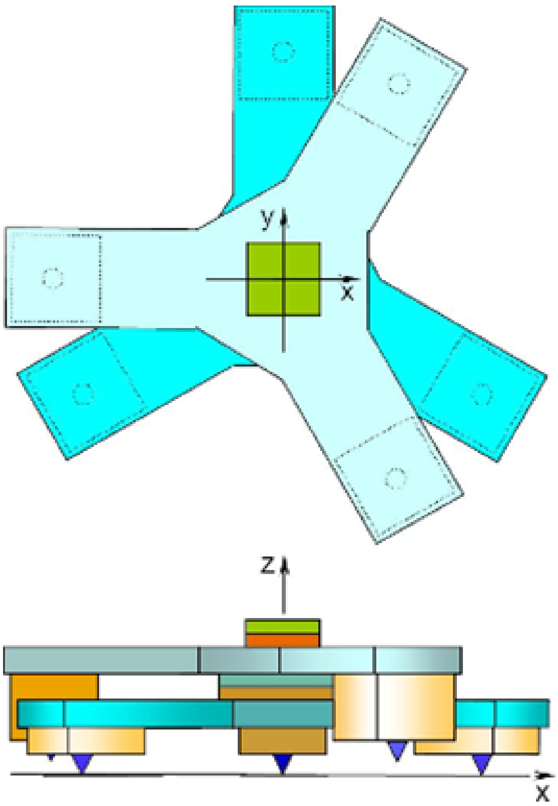
S&TRF
НАУКА И ТЕХНОЛОГИИ РФ

October 18 | Innovation

RUSSIAN SCIENTISTS INVENTED A WALKING ROBOT-NANOPOSITIONER

A new conception of the adaptive nanopositioner – a device capable to move stably on a rough surface with a very small step of several tens of nanometers has been developed at the Institute of Physical Problems named after F. V. Lukin (Zelenograd). According to suggested idea, the walking nanopositioner walks literally on a surface by detaching some supports and installing others instead. In comparison with other types of positioners, the main advantage of walking positioners is that they have an unlimited range of travel.



The walking robot-nanopositioner (an embodiment of the suggested device is shown in figure) is intended for precision movement of micro/nanoprobes, investigated samples, technological substrates, micro/nanosensors, micro/nanotools, etc. that at present is required in such fields as scanning probe microscopy (SPM), nanotechnology, micromechanics, molecular biology and others.

Why the walking nanopositioner is called robot? Dr. **Rostislav Lapshin**, a staff scientist from the institute, explains: The point is that the walking nanopositioner automatically determines the location on a bearing surface where the transferring support should be put so as this support would remain stable after its installation on the surface. This process is random in existing devices. Exactly the high stability of the installed supports allows for excluding uncontrollable nanometer shifts of the positioner during operation. To implement this strategy, the positioner possesses a sort of machine vision. The function of machine vision is implemented by measuring micro/nanotopography of bearing surface within a neighborhood of location, where the support is supposed to be installed, followed by realtime recognition and analysis of the obtained topography on a computer.

Since we are talking about distinguishing nanoroughnesses, i. e., surface elements with linear dimensions that are less than a light wavelength in visible region, the robot's machine vision cannot be built on a video camera "looking" in an optical microscope on imperfections of the surface by which the positioner moves. In addition, the overall dimensions of such apparatus would be unacceptably large. In the suggested robot-nanopositioner, which has miniature sizes, determination of micro/nanotopography of a bearing surface is carried out by scanning this surface with a probe located on the support like in a scanning tunneling microscope (STM) or in an atomic-force microscope (AFM). Moreover, in contrast to the existing walking positioners, our positioner detaches completely support off the surface during its movement that excludes uncontrollable shifts of the device, which appear inevitably because of friction between the rough support and the rough surface.

In addition, the positioner during operation continually determines and compensates for its own spatial drift caused by thermal deformations and creeps. This feature makes the device weakly sensitive to temperature changes of environment. When one has deal with nanoscaled objects, the equipment becomes extremely sensitive to external disturbing factors – vibrations, temperature changes, electromagnetic fields. It is worth noting that the negative influence of drifts in our apparatus is eliminated by applying both active compensation methods ("intelligent" control) and construction solutions (symmetrical arrangement of the functional units, opposite connection of the support drivers, using materials with a low thermal expansion coefficient, and using thermal compensators with a negative thermal expansion coefficient).

The proposed robot-nanopositioner is capable to work both in air and in vacuum; it operates in two configurations – “feet up” and “feet down”. In the “feet down” configuration, the robot-nanopositioner capable to move directly by a rough surface of large-sized objects under investigation without necessity of their disassembling or disintegration. The robot-nanopositioner is not autonomous; it is supplied with electric power to operate drivers and sensors as well as with control signals from an external computer. The robot-nanopositioner under consideration can be built in a scanning probe microscope (SPM), a scanning electron microscope (SEM), a focused ion-beam (FIB) system, an Auger electron spectroscopy (AES) system, an optical profiler (OP), and in a number of other instruments.

It should be noted that the suggested conception of walking robot-nanopositioner embeds well into the methodology of feature-oriented scanning (FOS) that is being developed in the Institute of Physical Problems for many years. The FOS methodology opens a way for building completely automated experimental probe bottom-up nanofabrication. In such nanofabrication, creation of new materials and devices is performed at room temperature by means of elementwise assembly of nanoparticles, clusters, molecules or even of separate atoms.

More details about FOS can be found in the article “Feature-oriented scanning probe microscopy: precision measurements, nanometrology, bottom-up nanotechnologies” recently published in the journal Electronics: Science, Technology, Business (special issue “50 years of the Institute of Physical Problems”, pages 94-106, 2014, in Russian). It is noteworthy that once a movement has been performed by some route during a nanotechnological process, the walking robot-nanopositioner is capable to remember the coordinates of features (pits) of bearing surface which were used in the course of the movement for support installation, after that this route can be precisely reproduced as many times as necessary.

Design and control method of the walking robot-nanopositioner have been patented (patent of Russian Federation “Walking robot-nanopositioner and method of controlling movement thereof”, no. 2,540,283). This invention has been recognized as perspective by the Federal Institute of Industrial Property (FIPS) and has been inserted into the special database “Perspective Inventions” (IMPIN).