ON THE QUESTION OF APPLICATION OF LOW VOLTAGE ACCELERATORS FOR RESEARCH OF MATERIALS OF SPACE VEHICLES

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The application of accelerators for the study of spacecraft materials best described in the monograph [1]. Low-voltage accelerators of protons and electrons with an energy of up to 200 kV produce particle streams observed in near-space in the Earth's radiation belts, where most human space activity takes place. The accelerators consist of the following main components and systems: the source of charged particles, the acceleration tube, the magnetic analyzer, the beam scan system on the target, the vacuum and the electrical power supply systems. Low-voltage accelerators divided into two design groups. The ones accelerate particles from the source at first and then analyze the particles by mass. For others, particle analysis from the source performed before acceleration. The latest accelerators are simpler and cheaper. However, it is possible that the particle beam charging composition will change during acceleration and neutral atoms will formed. This is particularly the case with large particle accelerator currents and low gas efficiency ion sources.

At the Harbin Polytechnic Institute (HIT), the 200keV proton accelerator measured the current homogeneity of a beam on the target of 100x100m^2. A new method used to scan the target. It can called the 'grated'. This invention received a patent [2]. In Figure 1 presented view of the quartz screen scanned with proton beam (1) and view of the electrical signal overlay on the X and Y – axis on the oscilloscope screen (2). Triangular electrical signals with close frequencies used. The current measured with a strip detector. The general view of the detector shown in Figure 1. Eleven sensor linear elements used. The 1st and 13th elements located on a limiting frame and used to check the size of the sweep. The frame electrically connected to a substrate on which the sensor elements arranged. All the parts are made of a PCB material. The detector measures the current distribution on one of the selected axes. A high-frequency source with a probe ion system [3] used to produce a beam of positive ions from the gases on the accelerator. The source makes it possible to produce hydrogen positive ion currents up to 250 μA at a power consumption of 250 – 300 watts. Gas flow rate of 20 cm^3 /h. The content of atomic ions is 65%. A turbomolecular pump with a speed of 1500 l / c used to pump the accelerator tube from the exit side. At that place the vacuum during the admission of hydrogen was in the range $7,5 \cdot 10^{-4}$ - $1,3 \cdot 10^{-3}$ Pa .

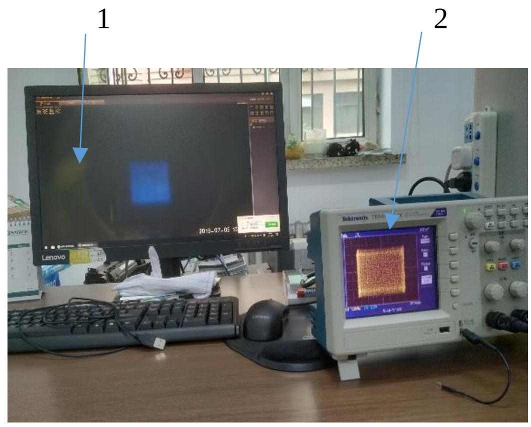

Figure 1. Presentation of new method to scan the target: 1 – view on the quartz screen; 2 – view on the screen of the oscilloscope.

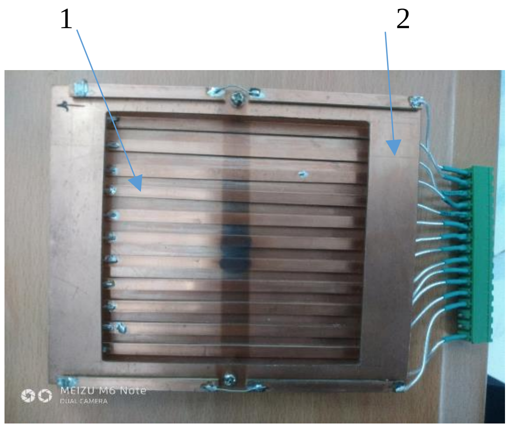

Figure 2. Overall view of strip - detector: 1 – sensor element; 2 - frame.

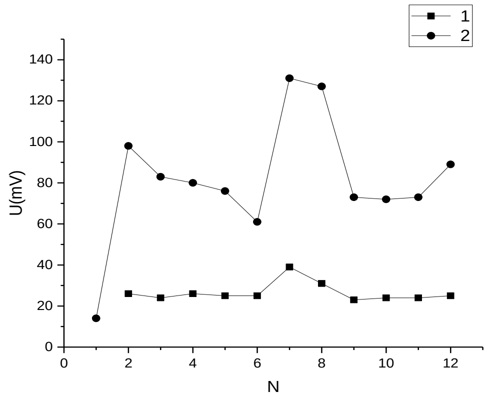

Figure 3. Dependence of sensor potential on the sensor number during target scan: 1 – Current on target 2 μA; 2 – Current 6 μA.

A neutral beam of protons with a diameter of ~ 15 mm in the center of the target observed on the quartz screen. Its position did not change when the voltage applied to the deflecting plates. Neutral atoms formed due to proton charge exchange at the entrance of the accelerator tube immediately after the analyzing magnet. The beam energy is in the range of 10–20 keV and depends on the potential of the focusing electrode. Figure 2 shows the measured dependence of sensor potential on the number during target scan at a proton energy of 100 keV. The voltage is proportional to the current per element. The magnitude of the contribution of the neutral beam strongly depends on the total current of the target, and, therefore, on the gas inlet to the source. Already when the current on the target is 6 μA, the current distribution on the target is completely distorted and this prevents measurement.

Similar measurements were performed on the KIFK proton accelerator (complex simulator of space factors) FTINT NANU (Kharkov) [4]. The accelerator made in the same way (analysis of the beam before acceleration). An installed source of Penning type ions with a cold cathode consumes little gas at a proton current of up to 10 μA. To pump the accelerator, a magnetic discharge pump with a pumping speed of 250 l/s used. The vacuum at the outlet of the accelerating tube during the admission of hydrogen was $6{,}3\cdot 10^{-4}$ Pa. For protons with an energy of 90 keV and a current to the detector of 1.5 μA, a beam of neutral atoms not detected.

According to the results of the measurements, we can conclude that the correct choice of the ion source is very important for the considered accelerator design. A large working inlet of gas into the source leads to the formation of neutral atoms after the analyzing magnet. Their presence can significantly affect the results of studies of spacecraft materials. To study the properties of materials at high flows of charged particles, it is necessary to use accelerators in which the magnetic analysis of the beam carried out after acceleration near the target under additional vacuum pumping [5]. This eliminates the formation of neutral particles.

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ДО ПИТАННЯ ПРО ЗАСТОСУВАННЯ НИЗЬКОВОЛЬТНИХ ПРИСКОРЮВАЧІВ ДЛЯ ДОСЛІДЖЕННЯ МАТЕРІАЛІВ КОСМІЧНИХ АПАРАТІВ

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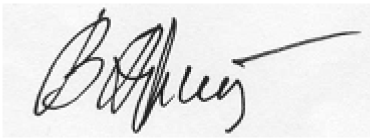

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