The Simulation of Pulsed Heater for a Sampling System for the Ion Mobility Spectrometer

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***Abstract* – The development of the sampling device with pulsed heating of the intermediate carrier for ion mobility spectrometer is described in this article. Numerical simulation of a pulse heater structure of is presented. The design of the sampling device using a pulsed heating of the intermediate carrier is developed. Experimental results of approval of the sampling device are presented.**

I. INTRODUCTION

Safety in public transport, places of a mass density of people, at the site of potential danger or high priority remains extremely important. For these purposes points of the control established at the airports, railway stations, port and customs terminals, should be equipped by the high-sensitivity equipment, that is sensitive to ultra low concentrations of explosives. The ion mobility spectrometry has been most demanded and widespread technology in these areas for the detection of trace of explosives over the past few years. Among the main advantages of devices based on this principle, it is possible to note simplicity of a design, compactness, low cost and possibility of operation in the field in real time.

Ion mobility spectrometers can detect the substance by sampling air from the environment and the research of composition of particles at different solid surfaces (documents, clothes, tickets, case handles, etc.). The most effective is the selection of trace of particles from the surface of objects with intermediate carrier, followed by heating and evaporation of the sample. The need for heating the intermediate carrier with the sample determined by a small amount of substance in the sample and low vapor pressure for a number of explosives. All existing portable ion mobility spectrometers, such as the Vapor Tracer, Ionscan, Sabre, Quantum Sniffer, as well as a spectrometer, developed at the Department of Micro-and Nanoelectronics MEPhI [1], have a heating unit of the intermediate carrier, which is constantly at high temperature. This leads to significant power consumption and time required to get the device to normal operating conditions.

The obvious solution to reduce energy consumption is the use of pulsed heating of the intermediate carrier. In this case, the intermediate carrier is placed in a heating device at low temperature, which prevents evaporation of samples during the positioning and the dependence of the results of further analysis of operator actions. In our case the analysis is started with moment of heating beginning. However, this approach is accompanied by a number of technological and structural problems associated with the requirements on the dynamics of heating and cooling, as well as issues of cleaning the device after a sample analysis. A similar approach is used in the design, use of pulsed heating of the gas-discharge lamp [2-3].

The purpose of this work is to simulate the pulsed heating of the intermediate carrier sampling device for ion mobility spectrometer.

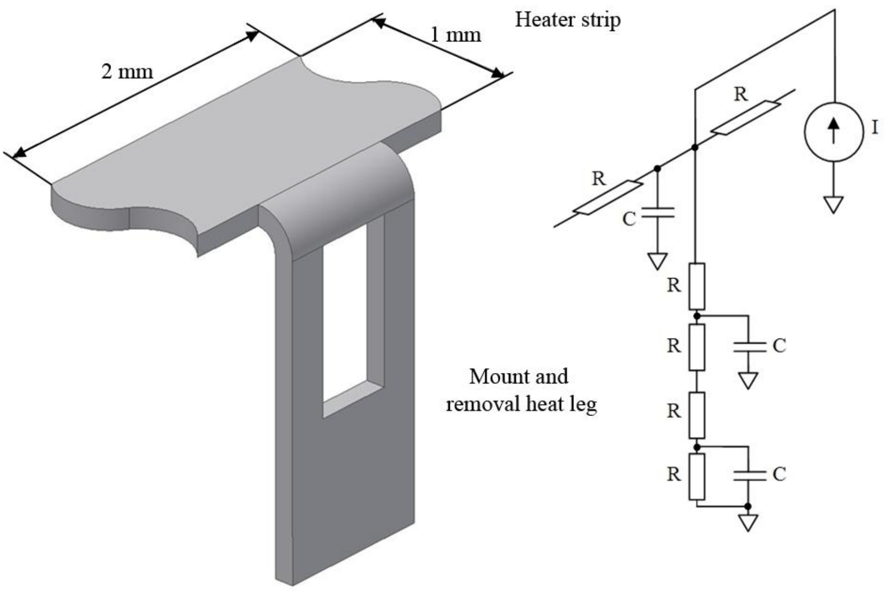

Figure 1. The structure of the segment and the equivalent circuit of the pulsed heater.

