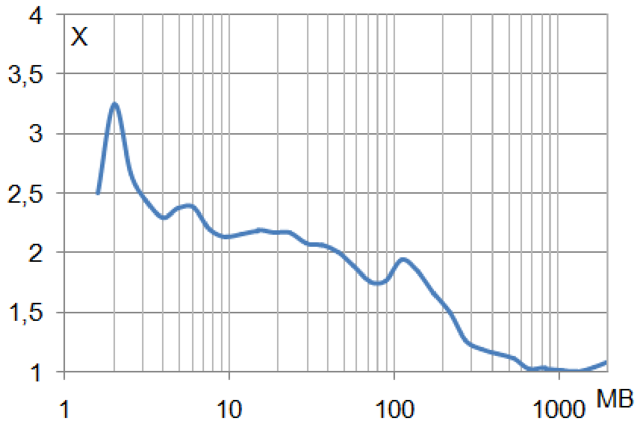

Figure 5 – The speedup (when saving data on Intel Optane DC P4800X compared to Intel SSD SC2BB48) vs. size of the stored block

III. CONCLUSIONS

A technique for fast calculating the characteristics and parameters of microstrip antennas and arrays using a resonator model and a modified Method of Integral Equations in a thin-wire approximation is developed. Significant acceleration of the calculation process is achieved through the use of CUDA technology and Intel Optane SSD.

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APPLICATION OF THE METHOD OF ELECTROTHERMAL ANALOGY FOR PREDICTION OF THE TEMPERATURE OF STRUCTURED SURFACES

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I. INTRODUCTION

Investigation of heating peculiarities of surfaces of different materials, as well as revealing the laws of temperature variation of such surfaces, can be useful in developing both the materials and the structure of their coatings. Such coatings can be special paints, that absorb radiation, screens or masking mesh to hide objects, and protective ablative materials, used to protect the surface from heating. For example, promising for development are coatings for unmanned vehicles or drones, providing stealth in different wavelength ranges or protecting them against heating by exposure of powerful laser radiation by enemy air defense systems.

Also promising are adaptive coatings, that ensure hiding of various ground and air objects in the infrared wavelength range from thermal imaging equipment. Cloaking is provided by reducing the temperature contrast of the object and the background, on which it is located, when the object is exposed to external solar radiation.

All the foregoing prospective coatings combine the fact, that the properties of materials at the micro and nano level, such as the structured surface, the porosity of the material, various dispersed inclusions, fundamentally influence the behavior of the material at the macro level, namely, the material's response to external radiation changes.

Laboratory studies of the dynamics of temperature changes of various structured surfaces cannot give complete information about the behavior of the material when exposed to solar radiation. In real conditions it is difficult to predict the further change in the temperature of the surfaces under study. Therefore, we need an analytical description of the obtained characteristics and the derivation of a function, describing the process under investigation with a minimum error of approximation, for the purpose of further predicting the temperature changes of the surfaces of various materials.

The aim of the studies was to determine the characteristics of the change in the temperature of various structured surfaces when irradiated with solar radiation during a certain observation interval. In the framework of the study, a task was set for an analytical description of temperature dependences using the method of electrothermal analogy.

II. METHODOLOGY OF THE EXPERIMENT

In the framework of laboratory studies, the surface temperature of the samples was determined on a stand, specially designed taking into account the features of the experiment [1].The stand is designed in such a way that it is possible, by registering infrared radiation, to obtain time dependences of the temperature variation of the surface of samples, heated by a source of solar radiation. For this purpose, an infrared camera that operates in the range of 8-14 microns is used in the stand, and halogen lamps are used as the radiation source, the total radiation intensity of which is chosen taking into account the intensity of the solar radiation. Also, the design of the stand, if necessary, allows the installation of both an infrared camera and a radiation source at various angles within 180° relative to the plane of the stage.

