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Dual ARC Chamber Heavy Ion Source — Source link

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DUAL-ARC-CHAMBER HEAVY-ION SOURCE

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Summary

A dual-arc-chamber heavy-ion source has been installed on ORIC. This source has exhibited a substantial improvement in performance for beams below mass 20. A 42-μA beam of $^{16}O^{5+}$ was extracted from ORIC using the dual-arc-chamber source, and a 2.5-μA beam of $^{20}Ne^{5+}$ was obtained 1.5 minutes after turning on the arc voltage.

Introduction

The internal heavy ion sources for cyclotrons such as ORIC are usually of the Penning cold cathode type.[1,2] The maximum charge obtained from these sources, at intensities sufficient for useful experiments, is limited partly by how low the arc chamber pressure can be maintained while maintaining sufficient ion bombardment of the cathode to sustain an arc discharge. Previously, a heavy support gas[3,4] such as krypton or xenon had been very successful in improving performance of the ORIC ion source, Fig. 1, by increasing the intensity of the higher charge states for ion masses of 20 or less.

An auxiliary arc chamber has now been added to the ORIC ion source in an effort to further improve the source performance.

Description of the Source

An auxiliary arc chamber was added to the ORIC cold cathode Penning ion source, Fig. 2. This chamber was separated from the main arc chamber by a 0.5-mm-wall tantalum sleeve that formed the liner of the auxiliary arc chamber, Figs. 3, 4 and 5. Support gas was supplied directly to the auxiliary arc chamber instead of the main chamber as is done with the regular ORIC ion source. The only connections between the two arc chambers are at the ends next to the cathodes.

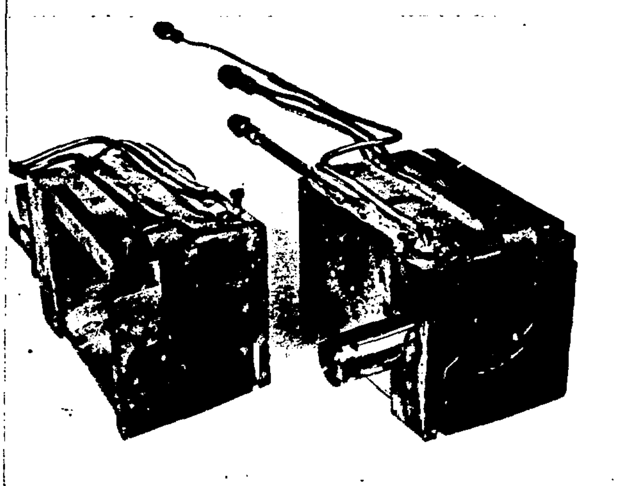

Fig. 1. ORIC Heavy Ion Source with one side of the cathode housing separated from the arc chamber to expose the 7.9 mm-diameter plasma region.

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The dimple in the cathode formed by the auxiliary arc is visible adjacent to the dimple formed by the main arc, Figs. 6 and 7.

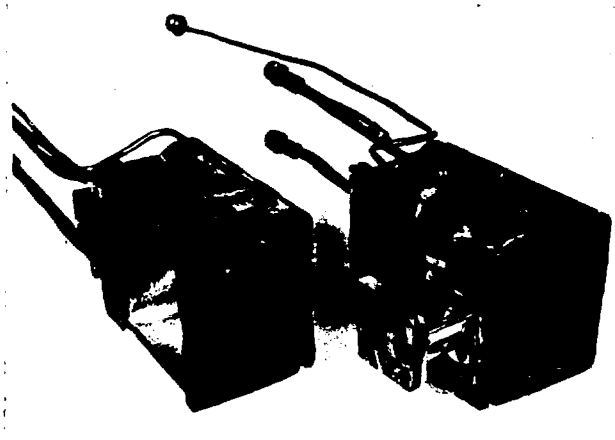

Fig. 2. Dual arc chamber heavy ion source.

