The possibility of using hybrid nanoscope in nanodiagnostics for security and defense

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Development, application and expansion of nanotechnologies generates a complex of threats and risks to national security and human life. The main causes of these threats are small geometric dimensions of nanoparticles and as a consequence their high penetrating power, reactivity and adsorption activity. Risks in connection with the development of nanotechnology relate to the production of nanomaterials and nanosystems of different structure and composition, many of which have a dual purpose. So, there is a growing role of nanodiagnostics, which should provide the means and methods of metrological support of production processes, monitoring and research of nanostruktural objects. Because of the variety of structure and composition of nanoparticles and nanocomposites, their identification and quantitative characterization is challenging. Data about the structure and composition of nanomaterials is obtained through the use of various types of microscopes. Electron and probe microscopy allow basically get two-dimensional images and it is difficult to obtain data on the internal structure as well as to do this without the distortion caused by pretreatment of samples.

Examination of the internal structure of objects and acquisition of three-dimensional images may be done by using the X-ray radiation. It practically does not interact with objects and in many cases does not require special preparation of the samples. Research can be conducted in air including the liquid phase and in a vacuum. Today, nanofocusing the x- ray microscopy is rare used because of low resolution (20 nm on the synchrotron and 50nm on the demountable X-ray tubes), high cost, large dimensions and high operating costs.

Modern research needs of the surface and structure of the objects on the micro and nanoscale are beyond the scope of a single method of research. One and the same microscope can not be equally adapted for use with the variety of objects. Combining methods allows to obtain detailed information on the chemical composition and structure of the sample using two or more methods without changing the position of the sample. To better meet the needs of nanotechnology the new hybrid instrument was developed. It's economy and modular design allows to combine the basic types of microscopes, as well as spectroscopic detectors. It is possible to change device specialization by replacement, extraction or adding the individual modules with minimal cost.

The base of the hybrid is a SEM microscope in tabletop configuration, and the main element is the electron probe module, which consists of a column with an electron gun and elements of the vacuum system. Column is a system of magnetic lenses with deflecting systems inside them. To maximize the density of electron beam, a system of the lenses with the optimal focusing was applied [1]. The electron gun is beneath, and objective lenses and the objects are a top. Collection of secondary and elastically scattered electrons is conducted through the OL with the aid of the detectors in front of the OL. After the OL there is a free space, where the detectors for transmitted electrons and X-ray can be installed, as well as probe and optical microscopes , x-ray spectral detectors and other devices. Such a construction enables to investigate the same area of the object with different means.
HN is focused on work with objects, that have dimensions in the range of a few millimeters. This allows on one hand to reduce the size and

manufacturing cost of the device and on the other hand - to improve the resolution by using the short-focus objective lens (OL) with small aberrations.

SEM is put on a transmission X-ray microscope regime, when the target (a thin layer of metal) is installed under the electron beam on a vacuum-tight substrate, that transmits X-rays on the air to the object and the X-ray detectors. For accurate and fast focusing of the electron beam on the target a secondary electron detector is used [2], since with nanoscale electron beams due to the low X-ray intensity is almost impossible to maintain focus via x-ray detection. To increase the resolution in the x-ray near focus mode is used micron and submicron substrate, that are used for minimizing the distance between the focal spot (the electron beam on the target) and the object. X-ray microscope operates in the projection mode, when the electron beam is placed at the target point, and the x-rays transmitted through the object is registered by the coordinate-sensitive detector. Furthermore, when scanning the beam over the target and using X-ray detectors with variable aperture one can receive X-ray image of the object, whose resolution is determined by the aperture of the detector. The use of multiple detectors allows to obtain multiple images from different angles to produce three-dimensional images.

The nanoscope utilizes the tungsten thermionic cathode operating under accelerating potential 1-HN has following main modes and parameters:

№	Name of mode	Conditions	Max. resolution (nm)
1.	Scanning mode in secondary electrons	vacuum	2-3
2.	Scanning mode in transmission electrons	vacuum	1-2
3.	Scanning mode in elastically scattered electrons	vacuum/air	10
4.	Projection x–ray mode	vacuum/air	20-30
5.	Scanning x–ray mode	vacuum/air	50

Developed device is a set of microscopes, which allows to carry out the study of nanostructured materials quickly and by different ways in vacuum and in air over a wide magnification range from a few to several million-fold respectively at micron resolution up to atomic resolution. It is simple to operate and has a small sizes with a high degree of protection against mechanical vibration and electromagnetic interference.

HN can be effectively used in the identification and quantitative characterization of the products obtained with the use of nanotechnology or containing nanomaterials. Thus, depending on the type of product one can use various combinations of the modes of operation. So, for biotechnology, medicine and pharmaceuticals it is appropriate to use a low-voltage mode at the small sizes of the device.. To work in the field a version of the device can be developed with small sizes and low power consumption. To date, for testing the design of HN several options electron- probe modules are produced (Fig.1,2) .

Figures

Figure 1

Figure 1

References

[1] Gelever, V. D. / / Izvestiya , ser. Fizichskaya, 2000, 64 (8), c. 1584.
[2] Gelever V. D. Patent RU № 2 452 052/ Russian/ 27.12.10.3.