As for Philae's drill, it was one of the last instruments to be activated before the lander switched off. Mission managers know the drill operated as expected, but because the probe was sitting at angle they don't know whether it delivered a sample to the instrument, which was designed to study molecules from the comet by heating material in an oven and measuring the resulting gas.

Fig. 2. Surface appearance of the comet 67P from a distance of 40 meters

Rosetta is now ramping up its scientific mission. The ESA has placed the spacecraft back into a higher orbit,30 kilometres above the comet, but it will dip to 20 kilometres on 3 December for 10 days to gather data on the increasing dust and gas spewing from 67P as it nears the sun. The plan is to stay as close to the comet as possible without putting Rosetta at risk from the comet's increasing activity.

In summary, use of passive video cameras and powerful software to sense direction and distance results in distinct advantages in a mission such as OLEV or Rosetta, which has to interact with objects that are not equipped with navigational aids to ease docking, and where low mass and power consumption is a primary requirement.

Landing on a comet was never going be easy. The European Space Agency's Philae spacecraft, the first robotic probe designed to grapple and drill a comet, bounced and skidded its way across the alien surface before settling in for what might be a long nap. The excitement of the landing may be dying down, but researchers are just beginning to take stock of events – and Rosetta, Philae's mother ship, might even get its own chance to touch the comet.

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АВТОНОМНЕ СТИКУВАННЯ З НЕКООПЕРОВАНИМИ КОСМІЧНИМИ ОБ'ЄКТАМИ

Традиційно, системи відносної навігації та бачення для зближення і стикування в космосі покладалися на коопероване об'єкти, такими що мали світловідбивачі, встановлені на космічному кораблі. Тому надійні системи на цільовій основі мають експлуатаційні обмеження, як цілі повинні бути встановлені на корисному навантаженні. Такі завдання, як автономне зближення і стикування, планетарні посадки зонда і навігації роботів вимагають більш високого рівня автономії. Системи бачення для цих застосувань необхідно буде ввести в експлуатацію відповідно з більш широким діапазоном умов. Порівняння двох успішних місій зі зближенням і стикування в 2014 році дає цікаві позначення для розвитку майбутніх систем.

Ключові слова: *супутникова зближення і стикування, система космічного бачення, автоматична навігація*

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АВТОНОМНАЯ СТЫКОВКА с НЕКООПЕРИРОВАННЫМИ КОСМИЧЕСКИМИ ОБЪЕКТАМИ

Традиционно системы относительной навигации и видения для сближения и стыковки в космосе полагались на кооперированные объекты, таки, что имели светоотражатели, установленные на космическом корабле. Поэтому надежные системы на целевой основе имеют эксплуатационные ограничения, так как цели должны быть установлены на целевой нагрузке. Такие задачи, как автономное сближение и стыковка, планетарные посадки зонда и автоматической навигации требует более высокого уровня автономии. Системы видения для этих приложений необходимо будет ввести в эксплуатацию в соответствии с более широким диапазоном условий. Сравнение двух самых успешных миссий с сближения и стыковки в 2014 году дает интересные направления для развития будущих систем.

Ключевые слова: *спутниковые сближения і стыковки, система космического видения, автоматическая навигация*

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SELECTIVE ENERGY-SAVING METAL-DIELECTRIC NANOCOMPOSITE COATINGS BASED ON COPPER

Spectral selective characteristics of metal-dielectric nanocomposite coverings on the basis of copper are investigated. The computing algorithm of determination of coefficients of reflection and a transmission of nanocomposite metal-dielectric structures on the basis of copper in dielectric matrixes of SiO2 is developed. Numerical modeling of their optical characteristics in the spectral range from 0.3 to 3 microns for various options of structures is executed. Possibilities of practical realization and application of nanocomposite structures on the basis of copper as the energy saving are discussed.

Keywords: *metal-dielectric structure, spectral-selective properties, nanocomposite coatings, energy saving.*

Introduction. Scientific and technological research on the development of energy-saving coatings in many countries belong to the priority areas of science and technology as the main attention is paid to date save energy resources.

Such coatings can be used as transparent heat filters, photothermal and photovoltaic cells with improved efficiency [2].

Special interest are transparent nanocomposite coatings with energy-saving properties based on nanoscale metal layers on optically transparent dielectric substrate to reduce energy losses due to light gaps [5, 6].

