§9. Development of an He^- source for a Diagnostic Beam of Alpha Particle Measurement

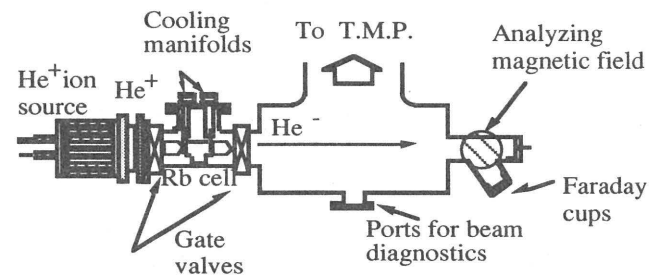
Sasao, M., Taniike, A., Nomura, I.
Wada, M. (Doshisha Univ.)
Yamaoka, H. (RIKEN)
Sato, M. (Himeji Technical Univ.)

Among the various elements, the production of He^- is known to be extremely difficult. The ground state of helium does not form a negative ion, but the a long-life metastable state of 1s2s (^3S) has a small electron affinity of 0.078 eV and a negative ion state of 1s2s2p ($^4P_{5/2}$, $^4P_{3/2}$) can be formed. This is an autodetatchment state having life-times of 10 μs (50%) and 300μs(50%) .

After much effort to certify the surface production of He^-, It has been concluded that the production rate of He^- from a Cs-Mo surface of minimum work function is nearly zero or much less than that of H^- [1]. Moreover, it is known that He^- can not be directly extracted from a helium plasma in a multicusp ion source.

On the other hand, He^- has been produced via a two step process in an alkali metal gas cell, such as Li, Na, Mg, K, Rb, or Cs [2]. The maximum value of the He^- fraction of 1.7% is obtained through collisions with a Rb target, at an He^+ ion incident energy of 6-9 keV. Using a sodium gas cell, Dimov et al. have reported the production of a 10-mA He^- beam at 12 keV in a 100 msec pulse with a current density of 2.6 mA/cm^2 [3]. A 70-mA He^- beam was also generated in a pulsed mode by Hooper et al.[4].

Development of an He^- source using a Rb gas cell in a DC operation has been recently initiated for the purpose of application to the alpha-particle measurement. Fig. 1 shows the shematic view of the experimental set-up.The essential point of the development is that of an effective and long-life Rb gas cell, which can be operated in a DC, or a modulated mode. Fig.2 shows the measured He^+ and He^- current as a function of the Rb cell temperature. In the present preliminary experiments, the Rb cell was operated in a DC mode at high pressure to convert He^+ to He^- at an efficiency of greater than 2 %. Since a positive ion current density of greater than $200mA/cm^2$ can be expected using a conventional source, a negative current density of $4mA/cm^2$ will be feasible.



Experimental setup for high current density He- beam production.
(The apparatus built at NIFS.)

Fig. 1

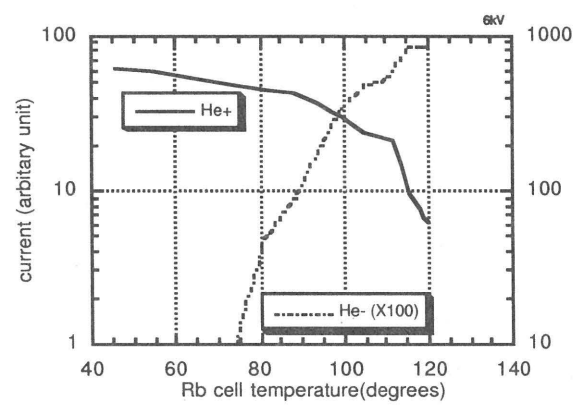


Fig.2 He^- and He^- current as a function of the Rb cell temperature.

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