Mathematical and Computer Modelling and Approach to Describe the Fractal Nanocluster Systems on Solid Surface; Formation of Conductive Coatings and Studies of the Electrophysical Characteristics of the Deposited Layer

D N Bukharov[1], A A Antipov[2], and S M Arakelian[1]

[1]*Physics and Applied Mathematics, Stoletovs Vladimir State University, 87 Gorky st, 600000 , Vladimir, Russia. Contact Phone: ++79162646041*

[2]*Institute on Laser and Information Technologies of the Russian Academy of Sciencies (ILIT RAS), 1 Svyatoozerskaya st, 140700, Shatura, Russia*

Contact Email: arak@vlsu.ru

1. A promising method for obtaining the metallic/bimetallic/semiconductor nanocluster systems by droplet deposition on the solid surface from colloid system (at room temperature), initially obtained by laser ablation technique, is presented, and allows the required coatings to be condensed in a controlled manner. The topology of the obtained structures significantly depends on the characteristics of the liquid fraction, the types of colloid particles, the temperature of the droplet and the substrate. The process of formation of structures was considered as a result of both the natural drying of the droplet and the forced process under the action of laser radiation.

2. The classification of the obtained samples in accordance with their fractal dimension makes it possible to determine the basic models that, in the first approximation, are applicable to describe the structure of the samples obtained by us. In connection with the obvious fractal nature of the obtained nanoclusters, the approaches of fractal geometry are applicable for modeling their structure. Today there are a number of algorithms for generating fractal objects. The processes of formation of the systems of nanoclusters are rather complex, and are caused by the influence of many factors that are difficult to take into account. Therefore, adequate models describing the structure of such samples should not be completely deterministic but contain random parameters that allow taking into account random factors. Such properties are possessed by models based on randomized fractals, which can be generated by various methods.

3.The formation of thin-film conductive coatings on a solid dielectric substrate was carried out by the action of focused laser radiation (wavelength 1,064 microns, power 10 W, scanning speed from 1 to 15mm/s, laser pulse duration 200 ns repetition, frequency 20 kHz) on both single-component and two-component colloidal system solutions. The colloidal solution was a mixture of, first, a liquid phase – from glycerol and, second, nanoparticles – Cu, Ni, obtained by laser ablation when these metal targets were placed in a liquid. In the first part of the electrical conductivity measurement experiments, the deposited linear structures obtained from a colloidal solution with copper particles were investigated. Depending on the number of passes and the scanning speed, deposited structures with different packing densities of nanoparticles were formed. As a result, they had different volt-ampere characteristics, and the resistivity calculated from these data was about 40.8 and 55.4 kOhm·m.

4.The principal achievement of this approach is the opportunity of obtaining a deposited layer with practically any multi-element composition of both the required concentration and topology. This is essentially an universal and easily developable future technologies for obtaining high-entropy materials of the desired composition, selected for the required improved functional characteristics of thin-film nanocluster structures of various purposes for solving problems of nanophotonics, nanoelectronics, and also coating the surface of critical parts to increase wear resistance in complex products. A prerequisite for the actual creation of such prototypes by considered technology is to conduct research, in progress, to determine the criteria for achieving their reliability and durability in different operating conditions, including extreme (high temperatures and gradients, vibrations, aggressive environment, exposure to external radiation). Obviously, this needs to be study for each specific application area of use.