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RESEARCH OF CHARACTERISTICS OF PHOTO- AND THERMOEMISSION CATHODES

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A description of the stand for research of photo- and thermoemission cathodes for an electronic gun of Linac-800 accelerator is given. The structure of the equipment and the basic characteristics of the stand are shown. The stand allows one to make tuning of control electronics, calibration of operating and measuring channels, debugging of the software. Introduction of the stand of mass spectrometers with the leaking subsystem into the structure of the equipment enables one to analyze gas structure of vacuum volume and to change its structure depending on a task in view. Application, at the stand, of the laser with wavelengths of 1064, 532, 355 and 266 nm allows one to investigate a wide spectrum of materials for photocathode. A description of model of cathode assembly, results of simulation and their coordination with experimental data is given. Issue characteristics of the impregnated cathode (tungsten with 20% of oxides of barium, calcium and aluminium) are presented. Data on research of this cathode as the photocathode (with heating and without it) at a lasing wavelength of 532 nm are given.

Дается описание стенда для исследования фото- и термоэмиссионных катодов для электронной пушки ускорителя Линак-800. Приводятся состав аппаратуры и основные характеристики стенда. Стенд позволяет производить настройку электроники управления, калибровку управляющих и измерительных каналов, отладку программного обеспечения. Введение в состав аппаратуры стенда масс-спектрометра с подсистемой напуска газов дает возможность анализировать газовый состав вакуумного объема и изменять его состав в зависимости от поставленной задачи. Применение на стенде лазера с длиной волны 1064, 532, 355 и 266 нм позволяет исследовать широкий спектр материалов для фотокатодов. Приводятся результаты моделирования катодного узла и сравнение их с экспериментальными результатами. Представлены эмиссионные характеристики импрегнированного катода (вольфрам с 20 % окислов бария, кальция и алюминия). Приведены данные по исследованию данного катода в качестве фотокатода (с нагревом и без него) при длине волны лазера 532 нм.

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INTRODUCTION

As JINR takes part in the construction of the International Linear Collider (ILC) [2] on the basis of the Linac-800 accelerator [2] the stand for solving some problems is created: testing of accelerating structures and means of diagnostics of a beam, creation on the basis of the accelerating, equipment (power supplies, modulators, klystrons, accelerating structures, etc.) elements of the prototype photoinjector and their research, studying of radiating stability of materials, etc.

Offers on creation on Linac-800 experimental installation with the volume free electron laser (VFEL) [3] are prepared.

The basic element of injector Linac-800 [4–7] is an electronic gun (Fig. 1). The gun is a triode type, with a constant high voltage on the cathode, the «ground» anode and operating

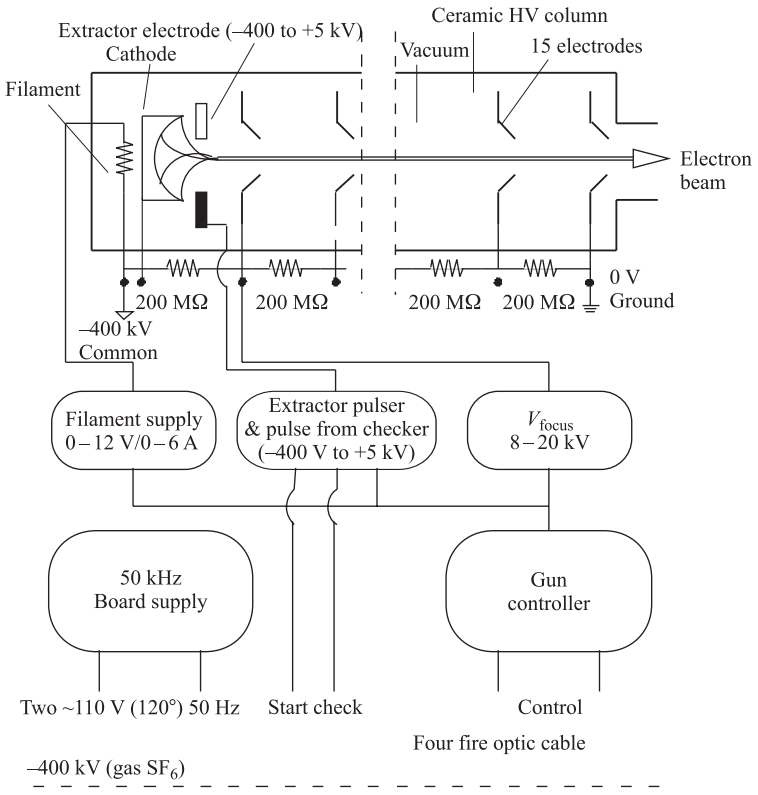

Fig. 1. Schematic diagram of the hot deck electronics with the gun

electrode. The gun is placed in the tank, filled with insulating gas SF_6 under pressure near 6 atm for increase of electric durability. In the electronic gun an impregnated cathode (tungsten from 20% of oxides of barium, calcium and aluminium) is used. The cathode has diameter 8 mm and the simulating surface makes 0.5 cm^2. Heat of the cathode indirect, a range of working values of currents and voltage is within the limits from 6.5 B/4 A up to 8.8 B/5 A. The resource of work of the cathode makes 15–20 thousand hours.