Analysis of the current state of energy consumption shows that the order of half the energy consumption accounts for the maintenance of thermal and lighting comfort indoors. Of these, 40% is lost through the light transparent gaps. In Ukraine such losses equivalent to the annual expenses of gas in 8 billion cubic meters in May 2014 prices, equivalent to 4 billion dollars. About 50% of energy loss accounts for the thermal radiation of glass of light gaps in the near infrared (IR) wavelengths. Removal of such losses is possible only through the use of heat-reflective filters based on transparent surfaces. By the experimental data are listed energy saving coating reduces heat losses from 50% to 2%.

Energy-saving coatings is being implemented mainly based on multilayer structures formed from thin films of silver and dielectric. These coatings have a high cost due to the use of precious materials. These coatings have significant drawbacks: high cost; possibility of degradation characteristics of multilayer coatings; insufficient mechanical strength; sophisticated manufacturing techniques and control parameters of multilayer structures; limited choice of materials for energy-saving features, etc. [2, 5, 6]. To avoid a large part of these drawbacks is proposed by the manufacture of nanocomposite metal-dielectric structures with energy-saving features based on the widely used in microelectronic technology metals, including copper [3, 8].

The aim of this work is to develop nanocomposite metal-dielectric coatings based on copper for use in energy-saving technologies.

Experiment technique. For the numerical simulation of optically transparent nanocomposite coatings used metal-dielectric structure consisting of thin layers of dielectric and metal on a dielectric substrate.

To calculate the parameters of spectral-selective characteristics of the electromagnetic response of each layer and the whole system is developed computational algorithm based on transfer matrix method [3, 4, 9]. This method is based on the theory of plane electromagnetic waves in a layered system [1].

An advantage of the method is that it does not impose any restrictions on the number of layers and can be used to calculate both the multilayer and single layer structures.

The calculations were performed under the following approximations:

- Layered structure consists of N plane-parallel, homogeneous, isotropic layers;
- Each layer is characterized by the effective thickness d_i (i – the index of the layer), the spectral complex electromagnetic parameters ε_i^* and μ_i^*;
- Coating located between two semi-infinite homogeneous isotropic medium (in this case there is air with a refractive index equal to unity).

In accordance with [4, 9], we represent the tangential terms of $E_\tau(z_1)$ and $H_\tau(z_1)$ are the electric E and magnetic H fields in the form of a two-dimensional vector:

$$G_i(z_i) = \begin{vmatrix} E_\tau(z_i) \\ H_\tau(z_i) \end{vmatrix} \quad (1)$$

The nature of electromagnetic wave propagation in layered environments will be determined by the terms of the continuity of E and H:

$$G_i(z_i) = G_{i+1}(z_{i+1}) \quad (2)$$

Given the continuity conditions (2) in [1] that the vectors $G_i(z_i)$ and $G_i(z_{i+1})$ are related as follows:

$$G_i(z_i) = M_i G_i(z_{i+1}) \quad (3)$$

or

$$G_i(z_i) = \begin{vmatrix} M_{11} & iM_{12} \\ iM_{21} & M_{22} \end{vmatrix} G_i(z_{i+1}) \quad (4)$$

The characteristic matrix M of i-layer provided homogeneity is [4, 9]:

$$M_i = \begin{vmatrix} \cos D_i & i\left(\frac{1}{u_i}\right)\sin D_i \\ iu_i \sin D_i & \cos D_i \end{vmatrix}, \quad (5)$$

where

$$u_i = \begin{cases} n_i \cos\varphi_i - \text{s - components}, \\ \dfrac{n_i}{\cos\varphi_i} - \text{p - components}, \end{cases} \quad (6)$$

$$D_i = \frac{2\pi}{\lambda} n_i d_i \cos\varphi_i, \quad (7)$$

where λ is the wavelength of electromagnetic radiation; φ_i is the angle of refraction of a i-environment; s is the polarization component of the electric field in a perpendicular plane to the plane of incidence; p is the polarization component in the plane of incidence.

Owing to a condition of continuity (2) on limit of the section of two environments the transfer matrix through border is single.

