Zeitschrift: Helvetica Physica Acta
Band: 59 (1986)
Heft: 4

Artikel: A magnetic quartz capillary proton source
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DOI: https://doi.org/10.5169/seals-115726

Helvetica Physica Acta
Vol. 59, 1986 632-635

018-0238/86/040632-04$1.50+0.20/0

A MAGNETIC QUARTZ CAPILLARY PROTON SOURCE

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ABSTRACT

A high intensity Lamb shift source developed in the tandem laboratory of Kyushu University is equipped with a special type of primary H^+ ion source, which uses a quartz capillary arc discharge. This source can give proton currents of several tens to 100 mA with a very high proton percentage of 95 %.

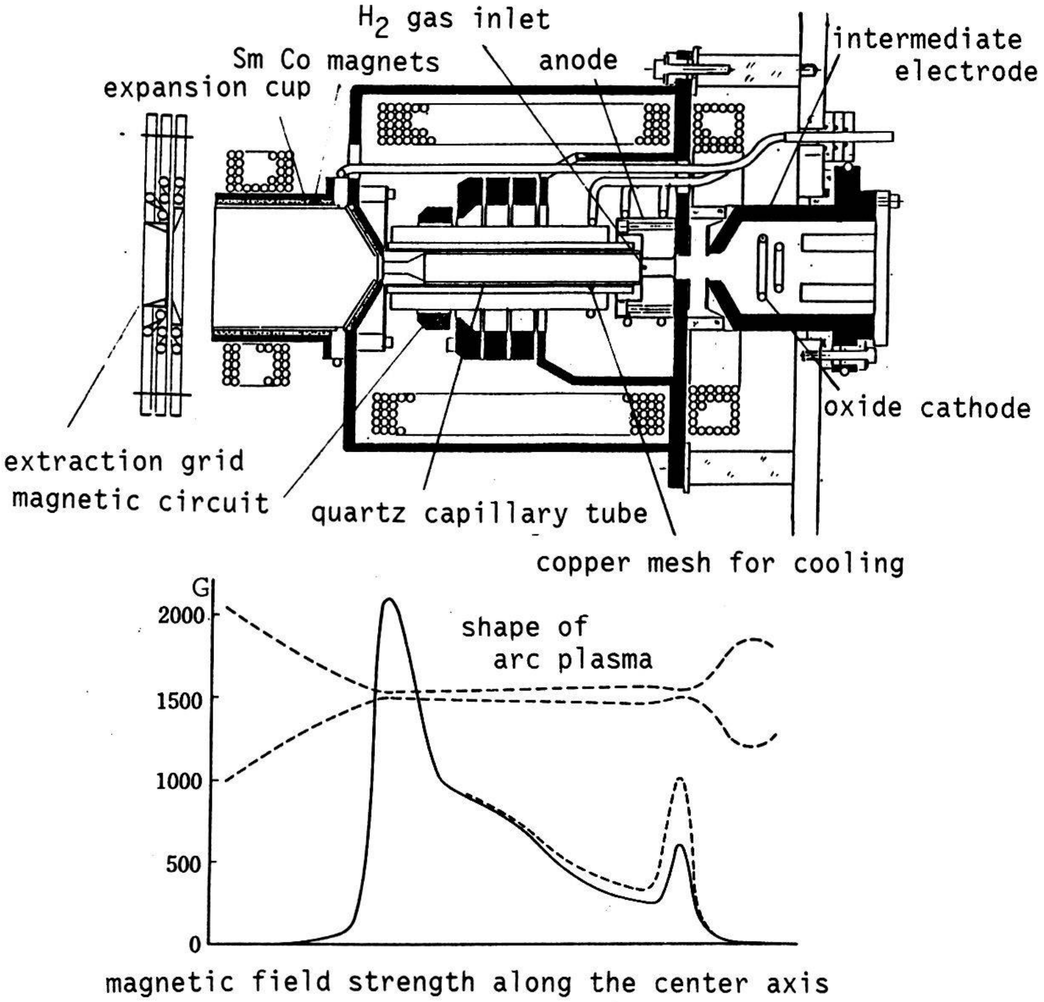

Fig. 1 Magnetic quartz capillary proton source

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A magnetic quartz capillary ion source has been originally developed as an efficient terminal proton source for the Van de Graaff accelerator by the present author. 1) Utilizing a low voltage arc discharge through a quartz tube, proton beams of a fairly high proton percentage could be obtained. After thirty years this type of proton source found a most suitable application in the Lamb shift source. In this case the output current of the source was increased by a factor of two orders with much higher operating power, and the proton percentage close to 100 % could be obtained. 2)

Fig. 1 shows the construction of this ion source with some changes of design to be suited to a high intensity Lamb shift source.

