STUDY OF POTENTIAL APPLICATION OF COMPACT ECRIS TO ANALYTICAL SYSTEM

MOPOT03

Masanori KIDERA*, Kazuya TAKAHASHI, RIKEN, Wako, Saitama 351-0198, JAPAN
Yasuo SETO, Shintaro KISHI, NRIPS, Kashiwa, Chiba 227-0882, JAPAN
Shuuichi ENOMOTO, Okayama Univ., Kita-ku, Okayama 700-8530, JAPAN
Tsuyoshi NAGAMATSU, Tatsuhiko TANAKA, Tokyo Univ. of Science, Shinjyuku-ku, Tokyo 162-8601, JAPAN

Abstract

The objective of this study is to develop a desktop-sized system of element mass analysis (element analysis system) with a compact ECR ion source in the ionization section. This system is different from other element analysis systems in terms of the effective use of ionization by ECR plasma. A compact ECR ion source is required to fit in the desktop-sized element analysis system.

This poster reports the development of the compact ECR ion source.

1. FUNDAMENTAL CONSIDERATIONS IN FABRICATION OF COMPACT ECRIS

Advantage of ionization by ECR Plasma in mass analysis

Ionization by using ECR plasma is done under high vacuum in plasma chamber. No molecular ions are generated by the collision of radical ions.

Ion temperature is low, mass resolution is good.

Numerous techniques have been developed to stably ionize gas and solid samples.

Fundamental consideration in fabrication of compact ECRIS

An intense ion beam is not required, because the high-sensitivity channeltron detectors cannot receive intense ion beams.

Charge number of the ions generated is optimaized to 1+ and 2+

The stability of plasma is closely related to the accuracy of the measurement results

A confinement magnetic field has to be generated using permanent magnets if compact size and low-power consumption are the criteria for the source

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A large magnetic field, however, cannot be generated with small permanent magnets

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Therefore, too high microwave frequency cannot be used

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On the other hand, when low frequency is used, the miniaturization of the ECR ion source becomes difficult. Because the inner diameter of magnet (i.e., plasma chamber diameter) cannot be small by the ploblem of the cutoff frequency.

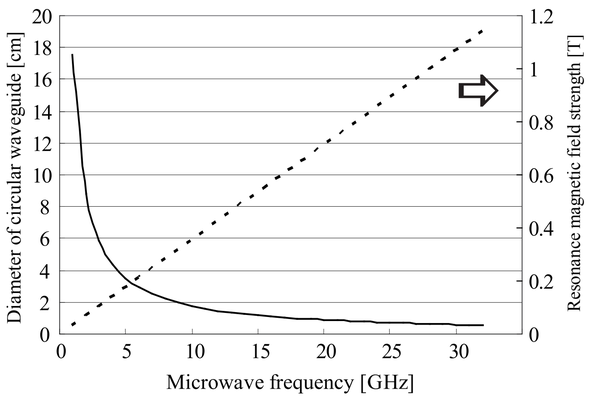

Figure 1.
Microwave frequency vs. lower limit diameter of circular waveguide in TE11 mode and resonance magnetic field strength.
The solid line indicates the diameter and the dashed line indicates the magnetic field strength.

2. FABRICATION OF PERMANENT MAGNET

The permanent magnet for the compact ECR ion source was manufactured by Hitachi Metals, Ltd.

Figure 2.
Photograph of permanent magnet for compact ECR ion source.

Table 1. Main specifications of the Magnet

Mirror magnet	
Maximum field strength	
Injection side	0.38 T
Extraction side	0.33 T
Minimum field strength	0.16 T
Hexapole magnet	
Maximum field strength	0.58 T
SIze	
Outer diameter	100 mm
Inner diameter	45 mm
Length	150 mm
Weight	7 kg

Microwave freqency and power

A solid-state-type microwave amplifier operating at a frequency of 5.76 GHz with an output power of about 100 W is used.

Figure 3.
Distribution of mirror magnetic field strength. The region from 0 mm to 150 mm is inside the magnet.

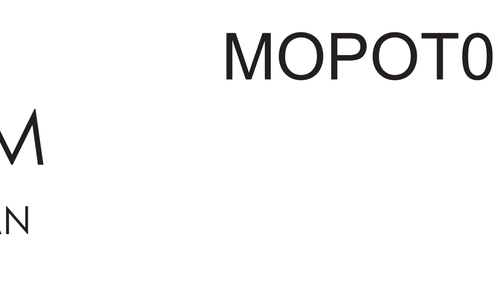

Figure 4.
Distribution of magnetic field strength of hexapole magnet. The region from the center of the magnet to its inner surface is shown.