The transfer matrix through all layered structure of M, according to [1, 9] presents work of characteristic matrixes of separate layers in it to M_i, starting with that on which the wave falls:

$$M = \prod_{i=1}^{N} M_i. \quad (8)$$

The full matrix of transfer of layered structure, as shown in work [9] has an appearance:

$$W_{(N+1),0} = V_{N+1} M V_0^{-1} \quad (9)$$

where

$$V_i = \frac{1}{2}\begin{vmatrix} 1 & \frac{1}{u_i} \\ 1 & -\frac{1}{u_i} \end{vmatrix}, \qquad V_i^{-1} = \begin{vmatrix} 1 & 1 \\ u_i & -u_i \end{vmatrix}. \quad (10)$$

Elements of a matrix W of layered structure are Fresnel amplitude coefficients of a transmission and reflection. For limit of the section between i and m layers the matrix of transfer is defined by a ratio:

$$W_{im} = \frac{c_{im}}{t_{im}} \begin{vmatrix} 1 & -r_{im} \\ r_{im} & d_{im} \end{vmatrix} \quad (11)$$

where

$$d_{im} = t_{im} t_{im} - r_{im} r_{im} \quad (12)$$

$$c_{im} = \begin{cases} 1 - \text{s - components}, \\ \dfrac{\cos\varphi_i}{\cos\varphi_m} - \text{p - components}, \end{cases} \quad (13)$$

where $t_{im}, t_{im}, r_{im}, r_{im}$ are respectively the amplitude transmission and reflection coefficients for a beam incident from the *i*-environment on the border with the m- environment.

Thus, on the basis of ratios (9) we find amplitude coefficients of a transmission and reflection of multilayered structure, using data about electromagnetic parameters and thickness of separate layers.

Energy monochromatic coefficients of a transmission of T_λ and R_λ reflections from a covering for unpolarized light according to [4, 9] are represented by ratios:

$$T_\lambda = \frac{n_2 \cos\varphi_2}{n_1 \cos\varphi_1}\left(\frac{|t_{\lambda s}|^2 + |t_{\lambda p}|^2}{2}\right), \quad (14)$$

$$R_\lambda = \left(\frac{|r_{\lambda s}|^2 + |r_{\lambda p}|^2}{2}\right), \quad (15)$$

where $r_{\lambda s}, r_{\lambda p}$ are the monochromatic Fresnel amplitude coefficients of reflection for s- and p-polarized light components from the coating; $t_{\lambda s}, t_{\lambda p}$ are the monochromatic Fresnel amplitude coefficients of transmission for s- and p-polarized light components; $\cos\varphi_1$ and $\cos\varphi_2$ are cosines of the angles formed by the ray and the normal to the surface of the environment, with the refractive index n_1 and n_2.

Value of $\cos\varphi_2$ is defined by the expression given [8]:

$$\cos\varphi_2 = \frac{1}{n_2}\sqrt{n_2^2 - n_1^2 \sin^2\varphi_1} \quad (16)$$

On a basis above the presented ratios the algorithm of calculation in the program MATLAB environment is developed for power coefficients of a transmission and reflection of metal-dielectric structures.

The initial data for the calculation of dielectric structures with energy-saving properties apply values of the optical parameters of thin-film layers of copper and dielectric layers SiO_2 [7].

Results. Results of numerical modeling of spectral dependences of coefficients of reflection and transmission in the range from 0.3 to 3 microns of lengths of waves metal-dielectric structures with nanoscale layers of copper and anti-reflect layers on the basis of oxide of silicon (SiO_2-Cu-SiO_2) are given in Fig. 1, 2 and 3.

