ION MICROWAVE SOURCE FOR LINEAR ACCELERATOR

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In the report microwave source with improved characteristics for linear accelerator is described. It is known, that ion microwave sources [1-3] have several advantages in comparison with other types of sources, working in continuous mode. It, the first of all, large full operation time, absence of incandesces elements with short life time, high stability of the characteristics.

From sources, creating beams of circle cross section, one of the most suitable is the source with RF power coaxial feeder and constant magnet [3]. The source provides beam of hydrogen ions with current up to 3 mA. Extraction aperture has diameter 2 mm in this source. Power feeding is small enough and not larger than 30 W. This source satisfies to the requirements to linear accelerator injector, however, it is desirable to receive a greater current of beam.

As a result of the analysis of the technical decisions, contained in known designs, following conclusions about ion source construction were made:

- RF power feeding to discharge chamber should be coaxial for reception of the beam minimum sizes,
- Expediently to make closed magnetic circuit, taking place through discharge chamber and ion extraction system,
- It is necessary to supply transverse components of electrical RF field in the discharge region, belonging close to extract aperture.

Except listed features of designing the new approach to the problem decision of the feeding waveguide and plasma accommodation was applied, which permits to receive the steady accommodation and to concentrate plasma in the ions' extraction area. In known ion microwave sources [1-3] for the plasma and RF- feeding waveguides accommodation the matching units are applied. For example, it can be transformer installed in the waveguuide near ion source input. Waveguide segment between transformer and source entrance is a resonator. As the plasma can widely change its impedance, it is difficult to choose suitable matching transformer, that satisfies resonance condition. The new approach consists in the compensation of plasma reactance inside breakdown region. This reactance is responsible for dismatching of feeding waveguide.

The ion source scheme, realizing given approach, is submitted on fig.1. The discharge region 1 is between two electrodes, one of which is central conductor of coaxial line 2, and other - central conductor of coaxial loop 3 with short connected piston, the electrical length of which can be selected during source setup. Loop entrance impedance is chosen in such way to compensate reactance of plasma pole between electrodes. Ion source magnetic system consists from two solenoids 4, magnetic screen 5 and extracting electrode 6 fabricated from magnetic soft material. It creates longitudinal magnetic field 0.1 T in the RF discharge region. Magnetic flux goes through the discharge region. The elements of the magnetic circuit are shown on fig.1. RF power is fed to discharge area from magnetron generator 7 through the coaxial quarter wave transformer 8, thus the electrical component vector of RF field between electrodes is directed perpendicularly to vector of the constant magnetic field. The ion source contains gas injection system 9 also.

The active impedance of plasma pole should be accommodated with feeder by means of one or several quarters of wave transformers. At magnetic field absence, as show valuations, the active impedance of plasma is very small. At availability of external magnetic field more intensive absorption of RF power by plasma at resonance occurs, consequence that is higher active impedance.

The volt - ampere characteristics' measurement of ion source was executed after beam extraction system geometry choice. In proposed system the ions' extraction was made from plasma border, located in plane of emission hole. Beam formation was executed by Pierce geometry. It was found the geometry, appropriate to the largest current I_i, flowing from the hole in extracting electrode, and minimum current on extracting electrode I_{ee} at extraction chosen working voltage U. On fig.2 the I_i and I_{ee} dependencies on U for chosen geometry, which is represented on the same drawing, are submitted. For given geometry the current on extracting electrode becomes rather small at voltage more than 12 kV. The further growth of extraction voltage does not lead to essential growth of beam current I_i, since current increase at $U < 12$ kV occurs only because of current redistribution between these two components. Extracting current remains constant.

Volt-ampere characteristics were measured at magnetron power 200 - 300 W and gas consumption 15 - 20 cm^3 per hour. Ions beam maximum current in separate modes of operation reaches 10 mA, that corresponds to reasonably high current density 250 - 300 mA/cm^2.

The degree of the plasma accommodation with RF feeder was determined with the help of measuring line, installed between magnetron and ion source, with the help of which VSWR dependence from short circuit loop length was measured. The results of measurements are submitted on fig. 4. It is visible that there is region, where the steady break down takes place. VSWR acquires essentially large significance (at least more than

6). From the other hand, there is region, where discharge is unstable. Minimum achieved VSWR, as it is visible from fig. 3, makes 1.6, that corresponds to power 95 % absorbing in plasma.

The plasma concentration and electronic temperature were measured by cold probe method. Probe characteristics were removed on known techniques, after processing of which plasma concentration and electronic temperature were received. Its values were 10^{12} cm^{-3} and 12 eV accordingly.

