EXPERIMENTAL INVESTIGATION OF A COLD-CATHODE MAGNETRON GUN

A.N.Dovbnya, V.V.Zakutin, V.F.Zhiglo, V.P.Romas'ko, N.G.Reshetn'yak Kharkov Institute of Physics & Technology 310108 Kharkov Ukraine

A cold-cathode magnetron gun operating in the secondary-emission mode is attractive from the standpoint of its rugged structure and long service life [1-4]. The secondary-emission mode can be set off, for instance, using the auxiliary voltage pulse [5, 6] employed to create the primary electrons.

In order to run the test a breadboard device was constructed (Fig. 1) which comprised the following:

- A HV-pulse generator *1* with a pulse amplitude up to 100 kV, duration up to 2 µs and reprate up to 1 Hz employed to start off the electron gun;
- a HV-seed pulse generator *2* ;
- a pulsed magnetic field generation system operating by way of capacitance discharge into the solenoid *S*, the magnetic field strength in gun being ≤5.000 Oe, field inhomogeneity ±10%, solenoid length 600 mm, its diameter 350 mm, pulse duration 700 µs;
- a vacuum chamber for the secondary-emission gun made as a coaxial system: anode *4* - stainless steel tubing 35 mm in diameter and 200 mm long, cathode *3* - cooper rod 5 mm in diameter and 150 mm long;
- a tell-tale system containing aluminum foil *5* and a Faraday cylinder *6* ;
- a pulse synchronization system employed to adjust the pulse position vs. time.

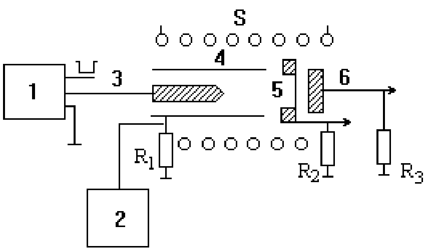

Fig.1

During the testing the electron beam was produced, its parameters and the electron emission mechanism studied.

With the on-cathode pulse amplitude being ~40 kV and the secondary-emission pulse set-off amplitude ~15 kV, the beam current in the collector was ~16 A; the magnetic field strength was ~3.000 Oe.

The beam in its transverse cross-section was shaped as annulus with the outer diameter being 9.5 mm and the inner diameter 5.5 mm.

Studied was the beam current amplitude vs. magnetic field strength relationship. Obtained was the near-threshold dependence of beam current buildup and droop on magnetic field (Fig. 2). The beam current pulse duration decreases with increasing magnetic field.

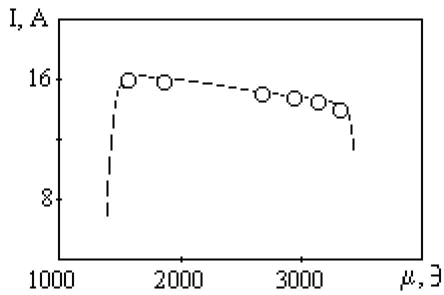

Fig.2

The energy of beam particles was measured using the aluminum foil absorption technique, with the aluminum foil thickness being 10 µm. The measurements came out with the mean particle energy~32 keV, the pulse amplitude being 39 kV.

Measured was the beam current pulse amplitude in relation to the in - chamber pressure. After changing the in-chamber vacuum from 6×10^{-5} Torr to 3×10^{-3} Torr the beam current pulse amplitude remained, practically, unchanged.

Based on these measurements, we can show that the beam current is associated with secondary-emission from the cathode.

Let us consider it in a more detail. This system in capable to provide for the following emission types during which the beam current can be as high as dozens amperes:

1) explosive emission
2) gas discharge-produced plasma emission
3) secondary emission.

The absence of explosive emission between cathode and anode was ascertained by applying pulsed voltage with the amplitude up to 60 kV, with the on-cathode current being non-existent at *H*= 0. Besides, during explosive emission the gap resistance is dose to zero, the in-gap current being determined by the voltage generator inner resistance. During the experiments no voltage pulse droop was recorded which is the sufficient indication of explosive emission absence. Beam current temporal characteristics also point out the explosive emission absence.

The gas discharge-produced plasma emission is absent, since beam current does not depend upon the in-chamber pressure.

The secondary-emission mode is proven to exist by the following factors:

- existence of the near-threshold beam current dependence on magnetic field;
- existence of the dependence of beam current duration on seed pulse in the following manner: once the pulse is applied, the beam current possesses an assigned duration and is stable all along; without seed pulse the beam current is shoot-lived, at the end of the voltage pulse with a random, chaotic shape and duration.

Upon increasing of the pulse amplitude and duration up to 1 μs, a spike was observable on the beam current pulse in the vicinity of the pulse sag that exceeded by a factor of 1.5 - 2 the secondary-emission current amplitude. Appearance of this spike can be, most probably, associated, during the pulse duration increase, with gas desorption off the cathode surface, deterioration of vacuum conditions in the anode-cathode gap and gas discharge buildup. Then, the gas discharge current does not lead to a decrease in the voltage pulse amplitude.

The experiments uncovered the inter-relationship between the observable gun glow, deterioration of vacuum conditions and spiking on the beam current pulse.

The vacuum discharge can be prevented by electrode conditioning and gun operation at a high repetition rate when the time interval is insufficient for gas to adsorb on the cathode in vizeable quantities.

REFERENCES

1. Crossed-Field Microwave Devices, Academic Press, N.Y. and L., 1961.
2. Vigdorchik I.M., Naumenko V.D., Timofeev V.P. “The Secondary Emission Cold Cathode Pulse, Magnetron of the Millimeter Wave Lengths”. Doklady of the USSR Academy of Sciences, series: phisico-mathematical and technical sciences, 1975, N 7, p.633.
3. S.A.Cherenschikov, “Multi-pactoring electron emission mode in a cold-cathode magnetron gun”, Book of Abstracts, 13-th Workshop on charged Particle Accelerators, Dubna, 13-15 October 1992.
4. G.M.Ivanov, S.A.Cherenschikov “A glow-free magnetron gun as electron source for resonance linacs”, Book of Abstracts, 13-th Kharkov Seminar on Changed Particle Linacs (Kharkov, 25-28 May, 1993), Kharkov, KFTI Publication, 1993, p.27.
5. S.A.Cherenschikov, “On a Cold Cathode Magnetron Startup Using the Voltage Pulse Sad”, Elektronnaya Tekhnika, Series RF-Electronics, 1973, N 6, p.20.
6. V.V.Zakutin, V.P.Romas’ko, B.G.Safronov, S.A.Cherenschikov, A.M.Shenderovich, “A Controlled cold cathode magnetron gun operating in the long pulse regime”, Book of Abstracts, 13-th Kharkov Seminar on Charged Particle Linacs (Kharkov, 25-28 May, 1993), Kharkov, KFTI Publication, 1993, p.28.