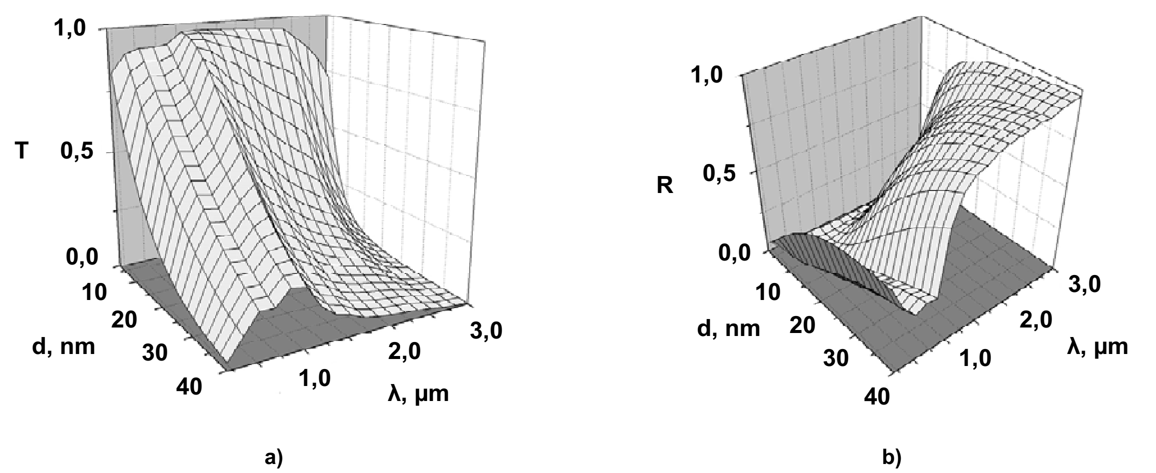

Fig. 1. Spectral dependence of coefficient of reflection of R (a) and coefficient of a transmission of T (b) of structure of SiO_2-Cu-SiO_2 (the top layer of SiO_2 = 50 nanometers) at various values of thickness of a metal layer

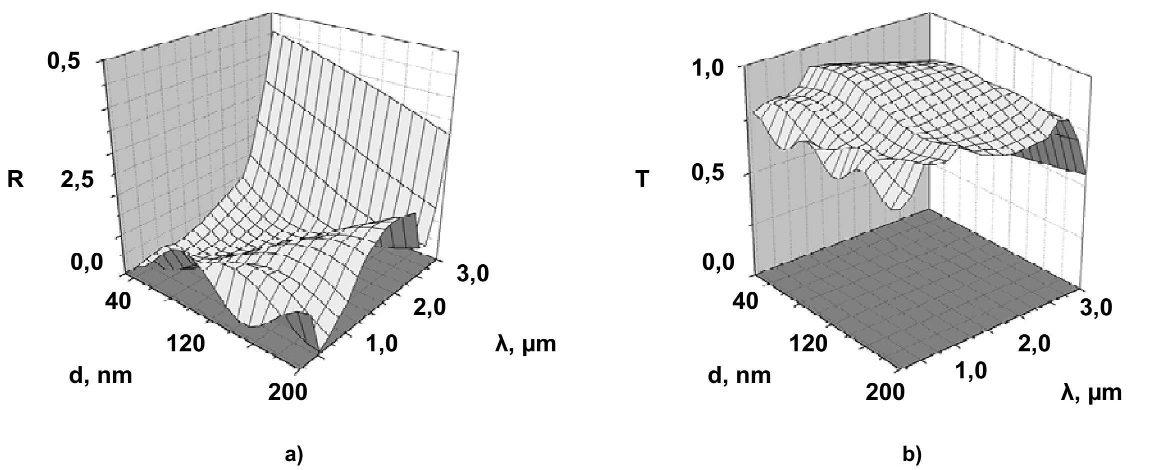

Fig. 2. Spectral dependence of coefficient of reflection of R (a) and coefficient of a transmission of T (b) of structure of SiO_2-Cu-SiO_2 (Cu=4 nanometers) at various values of thickness of a dielectric layer

