BEAM, MULTI-BEAM AND BROAD BEAM PRODUCTION WITH COMIC DEVICES*

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Abstract

The COMIC discharge cavity is a very versatile technology. We will present new results and devices that match new applications like: molecular beams, ultra compact beam line for detectors calibrations, quartz source for on-line application, high voltage platform source, sputtering /assistance broad beams and finally, a quite new use, high energy multi-beam production for surface material modifications.

In more details, we will show that the tiny discharge of COMIC can mainly produce molecular ions (H_3^+). We will present the preliminary operation of the fully quartz ISOLDE COMIC version, in collaboration with IPN-Lyon, we will present a first approach for a slit extraction version of a three cavity device, and after discussing about various extraction systems on the multi discharge device (41 cavities) we will show the low energy broad beam (2 KV) and high energy multi-beams (10 beams up to 30 KV) productions.

We will specially present the different extraction systems adapted to each application and the beams characteristics which are strongly dependent on the voltage distribution of an accel-accel two electrodes extraction system.

THE COMIC PRINCIPLE

The basic principle of the COMIC (COmpact MIcroonde & Coaxial) discharge have been previously presented [1]. This principle is a very basic and low power way of plasma generation and we will present here the different discharge customization ways for beam, broad beam of multi-beam generation. The plasma is ignited between a quarter wave antenna and grounded couplers where the over voltage can reach the Paschen's conditions (Fig.1). This discharge is magnetized by a small gradient of a magnetic field that reach ECR conditions at the level of this over voltage. The weak generated plasma (roughly 5eV and 5 10^{10} cm^{-3}, measured after 5 mm of diffusion outside the cavity) is very suitable for molecular and monocharged ion production .The very small confinement time allows the creation of non negligible current densities in the range of 0.1 to 10 mA/cm^2. The consequence of these compromises is the use of relatively high gas flux by respect to a high confinement ECR source.

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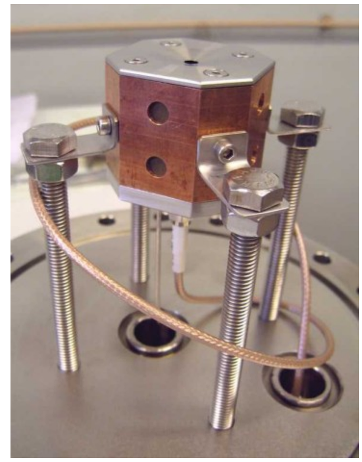

Figure 1: The elementary COMIC discharge.

We can see (Fig.2) an optimization for the production of H_3^+ molecular ions (15 µAe with 1 mm extraction hole). Due the poor pumping of hydrogen we have observe the breaking of the 20 KV H_3^+ in two peaces : H_2^+ at 13.6 and H^+ at 6.8 KV and also H^+ at 10 KV coming from 20 KV H_2^+. The production of high currents of hydrogen could be done only with a strong pumping dedicated to hydrogen.

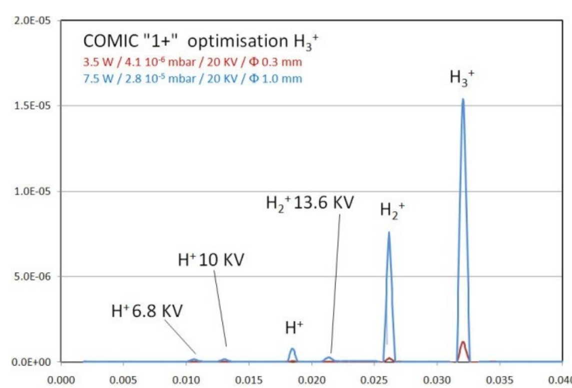

Figure 2: H_3^+ optimisation with partial energy beams generated by gas interaction of H_3^+ and H_2^+.

MONOBEAM / MONOCAVITY DEVICES

Due to the small size and low power operation, it is easy to match a COMIC source to compact devices.

