§18. Energy Spread of He^- Ion Beam Produced from Low Work Function Metal Surface

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There is a distinct advantage to employ surface production scheme to achieve high intensity, large current He^- beam source for realization of a high energy atomic He plasma-diagnostic-beam. The freedom to obtain geometrical focusing of the produced neutral beam, together with a release from a struggle to solve the problem of beam divergence deterioration due to space charge, makes the He^- beam source based on the surface production process more attractive than a double charge exchange type He^- source[1], though the conversion efficiency to form He^- out of surface back scattering is very low in a plasma [2]. However, one has to the energy and angular distribution of the produced beam to make a proper trade-off study to conclude which of surface or double charge exchange is more appropriate for a future plasma diagnostic beam.

To measure the angular resolved energy distribution function of the He^- ions produced from the surface back scattering from an energetic He meta-stable neutral beam, an experimental system as shown in Fig. 1 has been assembled. As shown in the figure, the He^- ions produced at low work function metal surface is detected after a momentum separation mechanism for the produced beam. The momentum analyzer has been modified from a Wien filter to a 90-degree magnetic deflection type momentum analyzer, as a high energy atomic He beam can cause a severe back ground noise. The iron yoke for the magnetic momentum analyzer is cooled by low conductivity water flowing inside of the sealed tube arranged in vacuum to avoid over heating.

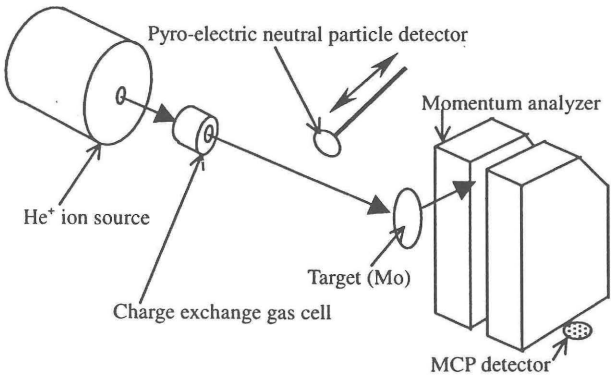

Fig. 1. Schematic illustration of the angle resolved energy distribution measurement apparatus used for He^- surface production at a low work function metal surface.

The beam detector was also changed from a simple guarded electrode to a multi-channel-plate (MCP) to realize the ion detection by a pulse counting to enhance the signal to noise ratio. The improvement in the detection efficiency has caused the observation of the appearance of a weak negative ion signal from adsorbates of electropositive atoms on the target surface. This is shown in Fig. 2 in a momentum spectrum of a negative ion beam coming into the magnetic-deflection–type-analyzer. The origin of these negative ions can be the surface of the analyzer, and a care should be made for the final measurement. This back-ground negative ion noise disappears by bombarding surfaces by energetic particle beams for a certain period of time.

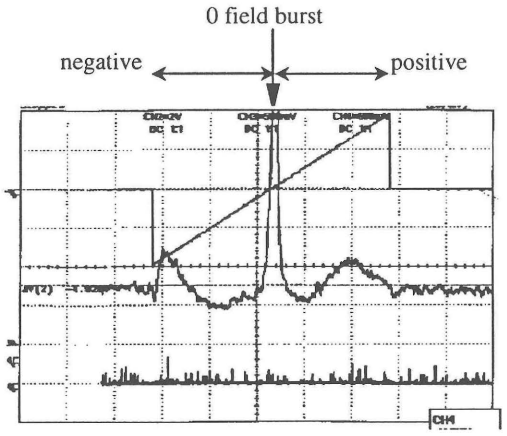

Fig. 2. Momentum spectrum of the negative ion beam produced from a He^+ ion beam scattered at Mo target surface.

Some preliminary results obtained from the constructed experimental system can be briefly summarized as follows.

1. The peak in the neutral to positive ion conversion is observed at the angel corresponding to secular particle reflection.
2. The conversion efficiency seems to show a strong dependence upon the fraction of meta-stable neutrals atoms in the incident beam.
3. Part of the positive and negative ions produced from the surface reflection, have energies substantially higher than the incident beam.

The experiment using a surface of reduced work function is now underway, and the correlation between the work function and the energy distribution of the produced negative ion beam will be investigated.

Reference

[1] Sasao, M., Taniike, A., Nishiura, M., Wada, M., Review of Scientific Instruments, **69**, (1998) 1063.

[2] Sasao, M., Wada, M. et al., Review of Scientific Instruments, **61**, (1990) 418.