ACKNOWLEGMENTS

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CALCULATING AND MODELING OF INTEGRATED DISPLACEMENT SYSTEMS FOR PRECISION EQUIPMENT OF MICRO- AND NANOELECTRONICS

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I. INTRODUCTION

Today coordinate displacement systems based on actuating parallel kinematics mechanisms have wide applications in the fields of realizing of precision motions with number of degrees of freedom up to six inclusive [1–3]. These systems consist of actuating mechanism, drives and control system, but the actuating mechanism is main part which determines the technical characteristics of displacement system. Parallel mechanisms have many possible structural configurations [4, 5] in contrast to sequential mechanisms which have fixed number of structural implementations. As result we can say that the specific topology of parallel kinematics mechanism directly determines its kinematic characteristics.

It should be noted that there is a considerable number of applications where it is necessary to implement motions with only four or five degrees of freedom, for example, multi-axis milling machines, cutting, welding, engraving machines for processing parts using laser tools. As the research results [6…8] show, such a stock of kinematic mobility gives a higher rigidity of the mechanical structure on the whole, and this fact is often used to improve the accuracy characteristics of realizable displacements. Thus the parallel kinematics mechanisms can be used in precision equipment for micro- and nanoelectronics.

II. RECONFIGURABLE PARALLEL KINEMATICS MECHANISMS FOR DISPLACEMENT SYSTEMS

The investigation of parallel mechanisms in terms of the possibility of their structural reconfiguration is actual task for design of equipment. Such mechanisms, with the ability to structural reconfiguration, allow us to change their structure in order to adapt to the requirements of new tasks and the environment. As such requirements may be, for example, a change in the degree of mobility, restrictions on the force torque characteristics or parameters of the workspace.

The main idea of constructing reconfigurable mechanisms of parallel kinematics is based on the use of modularity and uniformity of components (kinematic chains, nodes) of their structure. By mechanical detachment of one, two or three kinematic chains, the original mechanism can be reconfigured into a new mechanism of parallel kinematics with five, four or three degrees of freedom, respectively.

Kinematic analysis of any actuating spatial mechanism, including parallel kinematics, is based on the investigation of the position functions of all links obtained from the condition of closure of the kinematic chain consisting of input links and structural groups, the attachment of which to the latter does not change the overall mobility.

In the most general case, the actuator consists of a structural group including a platform and six connecting rods with spherical pairs (Figure 1).

The connecting rods may have different lengths, but all their free joints in relation to the platform describe the geometric locus lying on the corresponding six spheres with center at points A_i and $r_a d_{ii}$ $r_i=A_iN_i$ (i=1,2,…,6), as it shown on Figure 2.

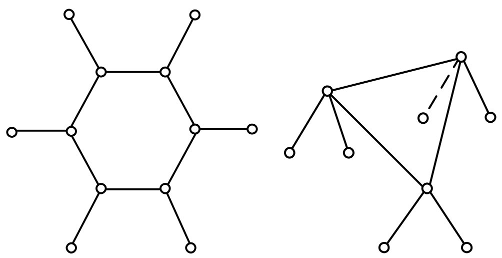

Figure 1 – Kinematic structural groups with 7 elements

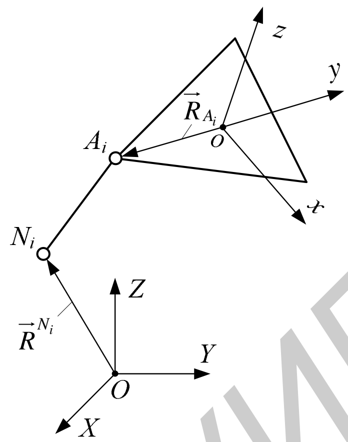

Figure 2 – Generalized representation of parallel mechanism

To find the position function, the topology of these moving spheres is considered in the fixed coordinate system XYZ (Figure 2), in which the trajectory of the points N_i as points belonging simultaneously to the structural group and to the moving parts of the actuating motors will be specified.