A first one, now under assembly, is a moveable beam line for detectors calibrations. The purpose here is to deliver very low ion and electron currents (down to some p/s) but with a high reliability. Inside a compact line (50 cm in length and 16 cm in diameter) it would be possible to focus or defocus the beam, with or without ion selectivity (Fig.3) for energy up to 50 KV. A Wien filter module can be placed in front of the source in order to get ionic selectivity up to the mass 20.

A second device is the so-called Q-COMIC, developed for ISOLDE/CERN that is a special version including a fully quartz gas and plasma chamber for ionisation of radioactive gas (Fig.4). The current and functioning point are very close to the COMIC one but here all the wall of the plasma chamber are quartz recovered from the gas injection to the current extraction [2].

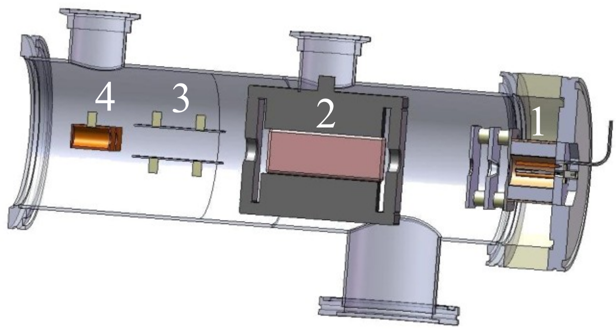

Figure 3: Moveable mini beam line for the MIMAC detector (1 - source, 2 Wien filter (or H deflector) -, 3 – V deflector, 4 – Faraday cup)

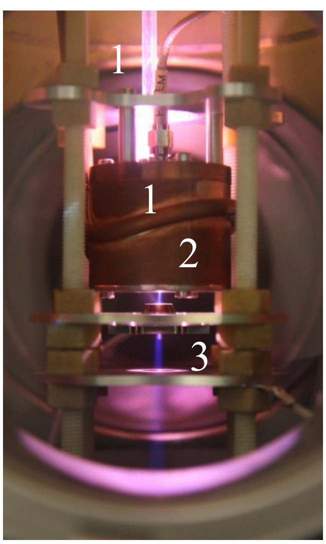

Figure 4: Q-Comic with quartz plasma chamber (1 - quartz, 2 - source, 3 - beam)

MONOBEAM / MULTICAVITY DEVICES

The principle of the COMIC discharge can be use also to generate slit or broad beams. A first device called T-COMIC (including three discharges) has been built in order to improve the reliability of Xenon beams initially produced with a Bernas ion source on a high voltage platform (Fig. 5). Here the microwave device has been introduced exactly inside the same volume and at the same place that the filament source. The plasma of three cavities feeds a small diffusion gap and after this gap a plasma electrode with a small rectangular slit extracts the beam extract the beam. Preliminary current measurements show a current density similar to a Ø 4 mm extractor (4 mA/cm2) but here produced as a slit beam (2 per 12 mm). The optical qualities of this beam are very similar to the Bernas one, so the possibility of matching the beam to the optical system of the high voltage platform is performed without problems (Fig. 6).

Figure 5: T-COMIC with up to three discharge and plug & play by respect to a filament source.

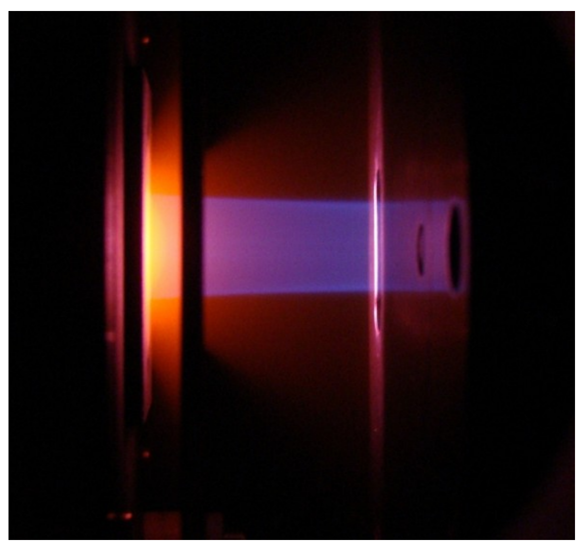

Figure 6: “Slit” beam produced with T-COMIC (1 mA, Ar, 30 KV, 20 W , 2.45 GHz, one cavity excited).