The gas profitability was evaluated from the gas consumption, made by 15 - 20 cm^3 per hour, and ion current. At 100 % ionization to get beam current 1 ìÀ it is necessary to consume about 1 cm^3 of gas per hour, located at atmospheric pressure. Thus, in the source best mode of operations with beam current 10 mA the gas profitability makes about 50 %.

Conducted experimental researches have confirmed expected main laws of given source and showed it's good characteristics. In particular, source surpasses known analogues on gas profitability, absorption factor of RF power, current density.

REFERENCES

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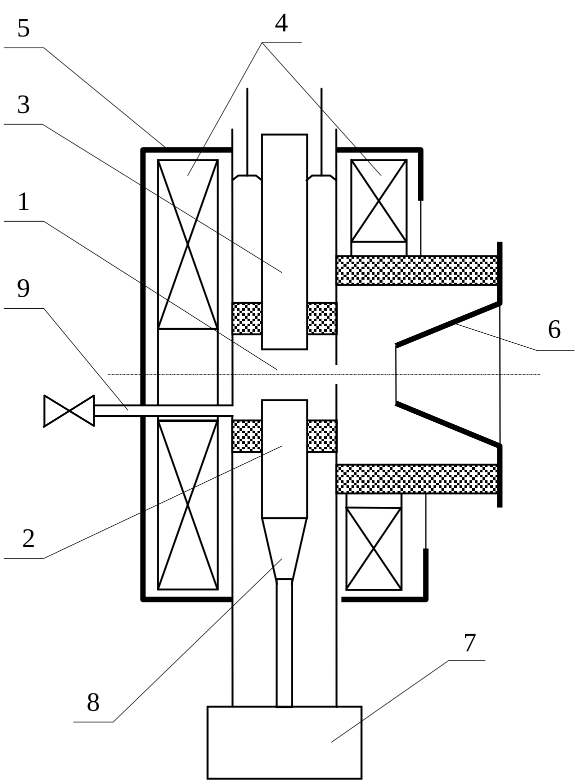

Fig.1. Ion source scheme.

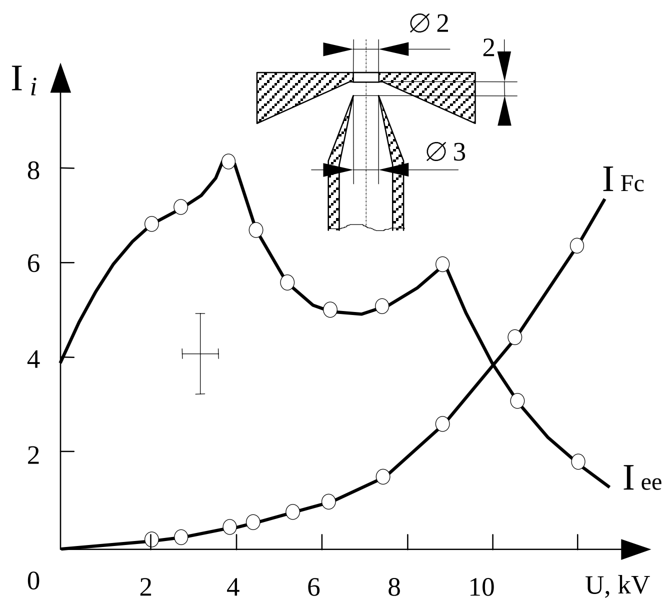

Fig.2. Ion and extracting electrode current dependence on operating voltage.

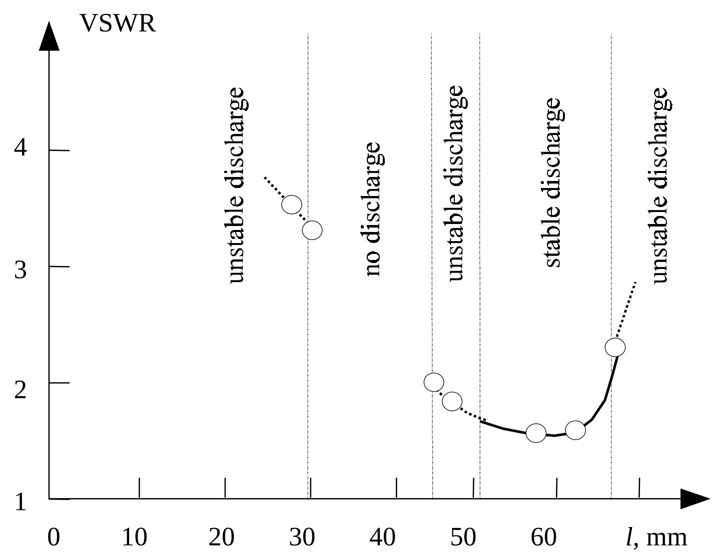

Fig.3. VSWR dependence on short circuit loop length.