II. H EAT TRANSFER MODELING

The major task of development was the creation of a pulsed heater with dimensions of 25x25 mm for the heating section of the intermediate carrier at 200° C for 10 seconds, and then cools it to the initial temperature for the same period of time.

The heater consists of 12 same elements spaced 1 mm apart. The heater element represent a strip of stainless steel in the thickness of 0,125 mm with the sizes 25x1 mm. For support, positioning and removal of heat, each element has a number of legs that are soldered to the printed circuit board. For heating the intermediate carrier with the sample is used the heat transfer from the heater operating in pulsed mode, through an air gap. On top of 1 mm from the heater install grid to support intermediate carrier.

Typical segment of the strip heater is shown in Figure 1. Its dimensions are 2x1 mm. The figure also shows elements of the thermal equivalent circuit model parts of the segment.

To calculate the dynamics of heating and cooling were performed numerical simulations of the structure using the circuit simulation package SPICE. The model take account of the thermal resistance and heat capacity the section of pulsed heater and air gap, supporting grid and section the heated intermediate carrier with the particles of the sample

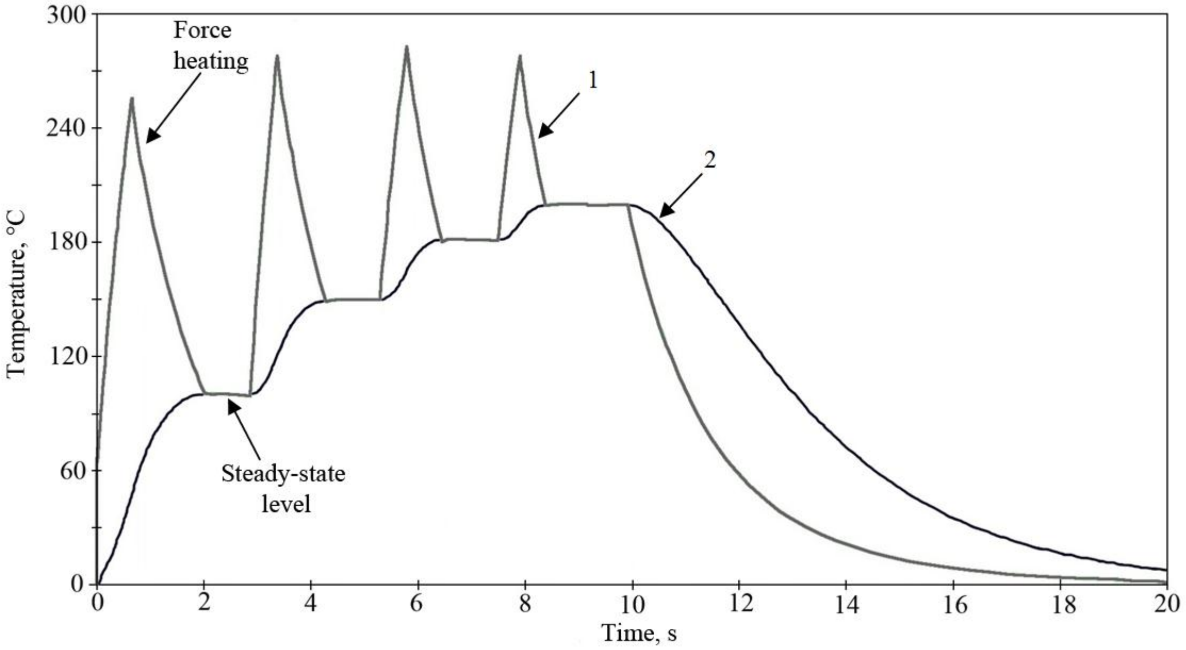

Figure 2. Dependence of temperature of a heater (1) and the intermediate carrier (2) from time.