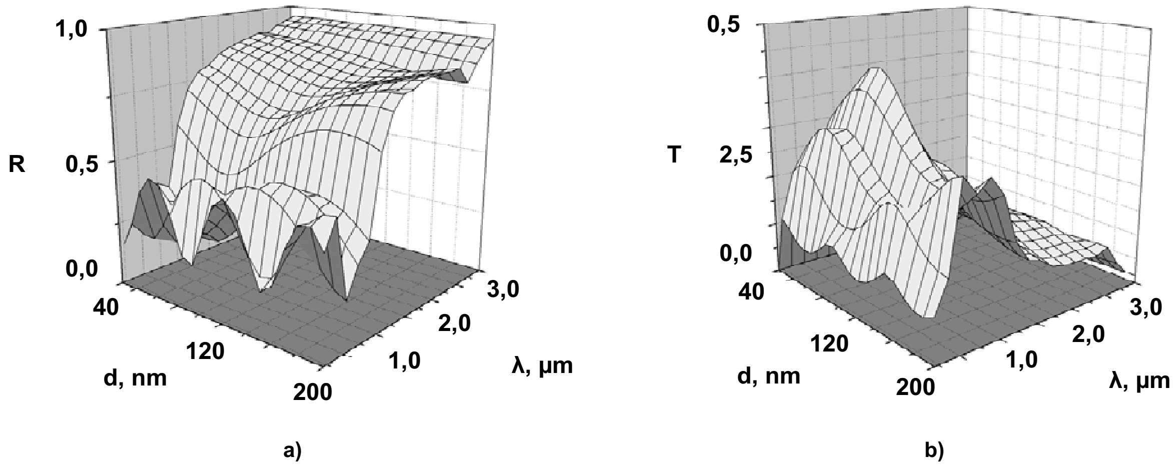

Fig. 3. Spectral dependence of coefficient of reflection of R (a) and coefficient of a transmission of T (b) of structure of SiO_2-Cu-SiO_2 (Cu=30 nanometers) at various values of thickness of a dielectric layer

Follows from Fig. 1 that in the spectral range of 0.3÷0.7 microns for copper layer thickness to 40 nanometers values of coefficient of reflection are observed low (to 0.2). Thus, in the spectral range over 2 microns for a copper layer more than 15 nanometers of value of coefficient of reflection increase to 0.9.

From Fig. 2 and 3 it is visible that change of thickness of the clarifying layer of SiO_2 doesn't lead to essential change of nature of spectral dependence of coefficient of reflection and a transmission.

Representation results show that changing parameters of structure of a metal-dielectric covering on the basis of copper it is possible to change values of coefficient of reflection and a transmission in the spectral range from 0.3 to 3 microns. The obtained results make it possible to determine the parameters of metal-dielectric structures to provide the necessary spectral-selective characteristics. Analysis of the results of numerical simulations show the possibility of using metal-dielectric structures based on copper as energy-saving coatings of various practical applications.

Structures of SiO_2-Cu-SiO_2 with nanoscale layers of copper up to 5 nanometers thick and with the clarifying layer to 170 nanometers can recommend to be used as energy saving low-issue coverings for a frigid climate (Fig. 2). And for copper thickness about 15 nanometers and with the clarifying layer of 50 nanometers – as energy saving low-issue coverings for warm climate (Fig. 1).

For structures with thickness of a nanoscale layer of copper of 30 nanometers it is characteristic values of coefficient of a transmission at the level about 0.5 in the spectral range of 0.3÷0.76 microns. It allows recommending for use such metal-dielectric structures as reflex coverings for warm climate (Fig. 3).

Conclusions. The computing algorithm of calculation of spectral dependences of coefficients of reflection and transmission of nanocomposite coverings with metal and dielectric components on the basis of a method of matrixes of transfer is developed.

Numerical modeling of spectral characteristics of metal-dielectric structures on the basis of nanoscale films of copper with transparent dielectric layers is carried out.

Recommendations of practical application of metal-dielectric structures on the basis of nanoscale films of copper as transparent heat-reflecting filters in energy saving technologies are made.

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ЕНЕРГОЗБЕРІГАЮЧІ НАНОКОМПОЗИТНІ ПОКРИТТЯ НА ОСНОВІ МІДІ

Досліджено спектрально-селективні характеристики металодіелектричних нанокомпозитних покриттів на основі міді. Розроблено обчислювальний алгоритм визначення коефіцієнтів відбиття та пропускання нанокомпозитних металодіелектричних структур на основі міді в діелектричних матрицях SiO2. Виконано чисельне моделювання їх оптичних характеристик в спектральному діапазоні від 0,3 до 3 мкм для різних варіантів структур. Обговорюються можливості щодо практичної реалізації та застосування нанокомпозитних структур на основі міді в якості енергозберігаючих.

Ключові слова: *металодіелектричні структури, спектрально-селективні характеристики, нанокомпозитні покриття, енергозбереження.*

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ЭНЕРГОСБЕРЕГАЮЩИЕ НАНОКОМПОЗИТНЫЕ ПОКРЫТИЯ НА ОСНОВЕ МЕДИ

Исследованы спектрально-селективные характеристики металлодиэлектрических нанокомпозитных покрытий на основе меди. Разработан вычислительный алгоритм определения коэффициентов отражения и пропускания нанокомпозитных металлодиэлектрических структур на основе меди в диэлектрических матрицах SiO2. Выполнено численное моделирование их оптических характеристик в спектральном диапазоне от 0,3 до 3 мкм для различных вариантов структур. Обсуждаются возможности практической реализации и применения нанокомпозитных структур на основе меди в качестве энергосберегающих.

