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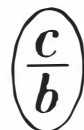
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INSTRUMENTS AND EXPERIMENTAL TECHNIQUES

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TABLE 1

Type of SEM	Supply voltage, kV	Gain	Amplitude range, mV
VEU-1A	4	10^6	0-3
VEU-4	3.2	10^7	0-25
VEU-6	3.0	$2 \cdot 10^6$	20-560

313, and 254 nm, respectively. The emission was recorded at a vacuum of 10^{-5} torr in the facility of [3]. The dynamic range and the sensitivity of the electron recording system was controlled in studying the amplitude distribution of the SEM signals. An amplitude spectrum was taken at different signal gain levels. The pulse amplitude was calculated as the integral discrimination level, referred to the amplifier input.

The SEM signal distribution is shown in Fig. 1. Each SEM type has its characteristic shape of amplitude spectrum, whose width increases with increased energy of the photostimulating light quanta. Table 1 shows the supply voltages, the SEM gains [4], and the range of output pulse amplitudes.

The results obtained can be used to adjust the dynamic range and the sensitivity of equipment for recording low-energy electrons.

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CHARACTERISTICS OF A MICROCHANNEL PLATE UNIT IN RECORDING HEAVY PARTICLES

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UDC 621.385.831

The authors investigate the characteristics of a block of two microchannel plates (BMCP) under conditions where ions of different elements are being recorded. It has been established that the BMCP can be used to detect ions with energy of several keV, when the flux into the first plate channel does not exceed several particles per second.

The authors used industrial microchannel plates (MCP) of $\phi 28$ and thickness 1.1 mm. The channels were $\phi 19$ straight, and with a structural pitch of 23 μm [1, 2]. The work was conducted on the test facility of [3]. The block of microchannel plates consisted of two MCPs, parallel to one another, a collector, and an electrical circuit. The BMCP was monitored on a moving platform with two degrees of freedom, moveable in a plane perpendicular to the beam of heavy particles being recorded. The angle between the normal to the MCP working surface and the channel axis was 6° , the beam fell at angle $10-15^\circ$ to the normal to the working surface. The linear dimensions of the beam did not exceed 150-200 μm , so that 50-60 channels effectively operated in the first plate. The distance between the plates was 0.4 mm. The resistance of each MCP in vacuum was $\sim 10 \text{ G}\Omega$. The MCPs were positioned in herringbone fashion, avoiding ion feedback. The chamber pressure during operation was $P \approx (2-3) \cdot 10^{-6}$ torr.

A potential of -170 V relative to ground was supplied to the input of the first plate, so that electrons caused by ions entering the space between the channels should not initiate pulses. In fact, the count rate with the first plate input grounded was larger than when it

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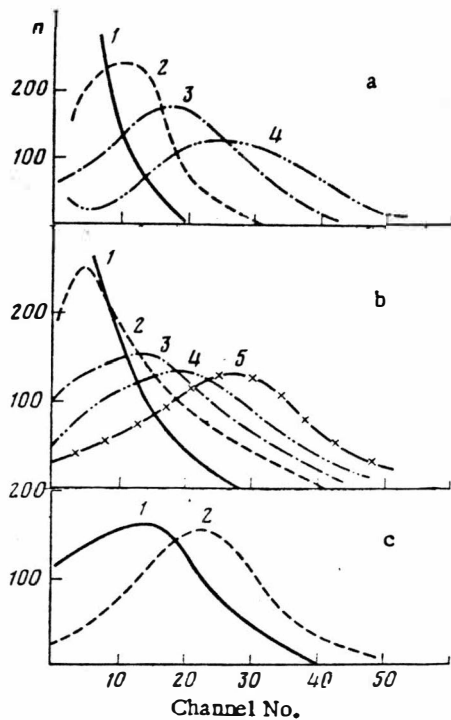


Fig. 1

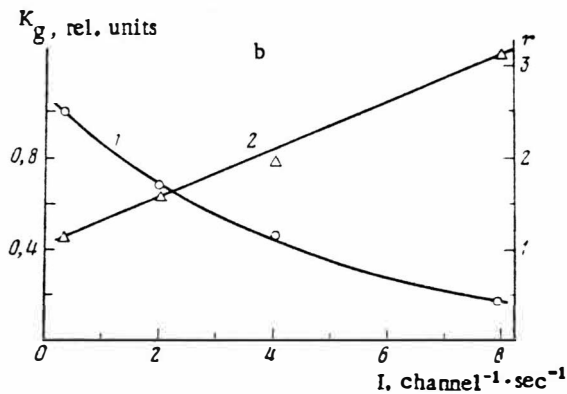
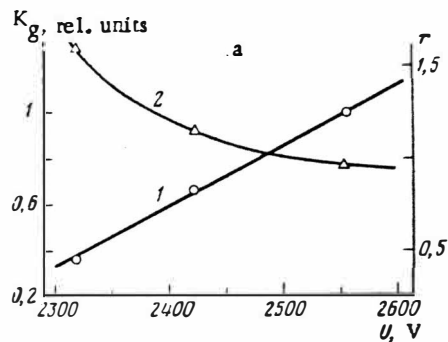


Fig. 2

Fig. 1. Pulse amplitude distributions: a) as a function of voltage $U = 2210$ (1), 2315 (2), 2420 (3), 2550 V (4), $I = 0.3 \text{ channel}^{-1} \cdot \text{sec}^{-1}$; b) as a function of beam intensity $I = 29$ (1), 8 (2), 4 (3), 2 (4), $0.3 \text{ channel}^{-1} \cdot \text{sec}^{-1}$ (5), $U = 2550 \text{ V}$; c) as a function of beam energy $E = 1670$ (1), 3170 eV (2), $I = 0.3 \text{ channel}^{-1} \cdot \text{sec}^{-1}$, $U = 2550 \text{ V}$. The quantity n is the number of pulses in a channel.

