mass-charge spectrum of the produced ions were automatically acquired in the PC.

Various performance tests of the present system are under way.

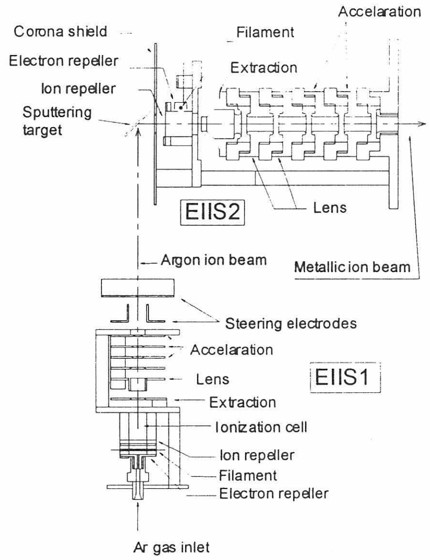

Fig. 1. Arrangement of the present sputtered ion source for extracting metallic ions.

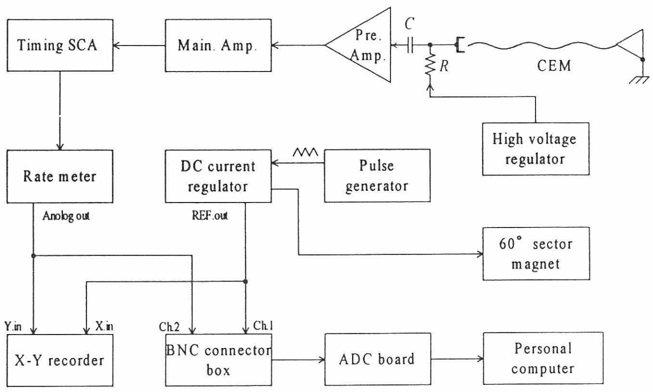

Fig. 2. Block diagram of the ion mass-charge analyzing system.

Reference
1) Janev, R. K.: "*Atomic and Molecular Processes in Fusion Edge Plasmas*", Plenum Press, (1995) p. 1.
2) Kusakabe, T., *et al.*: J. School Sci. Eng. Kinki Univ. **35**, (1999) 107. / Kusakabe, T., *et al.*: Ann. Rep. NIFS (1998-1999) p. 258.
3) Wolf, B.H., *et al.*: Rev. Sci. Instrum., **61** (1990) 406. / Assoufid, L. and Kostroun, V.O.: Nucl. Instrum. & Methods, **B69** (1992) 492.