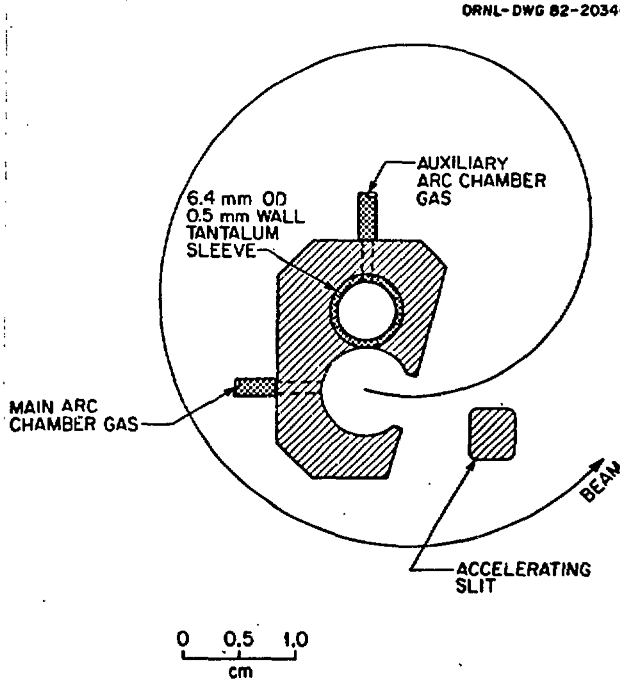

Fig. 3. Median plane cross section of the dual arc chamber source showing the 0.5-mm-wall tantalum sleeve separating the 5.3-mm-diameter auxiliary arc chamber from the 7.9-mm-diameter main chamber.

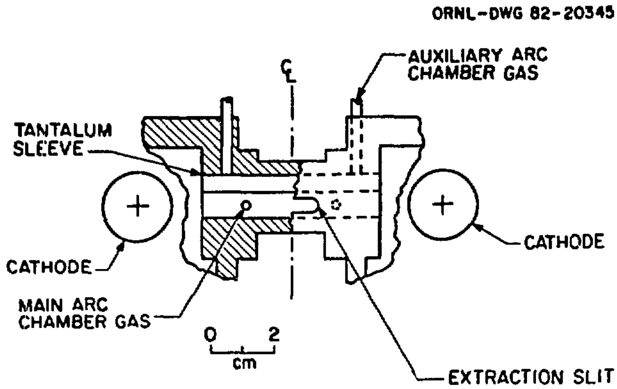

Fig. 4. Front view of the dual arc chamber source with a section removed to show the gas entry port to the main arc chamber and the cathode position in relation to the main and auxiliary arc chambers.

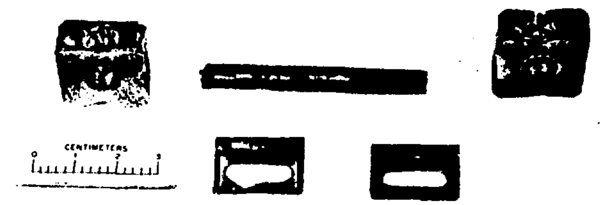

Fig. 6. A pair of square tantalum cathodes along with the auxiliary arc chamber tantalum sleeve and a new and used extraction slit are shown. Note the small dimple formed by the auxiliary arc beside the large dimple formed by the main arc.

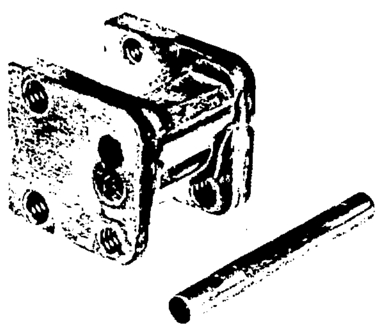

Fig. 5. The dual arc chamber unit including the tantalum extraction slit is shown before being mounted on the source heads. The 5.3-mm-bore, 0.5-mm-wall tantalum sleeve has been removed to show the gas supply holes for the auxiliary arc chamber.