The samples under study were placed in special cuvettes of thermal-insulating material and placed in the center of the objective table of the stand. The surface temperature of each sample at the beginning of the experiment corresponded to the ambient temperature. The radiation source was set at an angle of 0° from the normal to the sample plane, and the infrared camera at an angle of 45°. Previously the radiation source was preheated within 3 minutes. After that, the radiation irradiated the surface of the sample, thereby subjecting it to heating. The change in temperature was registered by the infrared camera by recording the thermograms at time intervals determined taking into account the time of the experiment and the number of points necessary to obtain sufficiently accurate results reflecting the temperature dynamics. The obtained thermograms were analyzed with the help of software, as a result the average surface temperature of the sample was determined at each time of fixation of the thermal distribution. Thus, for each test sample, graphics of the temperature dependences of their surfaces versus time were plotted.

III. EXPERIMENTAL RESULTS AND DISCUSSION

For the experiment to determine the temperature of the structured surface, samples of aluminum were taken, the surface layer of which was formed by anodizing in a solution of oxalic acid. In this case into the channels of alumina of sample No. 1 was injected nickel, forming conductive columns whose height did not exceed half of the thickness of the dielectric layer. The thickness of the oxide layer for each sample was about 10 μm. The heating of each sample lasted 1 hour. Figure 1 shows plots of the surface temperature of the samples under study.

As can be seen from the given dependences, the surface of sample No. 1 is characterized by a higher absorbing capacity than the surface of sample No. 2. This effect is caused by the presence of a structure of nickel columns in the oxide channels, when interacting with which the radiation undergoes multiple reflections inside the surface layer, which ensures intensive absorption of the incident radiation by the formed surface. But the law of surface temperature variation for the two samples remains unchanged since the structure of the samples differs only in the surface layer. Thus, knowing the temperature dynamics corresponding to a certain surface structure, it is possible to predict a further change in temperature under the condition, that the intensity of the incident radiation is constant.

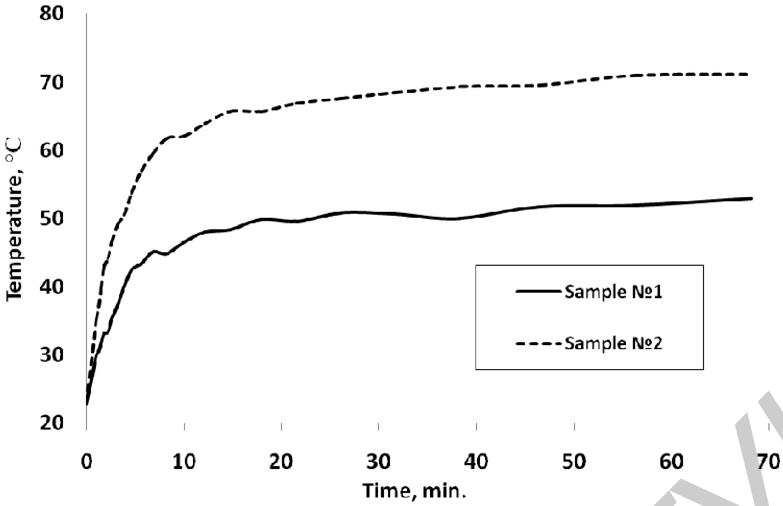

Figure 1 – Graphs of the dependence of the surface temperature of sample No. 1 and sample No. 2 on time

IV. ELECTROTHERMAL ANALOGY

The method of electrothermal analogy can be used to predict the temperature change of structured surfaces. Sample is considered in the form of an equivalent electric circuit of substitution [2]. Thus, description of the change in the temperature of the surface of the sample is based on the description of electrical processes occurring in an equivalent circuit. Figure 2 shows a simplified replacement circuitry, which is an electrothermal analogue of the stationary temperature regime of heating of the samples under study.

