Template as an Instrument of Group Nanotechnology

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Methodology of template formation on basis of photosensitive nanocomposite materials in electrophotographic process is worked out. Spatial surface relief modulation and built-in film charge is realized by method of optical holography with the help of exposure by a light field. It is shown by methods of optical microscopy and scanned force microscopy that gold nanoclusters formation at spraying on template surface in vacuum happens only in determined, spatially ordered surface areas.

Keywords: Template, Electret, Optical holography, Electrophotographic process, Self-organization.

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1. INTRODUCTION

The task of material structuring in nanoscale is one of main objects in nanotechnologies. An important run of nanotechnologies is an organization of nanoobjects ordering processes with the help of templates. Template, a system, organized in space, is an instrument for organization in space and time of physic and chemical processes of nanoobjects structuring on its surface for account of near field nanoobjects interaction with template structure.

In molecular technology template is regarded as a macromolecular model for synthesis of other macromolecules. In nanoengineering a template synthesis is determined as a design of materials of determined size, form and with defined chemical surface properties [1]. Template can be regarded [2, 3] as an attribute of supermolecular chemistry, that is an ensemble and intermolecular interactions. In the difference from traditional chemistry, which, manipulating by chemical junctions from a defined element outfit creates an uncountable world of molecules, supermolecular chemistry uses univalent interactions for creating and organizing of supermolecular ensembles from a limited molecules outfit. In supermolecular chemistry defined factors are a size and a form or a space molecules complementarity, but not their reactive capability. Methods of supermolecular chemistry allow to unite coordinate-saturated molecules, which didn't come into chemical interaction, into new chemical objects with new physic and chemical properties.

It is considered that structure is caused by determined space material organization as a minimum in nano- and microsizes scale thanks extremely hard hierarchical interaction organization in open schemes. Therefore one of some effective ways of creating of new materials is templates using – such systems, which initiate a structure formation with a given type of content elements ordering [4]. In [5] two templates synthesis ways were regarded. Template synthesis top-down (photo-, X-ray, electric and ion-beam lithography, laser etching) goes on by the way of material removing from macroscopic objects. Template synthesis bottom-up goes on by the way of self-organization of molecules, atoms or nanoclusters. A destructive power of such process is a define chemical or a physical mechanism.

Creating of a tunnel and atomic-power microscopes gave a possibility to manipulate by detached atoms and nanoparticles, to build from them ordered molecular structures. These researching methods give a big volume of various and most detailed information concerning nanoobjects, but they are individual in their nature. It limits its practical use in manufacture goods. Mass manufacture goods is based on using of group methods. One of approaches to nanotechnologies development may be an organization of nanoobjects self-ordering processes with the help of templates.

Thin films of photoconductive materials may be regarded as an environment, and an electrophotographic process as an instrument for templates formation. Relief and field topologies of template surface are formed in electrophotographic process by methods of optical holography with the help of exposure by light field [6, 7]. Template size contains some square centimeters. Characteristic space frequency formed by such way these structures lies in submicron range. Electric field tension at template surface is in order of 100 MV/m. Local fields of film surface are compensated by the way of applying on template [8] of exterior sphere with using of organic molecular junctions, nanoparticles, organics – non-organics and biological objects. Topological motive of template causes a space organization of nanoobjects at its surface, which is controlled by optical methods [9, 10].

The purpose of work is a development of methods of templates producing on basis of photosensitive nanocomposite materials in electrophotographic process.

2. MATERIALS AND EXPERIMENT METHODS

Photowired sphere of template was applied from solution, was dried during one hour at temperature of 80 °C. Formation was done by electrophotographic method at example exposure by hologram after three-rayed scheme with cone angle at apex of 25°. Photowired sphere had an area of spectrum sensitivity of 0,4÷0,95 μm, holographic sensitivity at diffractive efficiency 1 % composed of 500 m²/J, space frequency

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stripe of 300÷1000 lines/mm. Time of surface relief formation composes some seconds. A characteristic showing was provided by automation of hologram registration process with the help of controlled module [6]. Automatic registration of holograms on a film of nanocomposite polymeric semiconductor includes three main stages (Fig. 1)