Performance of this type of proton source is shown in Fig. 2 and 3, which are obtained by a present source used at the Kyushu University tandem laboratory. Adjustment of distribution of the magnetic field strength along the source axis is very critical for getting a proper operation, but once a good form of distribution is attained a stable operation can be held constantly. The high proton percentage of this type of ion source is owing to a fact that hydrogen gas in the quartz tube is highly dissociated by electron bombardment. This situation can be proved by the emission of deep red light from the end portion of the quartz tube.

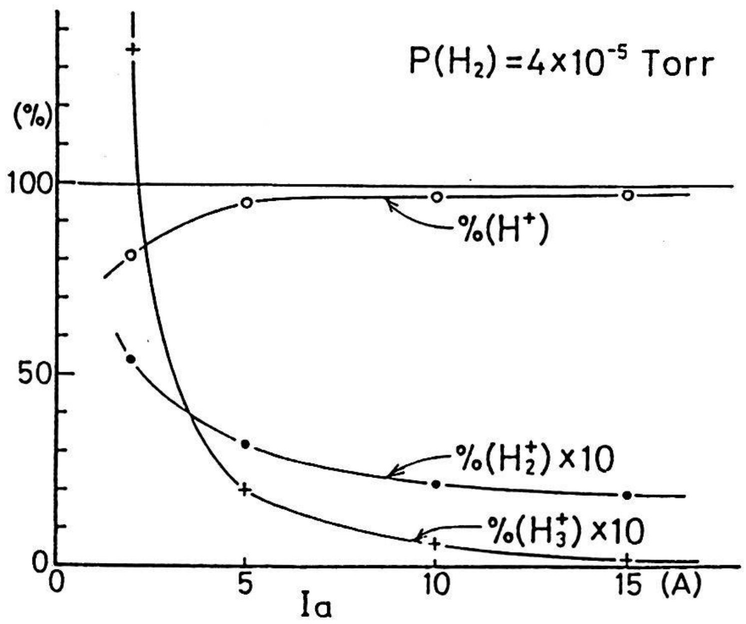

Fig. 2 Percentage of H^+, H_2^+ and H_3^+ ions in the extracted ion beam as a function of the anode current.

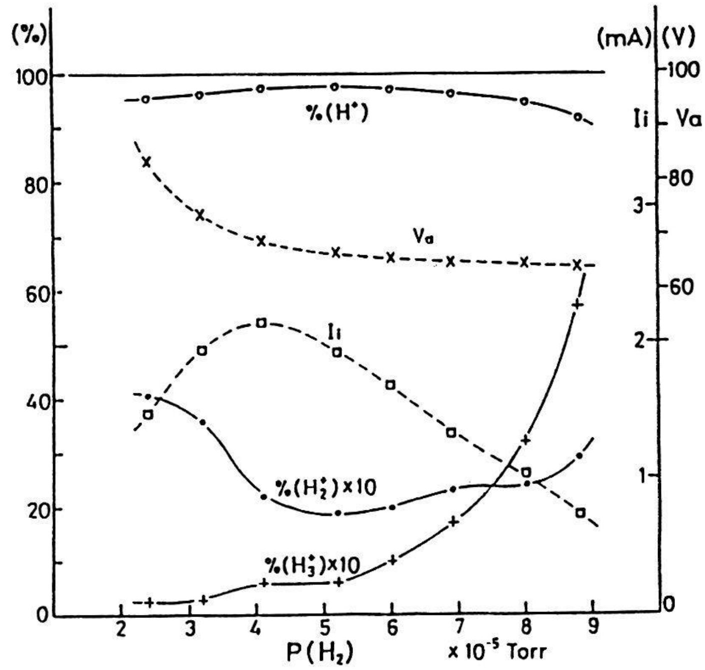

Fig.3 Percentage of H^+, H_2^+ and H_3^+ ions in the extracted ion beam as a function of the hydrogen gas flow rate and the corresponding changes of the anode voltage and the ion beam current observed at long distance.

