Nanomaterials are finding increasing application in nano-, opto-, radioelectronics, etc. Their structural perfection becomes critically important. To establish dependence of the properties of these objects from their structure one requires detailed structural diagnostics. The decreasing the size and increasing the complexity of the physical processes in the studied substances makes it impossible to analyze by any particular method only. It becomes necessary complex application of X-ray, synchrotron, electron-microscopic methods of diagnosis with thorough assessment of the technological processes of the structures growth, as well as a comparison of these data together with the functional properties of the materials.

The above-described integrated approach has been applied to a variety of promising nanoscale multilayer heterostructures, which are used in spintronics, optoelectronics, radiophysics, etc. The results of investigation of the real structure of these systems by a set of X-ray synchrotron methods of analysis, as well as by electron microscopy are presented.

Joint analysis of electron microscopy, and X-ray microanalytical data for the metallic magnetic periodic systems Fe-Cr-Gd with different thickness and composition superlattices was made. Structural features of these heterostructures allowed to explain the experimentally observed differences in the magnetic properties of complexes of Fe/Cr/Gd and Gd/Dy. Firstly, these systems are characterized by the occurrence of 2-3 monolayers thick sublayer close to Gd interfaces, inside which there is an increasing of the magnetic moment of Gd. The second feature of the systems Fe/Cr/Gd (and FeCo/Cr/Gd systems) is the reducing of the magnetic moment as compared with the bulk of Gd and with the superlattice and Gd/Fe/Gd system.

Objects on the basis of alternating layers of Gd/Dy studied as an example of chiral-ordered magnetic nanostructures. It has been established that Gd in the superlattice is almost completely dissolved in Dy indicating by the absence of domains with Gd content of 100%. The influence of the crystalline quality of the layers of studied heterostructures depending on the choice of specific materials was demonstrated.

It was made a joint analysis of the X-ray, and synchrotron electron-microscopic methods data of nanoscale multilayer heterostructures GaAs/InBiAs/GaAs in which the bismuth atoms are incorporated in the crystal lattice in place of the arsenic atoms. Restored structural characteristics of these advanced materials for optoelectronics allowed to clarify the features of their electronic properties which are critical for the production of semiconductor lasers and modulators. Investigation of the structure of multilayered heterocomposition containing formed quantum wells and quantum dots of InBiAs clarified the peculiarities of the electronic band structure within the samples.

A comprehensive study of the nanoelectronic materials structure by broad set of methods allows to clarify the behavior of charge carriers under the influence of quantum effects, which not only has implications for the technological application of the studied material, but also allows to analyze the fundamental characteristics of their physical properties.

Keywords: x-ray methods, electron microscopy, nanomaterials