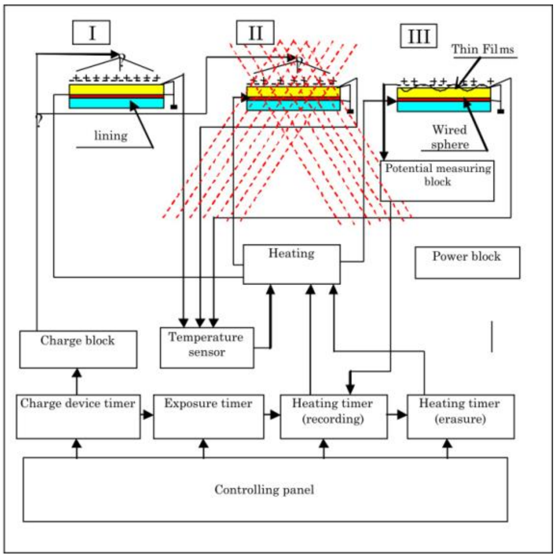

Fig. 1 – Hologram recording scheme. I – preparing to hologram registration, - uniform charge of film surface in corona discharge; II – exposition by hologram during that surface thickness modulation of electrostatic charge goes on and creating of electrostatic picture at film surface in result of light-induced conductivity; III – hologram development by fast controlled film heating; modulate electrostatic image is formed in film surface relief

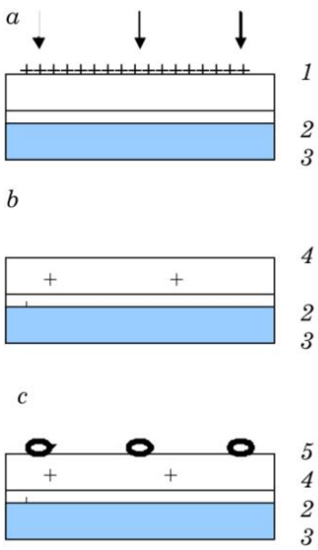

Fig. 2 – Formation scheme on template system surface of ordered placed gold clusters at gold sputtering in vacuum: *a* – exposure by hologram of charged film in photoconductor; *b*– formation of given charges at exposure; *c* – gold adsorption in fascicles of electric field and formation of gold clusters: *1* – charge at film surface, *2* – photoconductor film, *3* – conductive lining, *4* – given electric charge, spacely oriented by light, *5* – adsorb clusters

In places of film radiation the formation is possible not only of a relief (relief template), but also a given charge (electret template) (Fig. 2). Formation way of such electret systems and their control method was proposed by authors [6, 7].

Gold sputtering was researched by thermal method at pressure of residual gases $p \sim 10^{-2}$ at evaporation from tantalum rectifier.

3. RESULTS AND THEIR DISCUSSION

Examples researching were researching after scheme on light at optical device Biolam at increasing of 800. Surface morphometry was researched at scan atomic force microscope (AFM) Nanoscope in periodical contact by silicon probe with nominal radius of edge rounding of 10 nm.

Template surface image in optical microscope is shown at Fig. 3. Space two-measured periodic structure is formed by modular relief of film surface (Fig. 3a). In result of thermal vacuum gold sputtering at template surface the structure is formed (Fig. 3b), which is a system of spacely ordered gold edges.

There is a fact that pays attention that a gold is compensated in defined local areas, but doesn't distribute uniformly by surface. It should have waited that at sputtering on relief surface a gold will also be condensate on cups bottom, but it didn't happen. Locating and symmetry of local gold particles are given by lining structure.

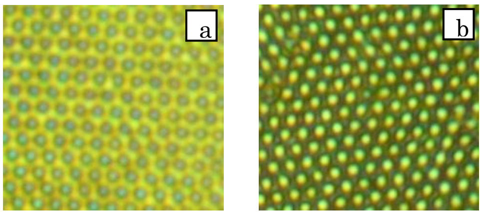

Fig. 3 – Films examples image in optical microscope: a – surface relief, b – adsorbed gold particles on surface, (dark areas). The period of structure is nearly 2 μm

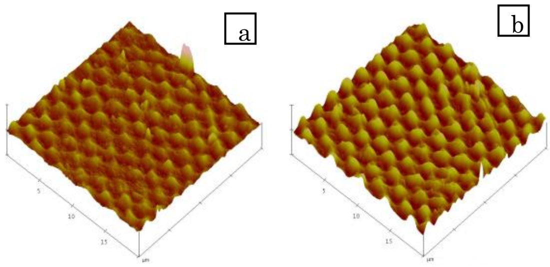

Fig 4 – Three-measured relief image of film surface, received by AFM method. Horizontal scale is 5 μm of division, vertical scale is 1000 nm of division. a – relief of polymeric film after hologram recording, b – surface relief after applying of gold on polymeric film a

Polymeric template surface has a periodic relief by height of 350 nm, Fig. 4-5, then a gold sphere template is 500 nm. So, one may to calculate approximately average sizes of gold edges: diameter becomes 400-600 nm, height is 150 nm.