Ключевые слова: *металлодиэлектрические структуры, спектрально-селективные характеристики, нанокомпозитные покрытия, энергосбережения.*

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SYNTHESIS OF NANOELECTRONIC DEVICES WITH PROGRAMMABLE STRUCTURES

The synthesis of reliable programmable nanoelectronic devices based on the technology of quantum automata has been described.While constructing majority circuits of combinational and sequential types the theory of finite automats is using. The order of construction and programming of various types of arithmetic-logic devices has been analyzed.

Keywords: *quantum nanodots, majority elements, field programmable gate array.*

Introduction. The contradictions between specialization and universatility can be eliminated through the development of field programmable gate array (FPGA), which algorithms of work can be changed at the request of the designer of a particular computer equipment, that is by creating the arithmetic logic circuits with programmable features.

Relevance of research. The development of theory and practice of using a majority principle is an urgent problem at present time, because the performance of nanoelectronic computing systems with programmable structures significantly reduces their cost and greatly simplifies the phase of automated circuit design. One programmable nanocircuit replaces from 30 to 150 integrated circuits with medium scale of integration.

Problem statement. The problem of developing the design principles of the reliable computer technology is very important nowadays. Application of mathematical and circuit analysis along with computer aided design can significantly improve the reliability of designing devices.

Main material. The most promising area of nanoelectronics is creation of multi-functional subsystems when one module combines a large number of logic elements into a single functional unit, intended to implement complex logic functions. These subsystems must satisfy the following basic requirements:

- have a minimum number of external connections;
- have a hardware compatibility;
- use the same type of cells if it is possible;
- have a property extension, that is to have a flexible structure.

To implement systems with variable structure (adaptive system), besides, it needs to be able to programmatically change the technical parameters of the subsystems during or before work. In terms of cheapening of nanoelectronic subsystems and improving the reliability of their work they should be performed on the same type of cells with the same configuration of connections between cells [1].

Programmable nanoelectronic device, which consists of three universal majority elements (UME), duly connected to each other (fig. 1), can be used as such cell to build majority adaptive systems (MAS). Informational (x_3, x_2, x_1, x_0) and control signals (r_2, r_1, r_0) are submitted to the inputs of UME [2].

With the help of FPGA of this type all the functions of two or three arguments can be implemented, including functions of sum, difference, carry and loan, functions of one, two and three memory elements, and some functions of four or five arguments. The feature of FPGA is that its logical possibilities and connections may be changed by the program that allows it to be used for constructing of MAS. The most important functions in majority basis, implemented on the base of FPGA, are shown in table 1.

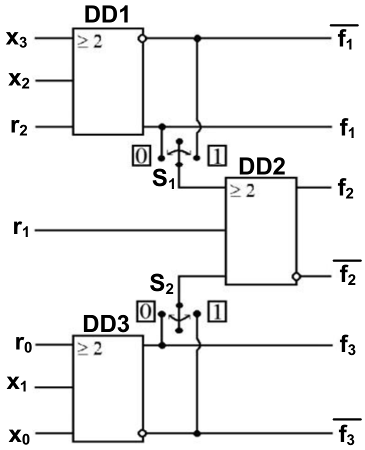

Fig.1. Block diagram of a universal programmable nanoelectronic device

FPGA is a functionally complete unit, because in its composition are functionally complete UME.

Synthesis of majority systems on the base of FPGA is recommended to do according to the following order:

1. The bolean functions, which are specified or obtained, are presented in majority basis.
2. The minimization of obtained majority function is performed.
3. The row, which is equivalent to the minimum form of the majority function, is sought in table 1.
4. A block diagram of the given subsystem is created, considering the opportunities of UME and specified number of inputs.

The functioning of the systems on quantum cellular automata (QCA) is based on the interaction of Coulomb forces of quantum dots for performing logic functions. They are designed to reduce the use of transistors and to solve the problems of density and connection of devices. The cellular automata consists of grouped quantum dots, connected with tunnel junctions and capacitors. Quantum