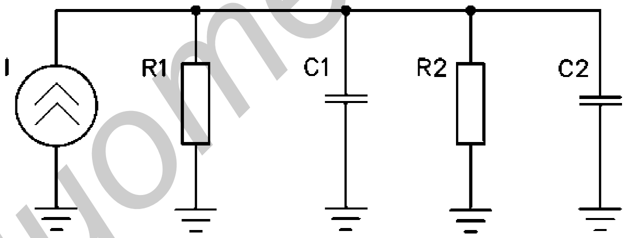

Figure 2 – Equivalent replacement circuit

This circuit is a second-order low-pass filter. In this substitution circuit, the electric capacity is an analog of the heat capacity of the substance, the electrical resistance is the thermal resistance of the substance. I.e. , and respectively. The first chain describes the behavior of the upper layer of the sample, and the second – the rest of its structure. In the substitution circuit, the current source is equivalent to the energy flux of solar radiation, since the radiated energy is constant per unit surface area of the substance and does not depend on the parameters of the irradiated surface under constant external conditions. Based on the electrothermal analogy, the process of changing the surface temperature of the sample will be described by the following function

(1)

where – the surface temperature of the sample at the initial time of the heating process, °C; – the surface temperature of the sample at the time when thermodynamic equilibrium with the environment is reached, °C; – the time constant for the surface layer of the sample, s; – the time constant for the aluminum layer, s.

The results of approximating the experimental data by the function (1) are shown in Figure 3.

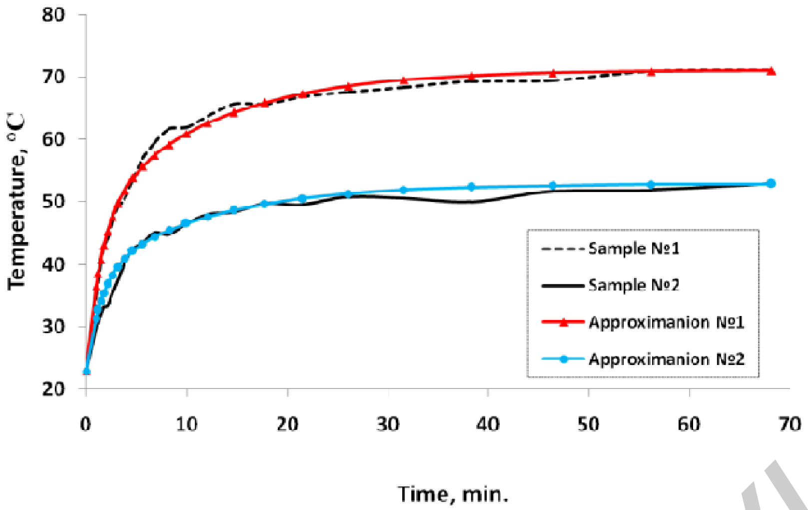

Figure 3 – Results of approximating the experimental data

Figure 3 shows that function (1) can be used to approximate temperature dependences, that was obtained experimentally. For the samples under study, the value of the time constant was the same, which indicates, that the addition of nickel increased the absorbing capacity of the surface, but practically did not affect the thermophysical characteristic of the oxide layer.

III. CONCLUSIONS

Based on the result of the work, it can be concluded, that the absorbing capacity of anodized aluminum depends on the structure of the oxide layer, and can be increased by the formation of nickel columns in the oxide channels. However, the law of temperature variation of the surface of aluminum samples in general will be the same.

Prediction of the temperature of structured surfaces can be carried out on the basis of the method of the electrothermal analogue, which allows replacing the actual sample with an electrical substitution circuit for simplifying thermal calculations.

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MAGNETORESISTANCE OF MULTILAYERED NANOSTRUCTURES

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I. INTRODUCTION

The technological achievements in recent years have made possible creation of ultrathin layers with an almost perfect structure and design of fundamentally new magnetic materials on their basis: magnetic multilayer nanostructures (MMNS) and superlattices. The discovery of the effect of giant magnetoresistance (GMR) in such systems gave a powerful impetus to the work on creation of superdense memory on magnetic media. However, the progress achieved so far in the field of creation of magnetic nanostructures makes possible as well other applications that traditionally perform semiconductor electronics.

In the field of fundamental research the GMR effect observed in a large number of MMNCs, consisting of alternating ferromagnetic and conducting non-magnetic layers, still attracts significant interest. The GMR effect is observed in many MMNCs, where ferromagnetic layers are separated by nonmagnetic metal layers with a 1-2 nm width. The resistance increases in the antiferromagnetic configuration and