We can see (Fig. 7) the machine called COMIC-Array that is made of 41 cavities distributed over a square of 16 cm per 16 cm. Between each cavity a small magnet magnetizes four adjacent discharge volumes. Therefore, more than 50 % of the surface (41 times Ø 2 cm) can be used as a plasma diffuser so the plasma can be homogenized after some centimetres from the plane of the discharges. This broad beam can be produced by the progressive activation of eight independent cavities and extraction after a diffusion gap of 9 mm like. This very preliminary test already shows that it is possible to build a large beam from the activation of small and well optimized discharges followed by the mixing of the different plasmas produced by each cavity. The beam (Fig. 8) is produced with a gas flux in the 41 cavities of about 1 mbar.l.s-1, but only 8 cavities are activated (only 8 transmitters available at this time) for an extracted current of 22 mAe at 2 KV.

Figure 7: COMIC-array low energy with grid extractor (gap size : 4 mm)

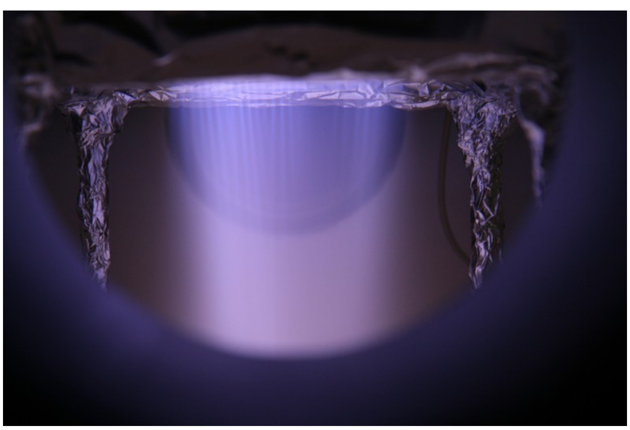

Figure 8: Low energy (2 KV) broad beam produced with COMIC-array (9 per 6 cm / 8 discharges).

MULTIBEAM / MULTICAVITY DEVICES

Such device can also be used at higher voltages (some tens of KV). In this case all the 41 cavities are closed by the plasma electrode so the discharge panel become just a juxtaposition of 41 independent COMIC ion sources (Fig. 9). The extraction system is a simple two gap extractor made of two plates with 13 holes of extraction. We can see (Fig. 10) 10 beams of Xenon produced in parallel. A strong defocus can be obtained just by tuning of the intermediate voltage and thus we can obtain a mixing of the different beams at a distance of some ten centimetres.

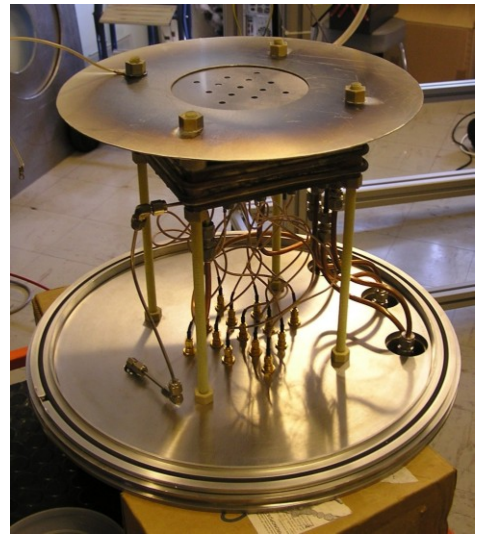

Figure 9: COMIC-array high energy with double gap extractor

Figure 10: 10 beams at 25 KV/ Φ 2mm of Ar (roughly 150 μA per beam) the “target” plate is placed at 10 cm from the extractor.

CONCLUSION

By the use of a small, simple and reliable microwave device it is possible to customize various devices for plasma or ion beam applications. Lot of new other customizations are possible.

REFERENCES

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