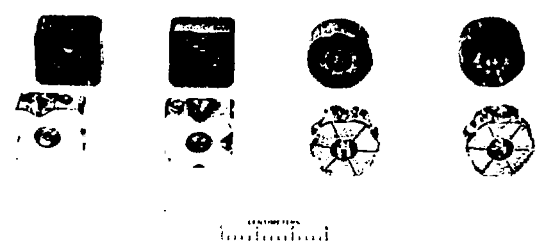

Fig. 7. Both square and round cathodes were used during the tests with comparable operating characteristics.

Justification for a Dual Arc

The function of the auxiliary arc chamber at this time is somewhat speculative due to the limited test data on the source. It was thought of as a means of controlling the cathode temperature without changing the pressure in the main chamber. Actually, it was assumed that the arc pressure could be reduced by separating the support gas from the main arc chamber and thus provide a more favorable condition for the production of higher charge state ions. It was also expected that if the support gas could be restricted from the main chamber the formation of copious quantities of copper ions due to back bombardment[5] of the source chamber would be reduced and hence reduce the dilution of the desired ions by the copper ions.

Test Results

When krypton gas was supplied in a sufficient quantity to the auxiliary arc chamber, an arc formed in the main chamber as well as in the auxiliary chamber. This indicates that there is leakage at the ends between the arc chambers. A test was made using neon gas in the main chamber and krypton gas in the auxiliary chamber. The cyclotron was set to accelerate $^{20}Ne^{5+}$ on the first harmonic and Kr^{7+} in the third harmonic. Beam output was measured while krypton gas was supplied to the auxiliary chamber and neon gas to the main chamber. The $^{84}Kr^{7+}$ output was compared with the results obtained with krypton gas being supplied as a support gas to the main chamber. Also, a measure of the production of $^{63}Cu^{5+}$ for the two modes of operation gives an indirect indication of the krypton leakage into the main arc chamber. Although the results of these tests are incomplete due to the limited time available for the measurements, it was determined that the copper and krypton beams were present with sufficient intensity for making useful measurements by adjusting only the main magnet current and the deflector voltage.

One of the first beams developed using the dual arc chamber was $^{12}C^{5+}$ with krypton gas in the auxiliary chamber. The 350 nA beam observed was about a factor of two larger than observed previously with the standard ion source. Formerly, at times, even a few nanoamperes of carbon 5+ could not be extracted from ORIC. This source thus appears to offer a substantial improvement over the regular ion source for this beam.

The source has performed exceedingly well for $^{16}O^{5+}$ beams. Up to 42 μA of $^{16}O^{5+}$ were obtained and 10 to 40 μA were extracted from ORIC over a period of about one day for one experiment. The time between cathode changes was similar to that for the single arc chamber source.

When $^{20}Ne^{5+}$ was being accelerated for one experiment it was observed that microampere-level beams were being extracted very quickly after a source change. Following a source change, the required 2.5 μA intensity was obtained 1.5 minutes after turning on the arc voltage; 30 minutes to one hour is usually required to reach this intensity. Similar results were observed after other source changes. In all the tests krypton gas was supplied to the auxiliary arc chamber.

Conclusion

The source has every indication of being more stable and having the capability of producing larger beam currents of the higher charge state ions for masses up to 20. It has been demonstrated that two arcs can be operated in parallel and that one of the arcs can be used to influence the output of the other arc (probably by influencing the temperature of the common cathodes). It has been suggested that to some degree the positive results may be due directly to the placement of the support gas where it interacts with the cathodes before it reaches the extraction region of the main arc chamber. Further tests are planned to determine if the dominating characteristics of the dual arc chamber source are due to the cathode temperature control, or to the placement of the support gas, or some as yet undetermined factor.

Acknowledgements

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