The Effect of Absorbers on the Operation of a Coaxial Magnetron

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Abstract: The results of calculating the S-parameters of a coaxial magnetron are presented. The results of modeling the dynamic mode of interaction of the electron beam with the RF field are presented. The effect of surface and volume absorbers on the operation of a coaxial magnetron is estimated. The simulation results are compared with experimental data.

Keywords: coaxial magnetron, microwave energy absorber, carburized dielectric, sendust.

Introduction

The article deals with the effect of absorbers on the operation of a coaxial magnetron. In contrast to the "classical" magnetrons, coaxial have a higher output power, high efficiency and frequency stability [1]. Around the anode block of this type of magnetron is a coaxial resonator (Fig. 1), in which TE011-mode is excited. This type of oscillation ensures that the currents and voltages are in phase in all resonators of the anode block having a coupling gap, which contributes to maintaining only π-mode oscillations in the slow-wave structure.

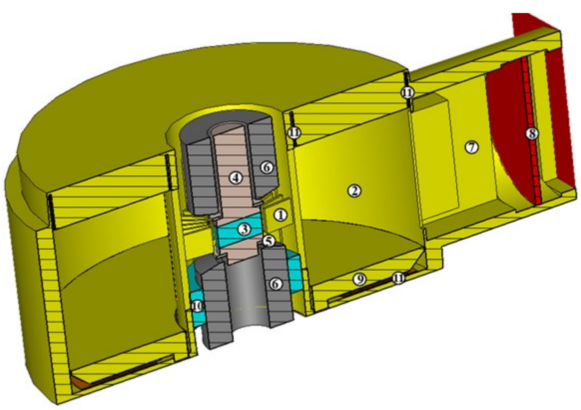

Figure 1. Longitudinal section of a coaxial magnetron (1 - anode block, 2 - stabilizing cavity, 3 - emitting cathode surface, 4 - cathode core, 5 - cathode limiters, 6 - pole piece, 7 - energy output, 8 - dielectric disk of the energy output bank, 9 - tuning mechanism, 10 - carbonized dielectric ring, 11 - surface absorber from sendust)

Although the high-quality coaxial resonator is intended to stabilize the π-mode, other types of oscillations arise in it, interfering with the normal operation of the pulsed magnetron.

Suppression of the slote TM111-mode

The TM111 is a degenerate operating TE011-mode. With the perfectly cylindrical shape of the coaxial resonator, the frequencies of these modes coincide, but the slot on the inner cylinder and the non-contact tuning piston provide a frequency separation of these modes. However, despite the significant separation of modes (20%), with a large impulse rate of rise, excitation occurs in the TM111, which leads to a decrease in the efficiency and output power.

To suppress the TM111-mode, a volumetric absorber made of VK94 ceramic impregnated with carbon was used. A ring with this material was located between the pole piece and the anode block, due to the fact that the TE011-mode (in contrast to TM111-mode) has the minimum electric field component in this gap. In Fig. 2. simulation results of a coaxial magnetron with a carburized dielectric and without absorbers are presented.

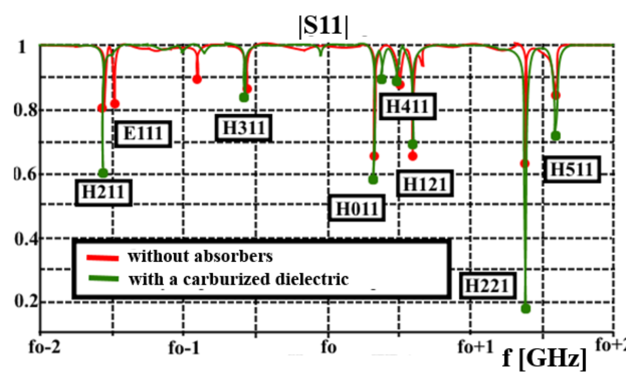

Figure 2. |S11| dependence of the coaxial magnetron on frequency without absorbers and with a carburized dielectric

Suppression of the TE121-mode

The stable operation of the coaxial magnetron is hindered by the modes in which ring currents flow along the cylindrical walls of the coaxial resonator, since they can communicate with the resonators of the anode block. With the azimuthal periodicity of the fields and currents of the coaxial resonator, they contribute to the excitation in the resonator system of the anode block of the modes other than the π-mode.