The mode of discharge in this ion source is very similar to that of a duoPIGatron. Higher output ion currents can be obtained when the PIG mode of discharge is promoted in the expansion cup with higher voltage and higher gas pressure in the expansion cup. But this operating condition is not useful for the present purpose since the proton percentage of the extracted ion current decreases as the ionization of residual gas in the expansion cup takes an important part (Fig. 4).

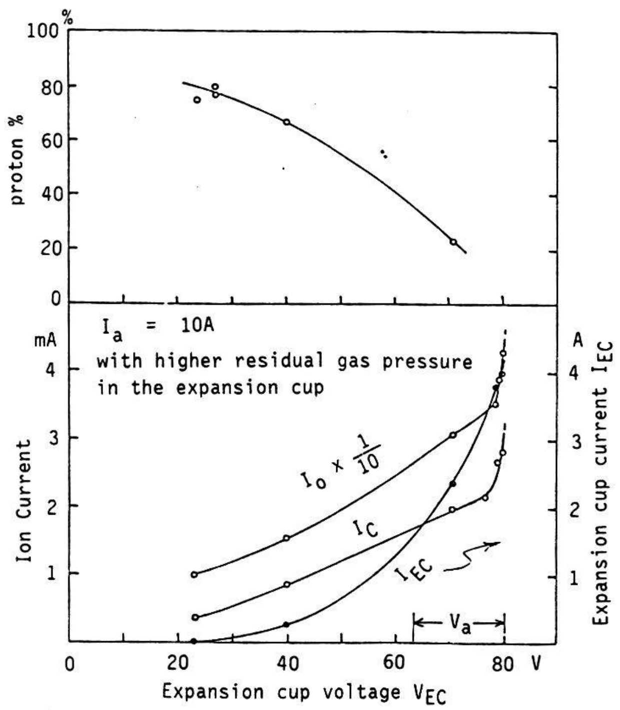

Fig.4 Output ion current intensity and proton percentage as a function of the expansion cup voltage V_{EC}. The measurement was made with a higher residual gas pressure in the expansion cup region which is attained by putting a cover plate around the cup for the friction of gas flow. Data were taken with the same anode current (10A) and a constant hydrogen gas flow. I_{EC} is the electron current to the expansion cup. I_o and I_C are the total extracted ion current and the ion current to the beam catcher, respectively.

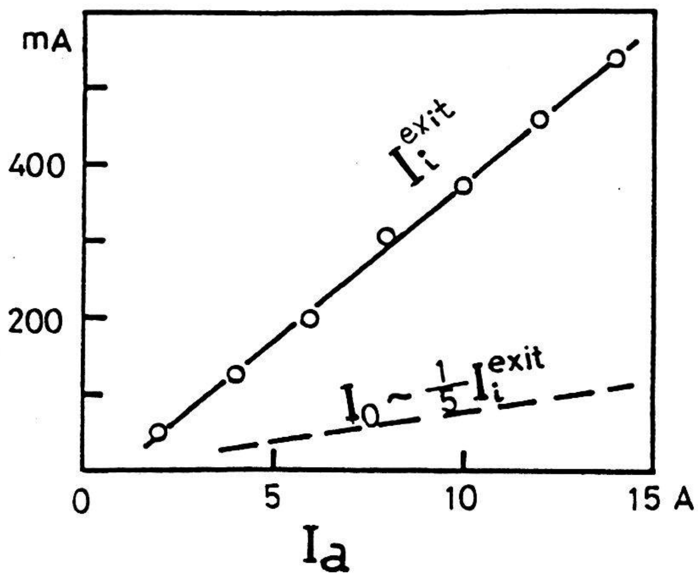

Fig.5 The ion current I_i^{exit} obtained from the exit canal at the end of the quartz capillary tube as a function of the anode current Ia. It is shown that I_i^{exit} is about 4% of the Ia. The ion current Io obtainable from the extraction grid is about 20% of the I_i^{exit}.

Output ion currents of this source can be very large (Fig. 5), and a high degree of gas ionization efficiency is attained (30%).

Ion current from the exit canal of the quartz tube is distributed uniformly over a wide extraction grid surface, being guided by an abruptly expanding magnetic field.

One of the difficulties of this type of ion source is that the proton percentage is degraded by the contamination of the quartz tube. It was possible to avoid contamination nearly completely in some case and proton percentage more than 90% could be maintained for a long time, but this situation was not always possible. Contaminations seem to come from sputtering of metal parts in the discharge region, mostly oxide-cathode materials. When deuterium gas is used, the contamination becomes worse. The way for eliminating the contamination is a point which needs a further investigation.

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