From the Figure 2 we can see that the set of points on the i-th sphere is determined by the radius-vector R_{Ai} specifying the position of the center of the sphere Ai in the coordinate system of the platform $\{x_i,y_i,z_i\}$ and the radius of the corresponding sphere, equal to $l_i=N_iA_i$, as the constructive parameter of the mechanism in the form of the length of the i-th connecting rod N_iA_i.

The necessary condition for the closure of the kinematic chain of the actuator will be geometrically formulated as a condition for common geometric places of the corresponding spheres and trajectories of the motion of the movable elements of the motors participating in the formation of spherical pairs with free elements of the structural group.

Depending on the type of engines used and their location in space, the trajectories can be completely different with different arrangements corresponding to moving spheres. The topology of the geometric places of the structural group under consideration is invariant, and independent of the drive used.

In general, the problem of the kinematics of any mechanism, including the parallel mechanisms, is based on the configuration of its kinematic chain from the structural groups of zero-mobility and the leading links directly belonging to the motors used.

Two possible displacement systems for equipment of micro- and nanoelectronics with reconfigured structure of parallel mechanism are shown on Figure 3 and Figure 4.

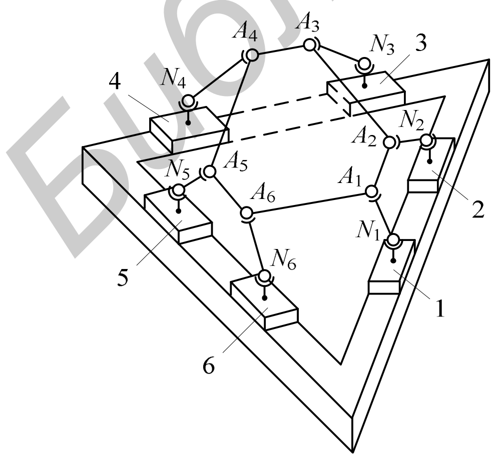

Figure 3 – Displacement system with 6 linear actuators on triangle stator

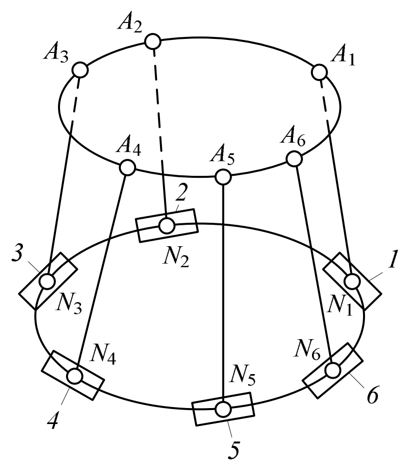

Figure 4 – Displacement system with 6 actuators on annular stator

Mathematical description of the position of all moving elements of the displacement system and their trajectories can be performed on the basis of vector and matrix calculus methods and methods of analytical geometry.

III. DISPLACEMENT SYSTEM FOR AUTOMATIC ADJUSTMENT OF PROJECTION SYSTEM OF PHOTOLITHOGRAPHIC EQUIPMENT

Characteristics of high-resolution projection systems for technological equipment of microelectronics are defined by the manufacturing accuracy of optical elements, the positioning accuracy of them within optical system and stability of these parameters within operating time of projection system [9].

The base adjustment principle for projection system is adapting of the size of optical element holders in order to avoid distortions, inclinations, misalignment of optical axes, and elimination of gaps when installed in the main body of the projection system [10]. This method can guarantee the characteristics of projection system within the required range of indicators, but at adjustment moment. The geometric parameters during operation are subjected to thermal drift (dynamic component) and time drift (constant component), and coordinates of optical elements can go beyond the allowable range. As result the main parameters of optical system (resolution, depth of field and image contrast, distortion) will be violated.

We propose to perform all adjustment operations in automatic mode on the assembled objective by using a computer-controlled system of small spatial displacements in the form of two kinematically connected rings that are embedded in the lens in place of one mandrel [11]. In this case, one ring is fixed with respect to the lens housing, and the other with the lens is connected to it by means of a parallel kinematics mechanism on an annular multi-axis synchronous drive. Structural kinematic scheme is shown on Figure 5.

