§12. Development of an Ion Source Producing Multiply Charged Lithium Ion for a Slow Ion-Atom Collision Experiment

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Lithium is a chemical element with atomic number 3 and symbol Li, and belonging to the alkali metal group. Li is sometimes used for plasma diagnostic purposes in fusion devices. Therefore, cross section data and any knowledge of collision dynamics for these atoms and ions are known to be important and useful in controlled thermonuclear fusion research. In order to establish the plasma modeling in the low-temperature boundary and edge plasmas which took in the behavior of Li ion more accurately, cross section data of the charge transfer for Li^{q+} (q =1, 2, 3) ions in collisions with various atoms or molecules are essential.

However these cross section data are still sparse, particularly at low collision energies. One of the reasons why these data are scarce is thought to originate in the difficulty of generating of slow multiply charged Li ions. In this study, therefore, an ion source which can extract the doubly and triply charged Li ions will be developed to measure the charge transfer cross sections of multiply charged Li ions colliding with many species of atoms and simple molecules.

As a first step of the present project, a new type ion source (called the SI-EIIS) which a surface ionization and an electron impact were combined was constructed to extract Li^{2+} ions in the previous year. The singly charged lithium ions were produced with a surface ionization method. A platinum foil spot-welded to a tungsten filament was used as an anode for a lithium ion emitter, which was coated with a mixed powder of Li_2CO_3, Al_2O_3, and SiO_2. The Li^+ ion beam was accelerated extracted up to 0.1keV by the electric field and decelerated to approximately 0.01eV. This beam collided and was ionized with an electron beam generated with tungsten filament, and the Li^{2+} ions were produced.

Performance test of this ion source was performed in this year. Figure 1 shows a typical mass spectrum of lithium and residual gas ions extracted from the present SI-EIIS. Extracted ions were mass-separated with homogeneous magnetic field in a 60° analyzing magnet, and were detected with a micro-channel plate detector (MCP). The electric potential for acceleration of electrons and ions are 0.20 and 1.5 kV, respectively. The pressure of the residual gas was approximately 8.5×10^{-5} Pa. The most intense peak is identified as Li^+ ion. H^+ and H_2^+ ions are also identified which are generated from the residual gas. The small peak labeled (a) in the Fig. 2 has the high possibility of $^7Li^{2+}$ ions. The neighboring peak labeled (b) in the Fig. 2 is unidentified.

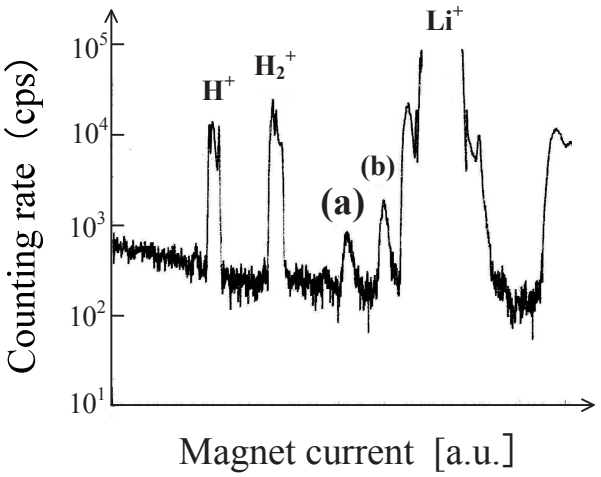

Fig. 1. Mass spectrum of lithium ions extracted from the SI-EIIS. The electric potential for acceleration of ions is 1.5 kV.

As a second step of the present project, an electron beam ion source (EBIS) with two small ring permanent magnets was designed and the parts were made. Figure 2 shows the cross sectional view of the present EBIS type ion source. The electric and magnetic fields in this EBIS were simulated using electromagnetic-field analysis software called μ-Excel (Ver. 6.4). The performance test of the present EBIS type ion source for generating the multiply charged lithium ions is under preparation.

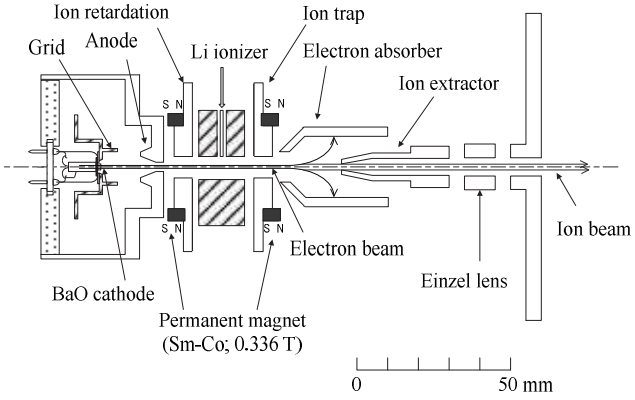

Fig. 2. Cross sectional view of the present EBIS type ion source.