THE STRUCTURE OF THE EQUIPMENT AND THE BASIC CHARACTERISTICS OF THE STAND

In Fig. 2 a block diagram of the stand for research of photo- and thermoemission cathodes is presented.

Vacuum System. Working value of vacuum in the chamber of the stand begins with $2 \cdot 10^{-7}$ Torr and above. One of the basic elements of the vacuum system is a quadrupole mass spectrometer of QMG type of 111 firm BALZERS [8]. By means of this device it is possible to solve a number of tasks:

• the qualitative and quantitative analysis of residual gases in ultrahigh and high-vacuum systems;

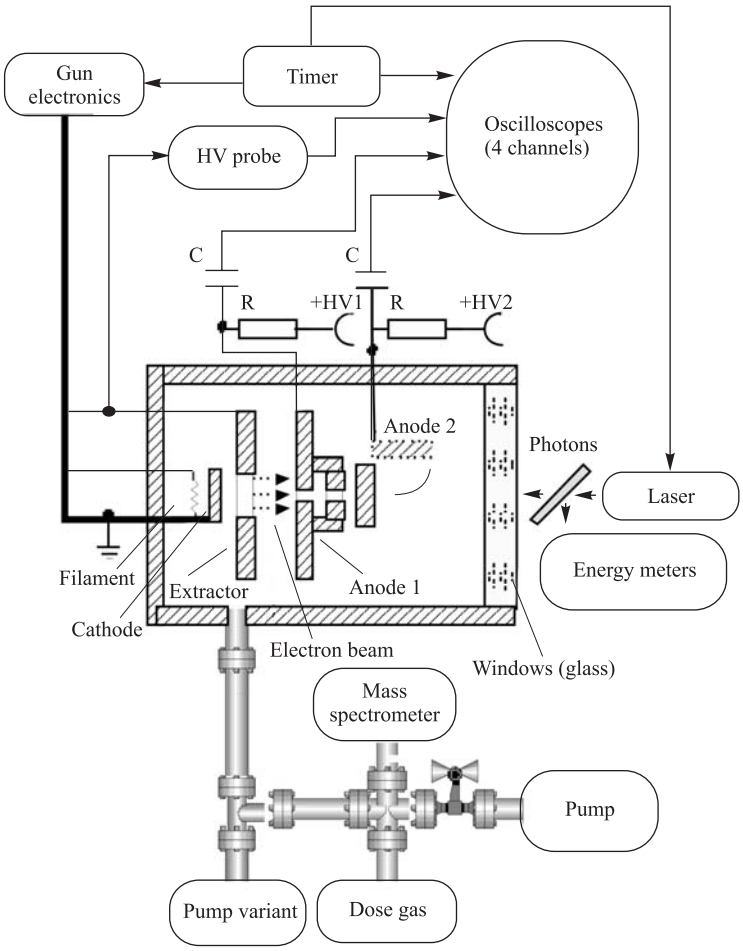

Fig. 2. Block diagram of the experimental setup

• research kinetics processes of gas evolution of various substances at their heating in vacuum;

• detection of leaks in vacuum systems;

• studying processes of adsorption, desorption, superficial reactions of diffusion that is especially important for the control of evaporation processes in thin films;

• research of selectivity pumping at production of ultrahigh vacuum, etc.

The Laser System. The structure of the equipment for carrying out research with the photocathode includes laser LS-2134 [9]. Laser LS-2134 is pulsed Nd:YAG laser with transformation of a wavelength of radiation of the basic frequency of generation to radiation of the second harmonic. The main characteristics are the following:

• energy — 250 mJ (1064 nm) and 150 mJ (532 nm);

• pulse repetition rate — 1–15 Hz;

- pulse duration — 10 ns;
- beam diameter — 6.3 mm.

The generator of harmonics HF-TF is applied to production of radiation in ultraviolet range (355 and 266 nm) at the stand [10]. At sharing with laser LS-2134 on its output it is possible to obtain energy of pulses up to 25 mJ (355 nm) and 15 mJ (266 nm).