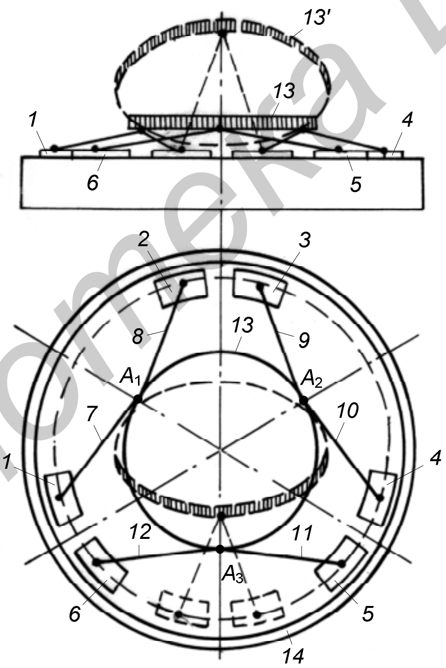

Figure 5 – Displacement system with 6 degrees of freedom on the annular synchronous drive

The necessary small changes of the position of the mandrel with the optical element at adaptive adjustment are realized by electromagnetic motion modules through intermediate kinematic chains or connecting rods with spherical pairs, eccentrics or wedge converters. As result it possible to realize the alignment of the optical system in an automatic mode at any time during the operation of the equipment. It is also possible to implement the adaptive control mode of the multi-axis drive by the boundary characteristics of the depth of field, the contrast of the image, the distortion and resolution of the optical system.

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EMISSION PROPERTIES OF AN ARRAY OF SILICON NANOCONES

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I. INTRODUCTION

At the present time, nanoelectronics expands its capabilities; new directions are developing and traditional areas are improving, such as vacuum electronics. In recent years, has developed such area as vacuum nanoelectronics which is directed to application of nanostructures with vacuum spacing, containing emitters for field emission [1, 2]. The advantages of such nanostructures are that it is not necessary to create a vacuum by airpumping, and there is no need for cathodes heating. In addition, a high speed of electrons in vacuum gaps permits to increase significantly the operating frequency of devices. The technological possibilities of creating nanoelectronic vacuum devices are determined by silicon technology. On its basis, it is possible to create vacuum silicon nanostructures, functionally analogous to traditional vacuum tubes (triodes, pentodes, etc.). For the implementation of devices of vacuum nanoelectronics in industry some problems remain to be solved, related to increasing of the efficiency of field emission of semiconductor (silicon) cathodes, the reproducibility of the formation of nanostructures, and the stability of their functioning, associated mainly with degradation of pointed cathodes.

In this paper the emission properties of an array of silicon nanocones containing cobalt nanoparticles at their vertices are investigated. Nanocons are formed on a silicon substrate by depositing a cobalt film, its processing to producing of an array of nanoparticles with a diameter of 20-30 nm, and subsequent silicon etching. Nanoconuses of silicon are separated from the conductive substrate by a layer of silicon oxynitride SiO_xN_y 8 nm in thickness. The purpose of this work is the simulation the current transfer in n-Si(Sb)/SiO_xN_y/Co nanoconesand the evaluation of their autoemission properties.

II. MODEL

To model the current transfer in the n-Si(Sb)/SiOxNy/Co heterostructure, we assume that the current transfer is monopolar, and the main mechanism of electron transport in SiO_xN_y is the capture on trap centers and subsequent ionization of such centers in a strong electric field. This mechanism is valid for the case of carrier transport in wide-gap semiconductors and dielectrics in strong electric fields at a high concentration of trap centers [3]. SiO_xN_y is characterized by a relatively high concentration of traps. To increase it, an electric breakdown can be carried out, which results in a prebreakdown condition characterized by an increase in the trap concentration almost up to 10^{20}cm^{-3} [4]. In this case, the current-transfer equation and the Poisson's equation, taking into account trapping and ionization in the stationary case, reduce to a system of equations of the form of [5]:

$$n_t(F) = N_t[1 + (q/J\sigma)P(F)]^{-1} \quad (1)$$