Figure 5.
Cut model of 3D image of compact ECRIS

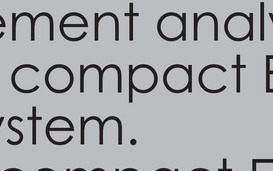

Figure 6.
Extraction electrode and Einzel lens

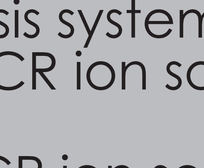

Figure 7.
XY deflector electrode

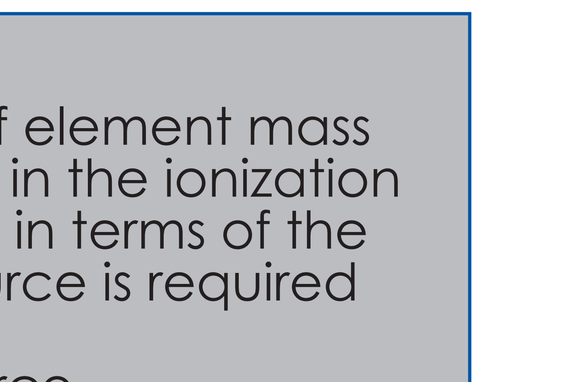

Figure 8.
Photograph of test setting of miniECRIS-MS

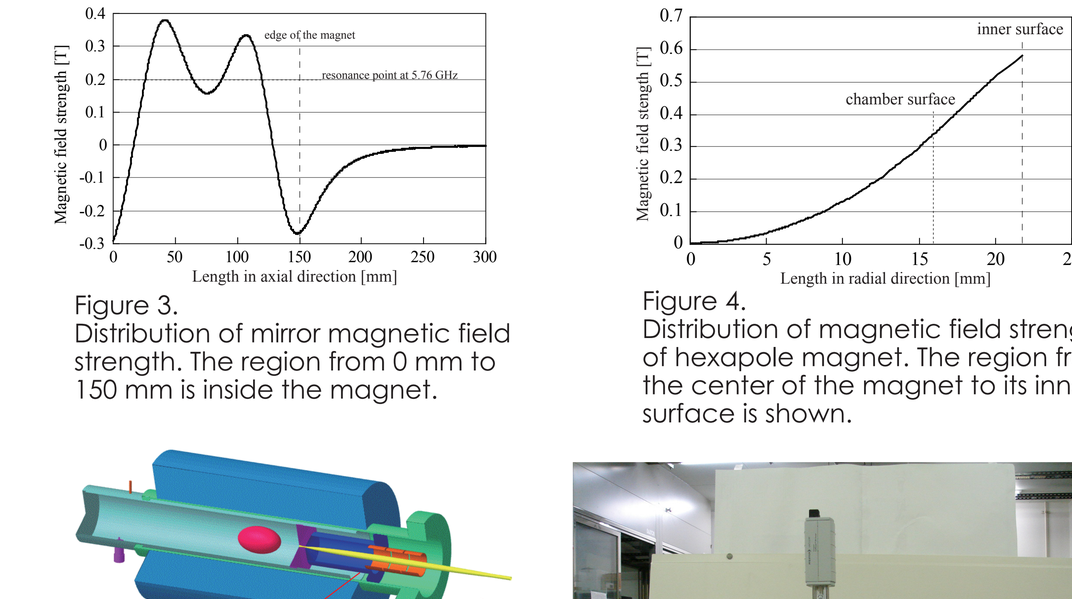

Figure 9.
3D image of desktop-sized element mass analysis system with the compact ECR ion source in the ionization section. Volume of out frame line is about 100 L.

3. SUMMARY AND FUTURE STUDIES

Summary

A desktop-sized element mass analysis system with a compact ECR ion source in the ionization section has been developed. The conditions for the compact ECR ion source to be installed in the desktop-sized element mass analysis system were determined, and the permanent magnet for the compact ECR ion source was fabricated considering these conditions.

Future studies

We plan to use this system for the high-sensitivity detection of contaminants (especially, specific elements in chemical warfare agents) in the atmosphere.

Most mass analysis techniques involve sample preparation processes, the use of expendable supplies, and setting up of a sample holder etc. for the introduction of the sample.
In contrast, the use of the ECR ion source simplifies the analysis by facilitating the direct sampling of air, generation of ECR plasma in air, and ionization of the elements in air. Therefore, this system is effective for the automatic long-term monitoring of environmental conditions.

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* kidera@kindex.riken.jp