MULTIPLE-CANAL DUOPLASMATRON ION SOURCE*

A. Takagi, K. Ito and S. Fukumoto

National Laboratory for High Energy Physics

High current ion sources have been developed for high energy accelerators and thermonuclear fusion devices.[1,2] To produce spatially uniform density distribution over the extraction area, some attemps are made in many laboratories. Duoplasmatron ion sources with a relatively large plasma expansion cup, which is widely used for high energy accelerators, have the non-uniformity of the plasma density at the extraction surface,[1] and this inhomogeneity is perhaps caused by a stray magnetic field in the cup and a point source of the plasma jet.[3]

In order to obtain the homogeneous distribution at the exit of the large plasma cup with the high gas efficiency, a multiple-canal duoplasmatron is developed. Fig.1 shows 7 holes array of plasma protrusion apertures and a large plasma cup. Plasmas which are delivered from 7 anode holes, are mixed in the plasma cup to achieve uniform distribution. The ion is extracted by means of a single aperture extraction system. An anode with hole diameter A = 0.6 mm is used with an intermediate electrode of canal diameter B = 2.0 mm in a preliminary test so that same gas consumption is realized for a given ion source pressre as an ordinary KEK duoplasmatron. Its cup exit diameter is 28 mm.

The beam intensity and emittance are measured by a Farady cage and slit images on an Aℓ-coated quartz plate. Beam of up to 1A are successfully extracted and a typical waveform of the beam pulse is shown in Fig.2. High arc current of 100 A is easily provided with an oxide coated nicket mesh filament. Beam intensities are measured at extractor voltage V_{ext} = 50 kV and 30 kV with extractor-cup exit distance L_{ext} = 15 mm or 20 mm. Fig.3 shows the intensities of the extracted ions as a function of the ion source magnet current. No saturation of the beam intensity is observed. The limitation of the beam intensity results from spread beam striking an aperture edge of the extractor.

Fig.4 shows emittance diagrams of the multiple-canal duoplasmatron ion source at V_{ext} = 30 kV and 50 kV. Both emittances are nearly same. They are about 0.24-0.26 π cm mrad (normalized) which is not worse than that of the ordinary duoplasmatron. The multiple-canal duoplasmatron was tested in KEK preinjector for short time during the shut down of the synchrotron. Beam were accelerated up to 750 keV. Fig.5 shows a emittance/profile display which is measured by emittance monitor with a multiple segment detector in the 750 keV beam transport line. The emittance of 750 keV beam from multi-canal duoplasmatron about two times bigger than that of the ordinary duoplasmatron.

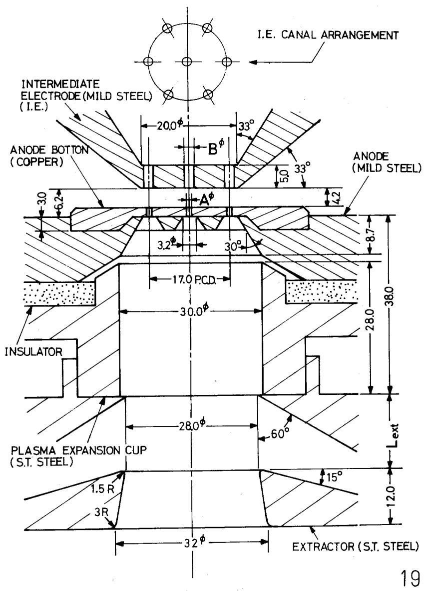

Fig.1 Detail of the multiple-canal system and a plasma expansion cup.

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The result seems promissing for the multiple-canal structure as a high intensity ion source of high energy accelerators. Further measurements are now being carried out to establish ion source parameters.

References

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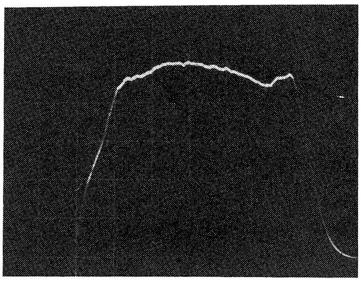

Fig.2 Waveform of a 1000 mA beam pulse
5 μs/div.
200 mA/div.

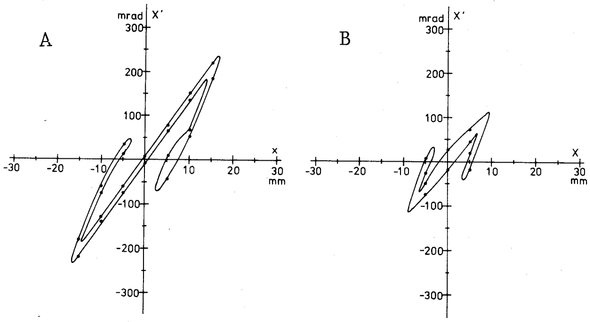

Fig.4 Emittance diagram of 500 mA beams,
A : V_{ext}= 30 kV, B : V_{ext}= 50 kV.

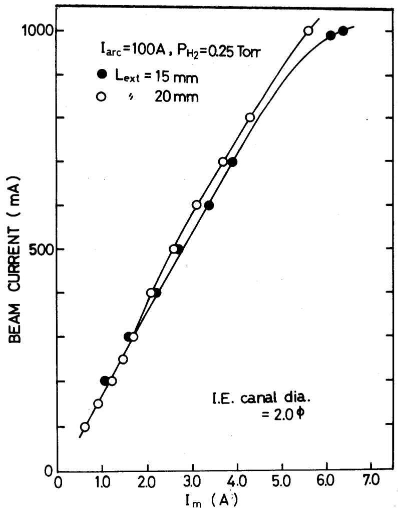

Fig.3 extracted beam current vs. ion source magnet current, (V_{ext}= 50 kV).

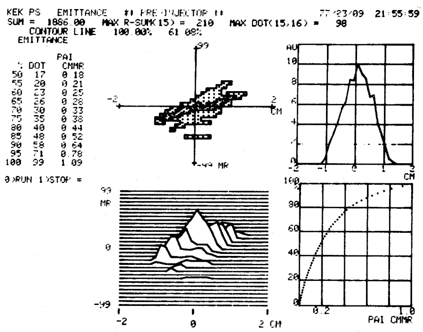

Fig.5 Emittance/Profile display of 230 mA/750 keV beam, (ion source output = 520 mA).