§9. Production of Negative Ions by Plasma-Surface and Beam-Surface Interactions

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High energy neutrals of H, He and Li produced from their negative ions are the promising candidates for beam diagnostic systems aiming at measurements of the velocity distribution of fusion produced alpha particles. One way to produce negative ions is to utilize surface chemical reactions. Negative ions of hydrogen (H^-) and lithium (Li^-) are emitted from the surface of chemical compounds under the irradiation of electrons. The incident electrons decompose the material and form low work function surface suitable for negative ion production. This method may yield high current negative ion beams, as high current electron beam can be formed more easily than ion beams. However, some more technical developments are required to solve problems associated with the operation of the ion source of this type, and the problems are being investigated using a compact powdery sample ion source.

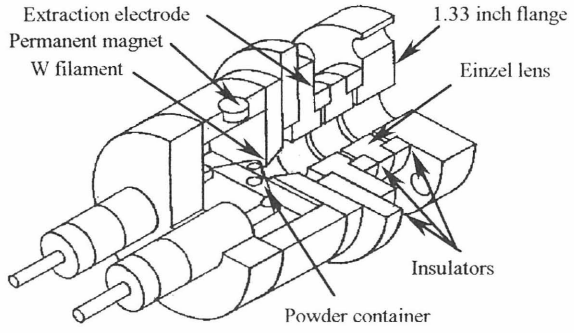

Fig. 1. Schematic illustration of a powdery sample ion source.

In Fig. 1 is shown the schematic of the compact powdery sample ion source. The test ion source developed under the NIFS joint research program is designed to fit on an widely used 1.33-inch copper gasket flange. The gas efficiencies for positive and negative ion productions have been investigated using the ion source, and they were found to be about 1 %, and 0.1 % for the positive and negative ion productions, respectively.[1]

In the present design of the source the ion source samples are loaded in the form of powder. The material is suspended by the gravity, and there is an in homogeneity of the ion emission in the vertical direction. Also, to reduce the electron current flow associated with the negative ion extraction, a transverse magnetic field is applied. This field should cause a bending of the produced negative ion beam in the horizontal plane perpendicular to the beam. The spatial distribution of the beam has been investigated and the result showed a satisfactory focusing of the beam as shown in Fig. 2.

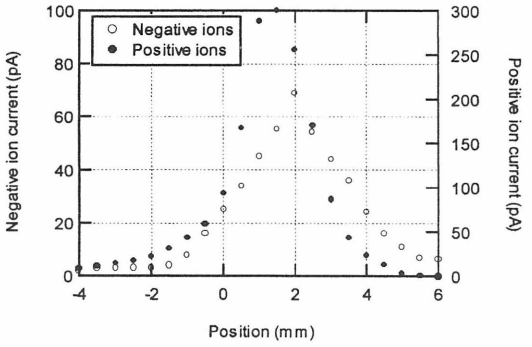

Fig. 2. Horizontal beam profile of the O^- ion beam extracted from the BaO powdery sample ion source.

The application of surface chemical reactions by thermal processes is also investigated, as shown in Fig. 3. The thermodynamic model of the thermal negative ion production has been studied for various species,[3] and can be applied to enhance the negative ion yield by properly choosing the combination of the substrate and the sample. Results from these researches to clarify the fundamental processes governing the negative ion formation at surfaces are applied to realize an efficient negative ion beam system.

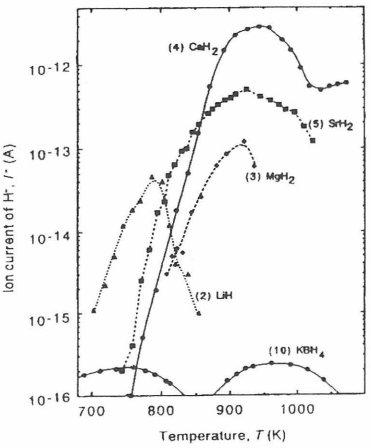

Fig. 3. Negative ion current produced from alkaline-earth hydrides by thermal process.

References

1) M. Wada, T. Kasuya, M. Sasao, and H. Kawano, "*Proceedings of the Ion Implantation Technology-98*", I. Yamada, ed., IEEE, (1999) 334.
2) M. Wada, T. Kasuya, M. Sasao, and H. Kawano, Rev. Sci. Instrum., **71** (2000) 719.
3) H. Kawano, M. Wada, M. Sasao et al., Rev. Sci. Instrum., **71**, (2000) 853.