The spurious mode (N/2-1), which is established in the slow-wave structure of a coaxial magnetron upon excitation of the TE121-mode in the stabilizing cavity, is the most dangerous in ordinary magnetrons. In Fig. 3. the spectrum of a magnetron without absorbers is presented.

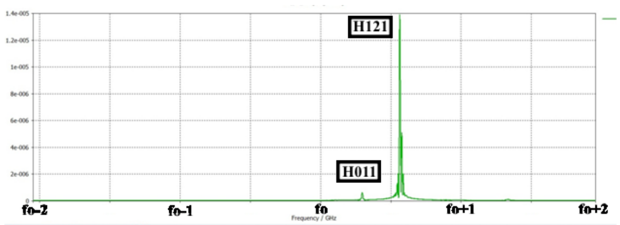

Figure 3. Spectrum of the RF field at the output port

To suppress spurious TE0mn-mode and TE121-mode, surface absorbers with high magnetic losses (sendust) were used. The absorber was placed in the cylindrical slots of one of the walls of the stabilizing cavity and on the surface between the displacement mechanism and the stabilizing cavity. In Fig. 4. simulation results and experimentally obtained values of VSWR for two extreme positions of the movement mechanism are presented

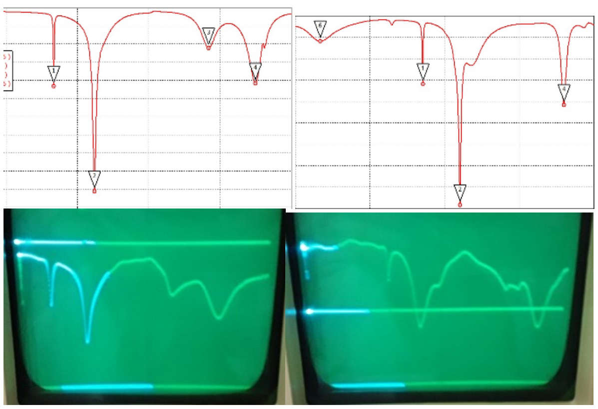

Figure 4. VSWR (top - calculation, bottom - experiment)

A magnetron design with the arrangement of surface absorbers was proposed, in which the loaded figure of merit of the main mode exceeded the loaded Q-factor of the spurious mode by 20 times. This made it possible to suppress the influence of TE121-mode on the magnetron output signal In Fig. 5. the spectrum of a magnetron with absorbers is presented.

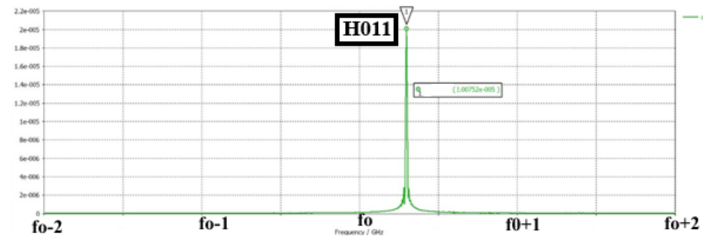

Figure 5. Spectrum of the RF field at the output port.

The calculation results were used in the design of a coaxial magnetron; the output signal spectrum is shown in Fig. 6.

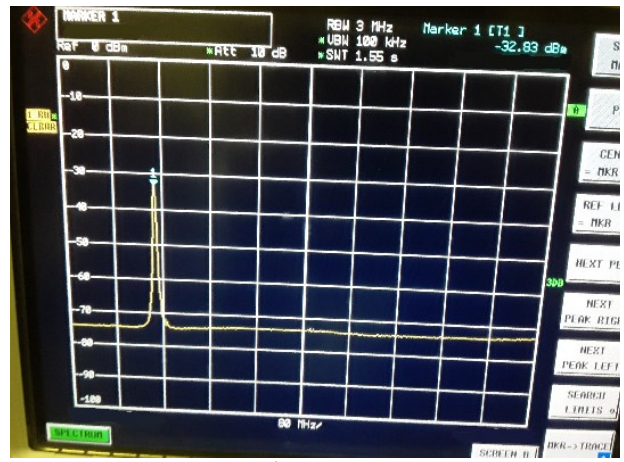

Figure 6. The spectrum of the output signal

Conclusions

The effect of absorbers on the operation of a coaxial magnetron was simulated. Based on the simulation results, the design of magnetron absorbers was proposed, which made it possible to suppress spurious oscillations. The calculation results were confirmed experimentally.

References

1. I. Feinstein, “Magnetron with a coaxial resonator,” Crossed-field microwave devices, 1961