PRERIMINARY OPERATION RESULTS OF JAERI ECR ION SOURCE OCTOPUS

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ABSTRACT

An ECR ion source, new OCTOPUS, was built for and AVF cyclotron of the Japan Atomic Energy Research Institute, Takasaki. The design of this source is almost identical to the first built OCTOPUS, except for the RF frequency for the 2nd stage. The first operation of the new OCTOPUS was performed. High intensity of X-ray leakage was measured outside the lead shield wall of the source.

INTRODUCTION

The first OCTOPUS source was constructed in 1985 at the Centre de Recherches du Cyclotron in Louvain-la-Neuve (Belgium)[1]. Its performance has been improved through some modifications such as reduction of octupole bore diameter and change of the 2nd stage RF feed from radial to axial feed, etc.[2].

As an external ion source of the AVF cyclotron, the new OCTOPUS is installed in coming spring at the Takasaki Radiation Chemistry Research Establishment of the Japan Atomic Energy Research Institute (JAERI)[3]. The basic design of the source is almost identical to the first OCTOPUS and was built from January to March this year, and ion production tests and X-ray measurement were followed for two months at Ion Beam Applications s.a. (IBA) in Louvain-la-Neuve. The design of the source, and results of the first operation and the X-ray measurement are described.

DESIGN OF THE NEW OCTOPUS

The characteristics of the new OCTOPUS is summarized in Table 1. The main differences in the parameters from the first OCTOPUS are:

[1] RF frequency for the 2nd stage (8.5 GHz for the first OCTOPUS).

[2] Type of vacuum pumps (diffusion pumps for the first OCTOPUS).

The pumping speeds are similar for both sources. It was found that the 1st and the 2nd stage pressures are quite close in both sources for typical source tuning, while the extraction stage pressure is lower for the new OCTOPUS by factor 3.

It provides three identical systems of gas feed and flow control, allowing independent operation. One feeds main gas into the 2nd stage, the other two feed support gases into the 1st and the 2nd stages. A low temperature oven is prepared for ion production of metal elements and is set in the 2nd stage cavity.

Table 1
Characteristics of the new OCTOPUS.

<u>1st stage</u>	
ECR frequency	14.3 GHz
RF power: maximum	2 kW
..... : typical	80-200 W
<u>2nd stage</u>	
length between mirrors	60 cm
cavity diameter	18 cm
type of multipole	octupole (SmCo)
ECR frequency	6.4 GHz
ECR field	0.2291 T
RF power: maximum	3 kW
. : typical	0.6-1.5 kW
RF feed	axial
<u>vacuum pump</u>	turbomolecular
typical pressure in operation	
1st stage	$1.0\text{-}2.0 \times 10^{-3}$ Pa
2nd stage	$0.7\text{-}1.0 \times 10^{-4}$ Pa
extraction stage	$1.0\text{-}3.0 \times 10^{-5}$ Pa

The operating parameters for ion production are current of four mirror coils, RF power of the cavities, gas flow rate, oven temperature, extraction voltage, puller voltage and puller position. Though we operated them manually this time, they are controlled through a computer network system of the AVF cyclotron.

RESULTS OF ION PRODUCTION TEST

Several ions are generated for He, C, N, O, Ne, Ar, Kr and Xe. Three days for tuning are devoted to O^{6+}, Ar^{8+}, Ar^{13+} and Kr^{20+}, while two hours to the other charge states and/or species. Therefore, the obtained beam currents are not for the best tuning. The generation tests was done with an extraction voltage of 10 kV, a full width of 20 mm for slit opening and with an acceptance of 400 π mm mrad, for the analyzing magnet system.

It was observed in generation of some highly charged ions that beam current fluctuated by a few tens percents with period up to several seconds, though the long term stability was good. The maximum beam currents obtained in the above mentioned terms are listed in Table 2. They are sufficient for acceleration with the AVF cyclotron and for the experiments in plan. The results shows that the new design enhances the currents at lower charge states, but reduces them at higher charge states in comparison with the first OCTOPUS. This tendency could be due to a lower RF frequency of the new OCTOPUS, but any clear conclusion can not be drawn by the present data.

MEASUREMENT OF X-RAY LEAKAGE FROM OCTOPUS

We measured energy spectrum and dose rate of X-ray leakage outside the source for the design of radiation shielding, using a NaI scintillation counter and an ionization counter. The NaI scintillation counter was set 5 m off the back of the 2nd stage cavity, for the sake of adequate counting rate. The maximum energy of the observed spectrum is about 900 keV with an RF power of 1.2 kW for the 2nd

Table 2
Maximum beam currents for preliminary operation (in eμA).

species	He	C	N	O	Ne	Ar	Kr	Xe
main gas	He	CO_2	N_2	O_2	Ne	Ar	Kr	Xe
support gas	O_2	He	He	He	N_2	O_2	O_2	O_2
charge state								
1		83	170	370	140			
2	220	121	128	300	147			
3		70	140	190	136	113		
4		50	97		92	102		
5		7	93	116				
6			18	120	58	78		
7				10	20	95		4
8					10	155	35	10
9						85	44	17
10							47	19
11						13	38	18
12						4		19
13						1	31	19
14						0.2		18
15							21	17
16								17
17							17	13
18								12
19							3	10
20							1	8
21								4.8
22								3.5
23								1.5

Table 3
Measured result of X-ray dose rates.

2 nd stage RF power (W)	200		400		600	800	1000
dose rate (mrem/h)	10	60	60	900	100	160	260
shield door	close	open	close	open	close	close	close

The 1st stage RF power is 100 W for all case.

stage. However, the effective energy spectrum of the X-rays required for shielding design could not be evaluated.

The dose rate was measured at points on a side of the source and a few meter off the central axis of the 2nd stage cavity in two cases that a shield door (5cm thick lead) of the source was open and close. Table 3 shows a result obtained at a point 1.5 m away from the cavity. The difference of the measured dose rate is much smaller than that expected from the shielding capability of the door. This suggests that certain amount of radiation comes out through the portions for turbomolecular pumps and reflected at floor. Dose rate, when the shield door is close, is proportional to square of RF power for the 2nd stage.

SUMMARY

The first operation of the new OCTOPUS ion source for the JAERI AVF cyclotron has been successfully performed. A rigid shield for X-rays is necessary for continuous operation near around the source. Further operation will be continued in Japan and is expected to improve performance of ion production.

REFERENCES

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