Fig. 2. The relative gain K_g (1) and the resolution r (2) as a function of the voltage U (a) with $I = 0.3 \text{ channel}^{-1} \cdot \text{sec}^{-1}$ and of the intensity I (b) with $U = 2550 \text{ V}$.

had a negative potential. The signal was taken off to a charge-sensitive amplifier, then to a type PP9-2M counter and a type AI-1024 pulse analyzer. The signal was monitored visually on an oscillograph, and the pulse amplitude distributions were put out on a digital printer by means of a B3-15M device.

Beams of N_2^+ , O_2^+ , N^+ , O^+ ions of energy 3170 eV were recorded. It turned out that the pulse amplitude distribution is practically independent of the type of particle. All the subsequent measurements were made with recording of O_2^+ .

The zone characteristics of the MCP block were investigated. It turned out that the pulse amplitude distribution was practically independent of the location of the point where the beam was recorded. The recording efficiency varied over the surface in the range $\sim 5\%$.

For different ion beam intensities we investigated the dependence of the pulse count rate for a beam of constant intensity on the applied voltage, for a fixed discrimination level of the PP9-2M counter. It turned out that with increase of voltage the curves do not come to a plateau, although a small intermediate plateau is observed at intensities up to $2.5 \text{ channel}^{-1} \cdot \text{sec}^{-1}$ and $U = 2100$ to 2200 V . This dependence is similar to the analogous characteristic of a channel electron multiplier with a funnel, type VÉU-6 [4].

Figure 1a shows the pulse amplitude distribution for various voltages U at an intensity of $I = 0.3 \text{ channel}^{-1} \cdot \text{sec}^{-1}$. Similar curves were obtained at intensities of 2 and 4 $\text{channel}^{-1} \cdot \text{sec}^{-1}$. All the curves are normalized with regard to "area," i.e., to the total number of recorded particles. It was found that an increase in applied voltage $> 2600 \text{ V}$ leads to the appearance of a considerable number of noise pulses in the first channels of the analyzer. In this sense the voltage $U = 2600 \text{ V}$ can be considered a limit. Figure 1b shows the pulse

amplitude distribution for various beam intensities, and here one can clearly see a departure from the saturation regime for $I < 4 \text{ channel}^{-1} \cdot \text{sec}^{-1}$. Further decrease in intensity does not lead to an appreciable change in the amplitude distribution.

From the measurements made we can construct the relative gain K_g and the resolution r of the BMCP as a function of the voltage U and the intensity I . We take the relative gain, conventionally, to be the amplitude of the most probable pulse, and we take the resolution to be the ratio of the total width of the pulse distribution at half height to the amplitude. Estimates of the absolute gain of the MCP block gave $(1-4) \cdot 10^7$.

Figure 2 shows the relative gain K_g and the resolution r as a function of the voltage U and the intensity I . With increase of U the relative gain increases, while the resolution decreases. A similar picture is observed for a decrease in beam intensity. With $U = 2550 \text{ V}$ and $I = 0.3 \text{ channel}^{-1} \cdot \text{sec}^{-1}$ we achieved a resolution of $r = 0.9$ (90%). It is reported in the literature that for a herringbone combination of a pair of MCPs with straight channels, one typically finds an r of 1 to 2 (100-200%) [5]. It was found that for an increase in the potential difference between the plates from 10 to 20 V, the gain K_g decreased somewhat, and remained constant in the range 20-120 V. The value of K_g increases with increase of the recorded particle energy, which is similar to the behavior of the VEU-6 [4]. For example, for an increase of energy from 1670 to 3170 eV, the value of K_g increases by a factor of 1.7 (Fig. 1c).

The MCP block normally operates at a chamber pressure of $P = (2-4) \cdot 10^{-6}$ torr. No degradation of the parameters was observed with a pressure increase to $P = (6-8) \cdot 10^{-6}$ torr. However, at a higher pressure $\sim 5 \cdot 10^{-5}$ torr for a period of 10 to 15 min operation there was a sharp increase in the number of noise pulses. The noise increased sharply following operation at pressure $P = 3 \cdot 10^{-6}$ torr under recording conditions of $(5-10) \cdot 10^4$ particles/sec, detecting electrons formed during operation of the ionization manometer tube. After the MCP block was "rested" at $P = 3 \cdot 10^{-6}$ torr and with the high voltage removed, the parameters returned to their previous values. We note that after 10^5 particles were counted in one channel of the first plate there were no noticeable variations in the parameters of the BMCP.

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