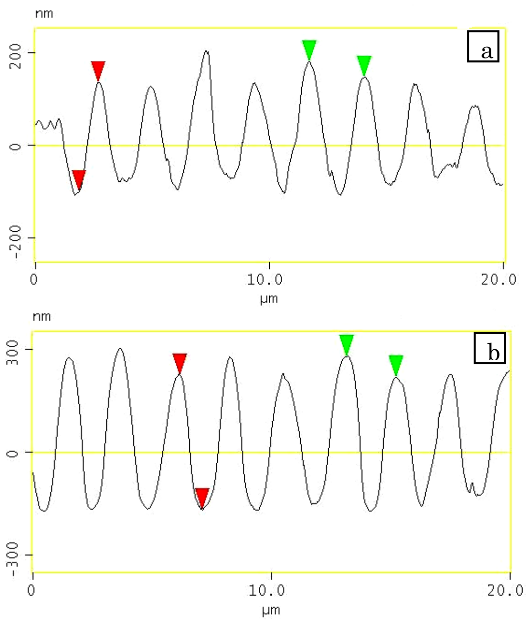

Fig. 5 – Relief of examples surface of polymeric film, received by AFM method. a – polymeric film relief after hologram, b – surface relief after applying of gold on polymeric film

Gold edges are extremely formed in areas, which are correspond to maximum tension of local field and given charge in surface area. In cups area, where exposure light field intensity had a minimum and given charge is not formed, gold clusters are no deposited. It may be thought that a movement is a mechanism of gold self-ordering during thermal sputtering in vacuum at template surface, atoms and clusters of molecular fascicle of gold, in local electric field near the surface. A high polarization of gold atoms leads to appearing of forces, which draw atoms and nanoparticles in gradient area of electric field [11]. Electric field with a great quantity and great gradient is localized near template surface in area of arrangement of localized electric charge.

4. CONCLUSIONS

1. Relief polymeric template by square of ~ 1 cm^2 with a period near 2 μm is formed by electrophotographic method at example exposure of polymeric photoconductor by hologram after three-rayed system.
2. Electric template is formed by electrophotographic method after the way [6, 7].
3. Templates surface morphology is researched by methods of optical microscopy and atomic force microscopy. It is shown that an effective self-ordering of gold nanoclusters at sputtering in vacuum appears on electret template surface. Diameter of gold clusters contains 400-600 nm, height is 150 nm.

Темплат як інструмент групової нанотехнології

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Розроблено методику формування темплату на основі фоточутливих нанокомпозиційних матеріалів в електрофотографічному процесі. Просторова модуляція рельєфу поверхні та вбудованого в плівку заряду здійснюється методами оптичної голографії за допомогою експозиції світловим полем. Методами оптичної мікроскопії та скануючої силової мікроскопії показано, що формування нанокластерів золота при напиленні на поверхню темплату у вакуумі відбувається лише певних, просторово упорядкованих областях поверхні.

Ключові слова: Темплат, Електрет, Оптична голографія, Електрофотографічний процес, Атомне впорядкування, Самоорганізація.

Темплат как инструмент групповой нанотехнологии

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Разработана методика формирования темплата на основе фоточувствительных нанокомпозиционных материалов в электрофотографическом процессе. Пространственная модуляция рельефа поверхности и встроенного в пленку заряда осуществляется методом оптической голографии при помощи экспозиции световым полем. Методами оптической микроскопии и сканирующей силовой микроскопии показано, что формирование нанокластеров золота при напылении на поверхность темплата в вакууме происходит только в определенных, пространственно упорядоченных областях поверхности.

Ключевые слова: Темплат, Электрет, Оптическая голография, Электрофотографический процесс, Самоорганизация.

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