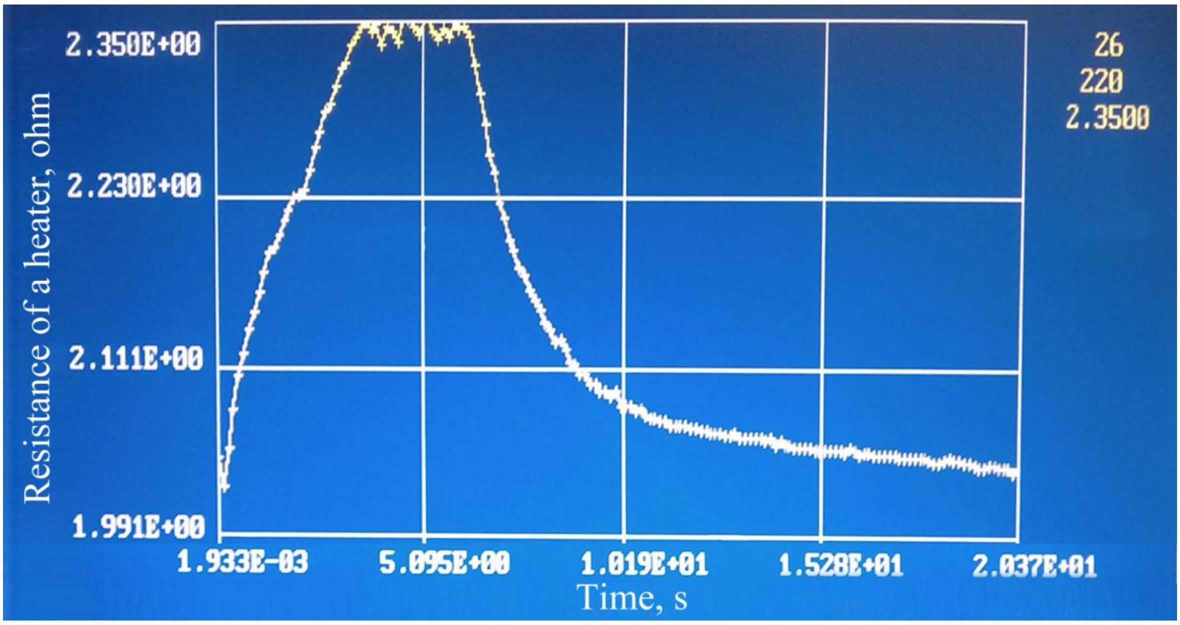

Figure 3. Changes of temperature of heaters in time.

Numerical calculation of the intermediate carrier heating dynamics for step change of temperature has been carried out. To accelerate the transition to the next level of the temperature of the intermediate carrier force increase in power pulsed heater and then get to the steady-state level is used. Model dependence of heating temperature on the time shown in Figure 2. From these results it is visible that for a ten-second interval it is possible to realize about 4 steps of heating of system. To improve the dynamics of heat necessary to reduce the air gap between the heater and the intermediate carrier to reduce its thermal resistance, and to ensure removal of the heat from the heater surface to the environment. Rapid cooling of the heater pulse is provided at a low temperature of the substrate through the attachment and support leg

III. EXPERIMENTAL RESULTS

Figure 3 shows the experimental dependences of the resistance heater at pulse heating. Curve shows the single-stage heating and cooling the heater pulse.

IV. CONCLUSION

The device sampling with pulsed heating of the intermediate carrier is developed.

The numerical simulation of a heater has allowed optimizing the dynamic characteristics of the device for power consumption and the dynamics of heating and cooling is carry out.

Tests of the device showed the possibility of rapid heating and cooling of the intermediate carrier for the typical cycle time of measurement. Further work will be directed to study the dynamics of evaporation of the sample in the analysis of trace amounts of explosives.

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