MODERNIZATION OF THE MULTIPURPOSE ACCELERATING SYSTEM "VGIK-1"

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The aim of VGIK-1 modernization is the possibility of metal surface processing by ion and electron irradiation, widening a range of applied energies and beam densities, vacuum condition control. This is reached by usage of two diodes, where one of them has isolated and defocussing magnetic system and another one has plasma emitter for extraction of ions and electrons. There is also the system of plasma parameters control. Vacuum system includes the cryogenic, diffusion and titanium sorbtion pumps and mass-spectrometric system

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INTRODUCTION

Nowadays the modification of surface - volumetric structure, composition and properties of materials under action of various kinds of an irradiation are intensively investigated. The application of pulse high density stream of particles and energy at a power level $10^7 \div 10^{11}$ W/cm^2 and energy stream up to 100 J/cm^2 allows to execute changing of materials properties in very short time, about duration of a beam pulse. The huge speeds of heating and cooling of a surface in case of a pulse irradiation essentially influence on structure and properties of superficial layers of a material. The increasing of durability hardness and corrosion resistance is the result of this influence.

The accelerating system VGIK-1 was developed as a pulsed microwave generator of a GW-power with a wavelength of about 10 cm operating in a microsecond range. This system, in particular, was used to carry out investigations of a possibilty to operate in a frequency-periodical regime of a herts range. In recent years, at this accelerator one conducted the experiments related with interaction of high-power pulsed electron beams with metal surfaces. The results of a study on the metal surface structure modification under influence of high-power pulsed electron beams in the range of densities from 10^7 to 10^{10} W/cm^2 [1-10] have showed a need and promise of further changing the operating conditions in a more extended range of parameters. For this purpose we perform the modernization of the irradiating system VGIK-1 with realization of the following capabilities:

- irradiation with electrons and ions;
- change of a particle energy in a wider range of energies;
- control and monitoring of vacuum conditions in rather wide limits for gas pressure and composition;
- control of plasma cathode parameters;
- change of a density and energy content of pulsed electron beams.

DESCRIPTION OF INSTALLATIONS

The schematic diagram of a new version of the accelerator installation VGIK−1M is presented in Fig. 1. Unlike the former variant, there used are two diodes for different irradiation energies. One of these diodes becomes magnetoinsulated, and besides the insulation, the magnetic field is also a guiding, forming and transporting one.

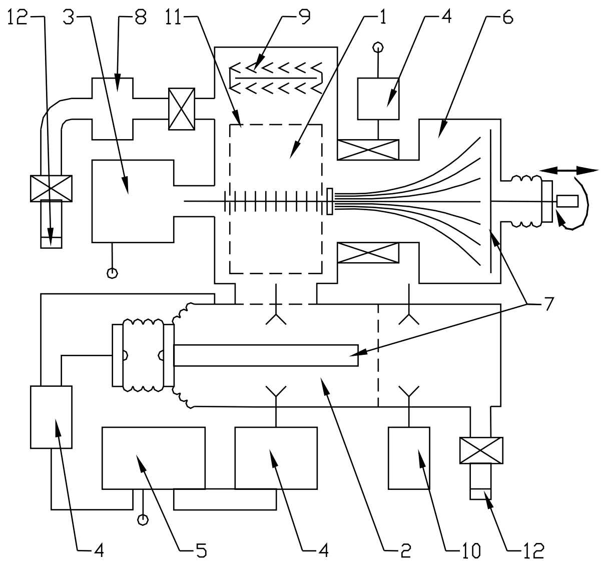

Fig. 1. *Schematic diagram of the installation BGIK −1. 1,2 - diodes; 3 -MG; 4 - PCG; 5 - control block; 6 - beam inlet chamber ; targets in diodes; 8 - mass-spectrometer; 9 - cryopump; 10 - microwave interferometer; 11 - nitrogen radiation screen*

-cryopump; 12 - pumpdown system; 13 - multigap plasma gun

When reversing the polarity of the Marx generator (MG) the cathode will be at a negative potential, unlike the former case with cathode grounding. The beam extraction, as before, will be perfotrmed with an anode grid. As the beam moves in a decreasing magnetic field its density decreases. Similarly the beam power density is changing. We have calculated and measured the topography of the magnetic system (Fig. 2) being simultaneously a magnetic insulation of the diode and a system of the guiding field. Movement of a movable target with samples along the beam trajectory will allow obtaining thereon the designed power density values. The power density control will be carried out with the use of thermocouple sensors attached on the sample holders. At instant of the current irradiating pulse the control system will be separated from the sample holders and will be switched on for measurement with a delay of about 1 s after passage of a pulse. Since, the time of setting an equilibrium temperature does not exeed 1 s, the radiation losses at a mean sensor temperature of about 100 ºC will be not higher than 1-2% that is well sufficient to control the irradiation conditions. Usage of metal- and dielectric anode units will make it possible to form ion beams. The targets will be placed in the cathode unit.