Measurement of energy of pulses of laser radiation at the stand is carried out by means of a measuring instrument calorimetric solid-state IKT-1M [11]. The main characteristics are the following:

- range of measurement — 0.05–1000 J;
- range of wavelengths — 0.4–4 μm;
- minimal duration of a pulse — 10 ns.

SOME EXPERIMENTAL RESULTS

Measurements of temperature of the cathode have been taken with the use of an optical pyrometer (OPPIR-017 [12], accuracy of measurement ± 20 °C).

For check of correctness of research methods, the model of cathodic unit has been made and calculations are performed. The scheme and result of modelling for these parameters are given in Figs. 3 and 4, respectively. Results of modelling will be well coordinated with experimental data (differences no more than 10–20%).

Table 1. **Dependence of temperature of the cathode on value of heat ($P = 2 \cdot 10^{-7}$ Torr)**

V_{cathode}, V	I_{cathode}, A	Filament supply, W	Temperature of the cathode, °C
4.5	2.99	13.5	850
5.0	3.19	16.0	910
5.5	3.35	18.4	950
6.0	3.5	21.0	1000
6.5	3.7	24.0	1030
7.0	3.9	27.3	1070
7.5	4.05	30.4	1109
8.0	4.23	33.8	1150
8.4	4.34	36.5	1170
8.8	4.5	39.6	1210

Table 2. **Dependence of a current of the cathode on a voltage on an extractor. Duration of a pulse of an extractor — 1 μs, filament current — 4.5 A, filament voltage — 8.8 V, pressure —** $2 \cdot 10^{-7}$ **Torr**

$V_{\mathrm{extractor}}$, kV	1.0	2.0	3.0	4.0
I_{beam}, mA	50	125	225	350

Table 3. **Dependence of a current of the cathode on value of heating and pulse of radiation (at 532 nm). Pulse duration — 10 ns, energy — 120 mJ, pressure —** $2 \cdot 10^{-7}$ **Torr,** V_{anode} **— 2 kV, repetition rate — 1 Hz**

V_{cathode}, V	I_{cathode}, A	I_{beam} (pulse), A	I_{beam} (average), μA
0	0	0.05	20
1.0	1.8	0.1	20
2.0	2.15	0.12	20
3.0	2.52	0.2	20
4.0	2.83	0.5	21
5.0	3.23	2.0	22

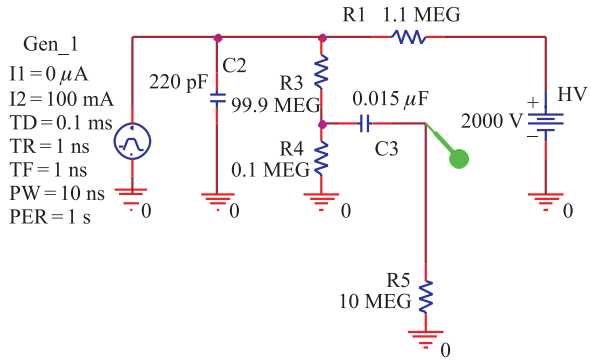

Fig. 3. The scheme of model of the cathodic unit

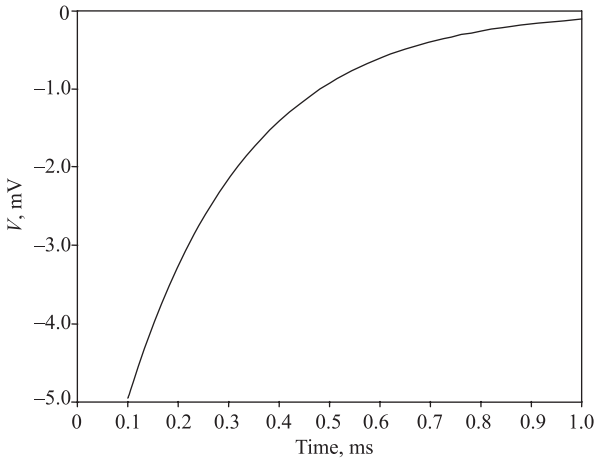

Fig. 4. Result of modelling for parameters of the scheme shown in Fig. 3

CONCLUSION

In the given article a stand for carrying out research of photo- and thermoemission cathodes for an electronic gun of Linac-800 accelerator is described in suffiicient detail. The structure of the stand construction includes the vacuum equipment, cathodic electronics, the laser with various wavelengths, operating and measuring electronics. The technique of research is presented. By means of the given stand it is possible to choose an optimum material for the cathode, to research an ego issue properties, conditions of operation and lifetime. The first experimental results at the given stand are obtained.

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