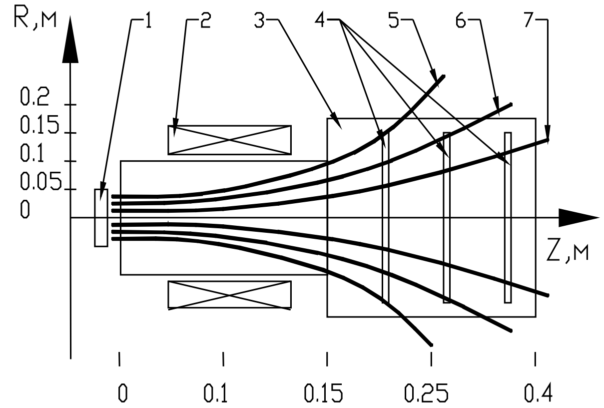

Fig. 2. *Trajectory of electron movement in the defocusing system with a device for changing the beam energy content. 1 - cathode; 2 - magnetic lens; 3 - measuring chamber; 4- movable target; 5 - trajectory of electron movement at* $HS=3.06 \cdot 10^4$*; 6 - at* $HS=4.6 \cdot 10^4$*; 7 - at* $HS=7.4 \cdot 10^4$

As it was mentioned, the change of the electron beam density will be performed with the help of a focusing and defocusing magnetic field. In this case the area of the surface under irradiation can change from 100 to 600 cm^2. Change of the gap of MG dischargers will allow one to enlarge the value of output beam energies from 270 kV in direction of energy increasing up to 350 kV that is a limiting value for the given acceleration tube. There is also a possibility to decrease the beam energies up to 150 kV in the case of MG switching over**.** For the further decrease of the beam energy we intend to use an isolated chamber of the second diode with a plasma cathode that will be formed by discharging the condenser bank of the pulse current generator (PCG) (capacity of 3 μF, voltage of 40 kV) onto the ring multigap (12 gaps) plasma guns. Movement of plasma bunchs into the inside on the system radius will occur due to magnetic fields of the reverse current lead. The parameters of the plasma gun and its power supply system enable one, according to the data of [2], to expect the plasma cathode densities at a level of $10^{13} \div 10^{14}$ cm^{-3}. For control of these parameters a microwave interferometer with wavelengths 4 and 8 mm was mounted. Irradiation of samples placed on a metal rod, insulated up to 40 kV, can be performed with a high-voltage system of the PCG №2 which is turned on via the system of controllable time delay. In so doing one can apply pulses of a positive or negative polarity onto the target relatively to the plasma cathode. The plasma composition of plasma guns, which in main is determined by hydrogen and carbon, can be changed by introducing in the discharge chamber additional gases: hydrogen, nitrogen, argon etc. The expected electron and ion beam parameters lie at the following level: energy from 20 to 40 kV, current from 10 to 50 kA, duration of about 500 ns.

Ones of the main parameters in the process of metal treatment in vacuum are the vacuum properties - pressure and composition - not only in the gaseous phase but on the surface of objects under irradiation too. In accelerator tubes of the majority of accelerators of a direct action one uses organic materials of plastic type with an insufficient temperature stability and, correspondingly, high vapour pressure, e.g. acrylic plastic, caprolon etc. Therefore, obtaining pure controllable conditions in the target region with the commonly used pumping means is a problematic task. However, the use of pumping means having a high capacity and not contaminating the volumes being evacuated, e.g. cryogenic condensation and adsorption pums, allows one to overcome positively this problem under a condition of the preliminary heating or plasma treatment of targets. Thus, in the design under consideration, besides the described in [4] helium- and nitrogen condensation and sorption pumpes, the titanium arc-evaparation pumps will be used. Helium cryogenic pumps have the hydrogen evacuation rate at a level of $1 \cdot 10^4$ *l*/s, nitrogen condensation pumps have the hydrocarbon evacuation rate of about $5 \cdot 10^4$ *l*/s, titanium pumps have the hydrogen evacuation rate of about $2 \cdot 10^4$ *l*/s. The gas composition will be controlled with the help of a mass-spectrometer IPDO–2 having a low sensitivity to pulse inducing**.** Since in diodes, at the instant of a pulse, the vacuum conditions can be changed more than by an order of magnitude [4] the mass-spectrometer is placed in a special chamber connected to the diode chamber by the controllable conduction and has the independent pumping system.

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