4.3.5. MIM LASER MICROSCOPE AS A NEW INSIGHT INTO NANOMATERIAL SCIENCE

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New generation of high-speed modulation interference microscopes is developed. These microscopes are adapted for solution of the wide spectrum of problems of non-destructive testing of modern materials, including nanostructured ones. Descriptions of optical scheme, operation principles, fundamental problems of extra-high resolution and optical metrology are presented. Measurement results for optical properties of nanomaterials, roughness parameters of extra-smooth substrates and anisotropy of photonic crystals are demonstrated. Prospects of application of modulation interference microscopy in material science and possibilities of its development for studying optical constitutive parameters of materials are discussed.

Simultaneously with development of material science, optical material examination methods were developing quickly. On the basis of this methods, many methods of non-destructive testing of materials were developed. However, application of optic microscopy methods for examination of some materials and, for example, nanostructured materials is very restricted due to insufficient resolution, while alternative methods of probe microscopy become unable to test brittle coatings without destruction.

New prospects in examination of optic properties of nanostructured materials appeared in connection with development of interference microscopy methods. Application of interference microscopy methods made it possible to extend the range of studied materials and to create the whole number of unique methods of examination of material optic properties. High spatial resolution (up to 0.1 nm in vertical direction and 10–80 nm in the specimen plane), possibility of non-destructive examination of materials and quantitative nature of obtained data allows these methods to be used as a versatile tool for studying optic properties of modern materials.

One of the mostly quick developing directions of interference microscopy is the method of modulation interference microscopy (MIM). Based on it, microscopes for solution of complex material science problems are developed successfully. Possibility to control radiation polarization and, hence, possibility of visualization of optically anisotropic inclusions is an important advantage of such microscopes.

Possibility to obtain distribution map of optically constitutive parameters of a specimen, as well as metrologically trustworthy interpretation of obtained data is another important advantage of MIM. Thus, MIM microscopes open new prospects in studying of modern nanostructured materials.

Analysis of roughness of extra-smooth surfaces. Analysis of structure and roughness of extra-smooth surfaces (for example, integrated microcircuit substrates of silicon and GaAs) is an important application direction in material science. It is known that roughness parameters of substrates along with defects presented in crystalline lattice define in great extent electric and magnetic properties of topology elements formed on them. Application of MIM for testing the roughness of extra-smooth substrates made it possible not only to determine with extra-resolution the roughness parameters of substrates, but to detect the number of defects inaccessible for other microscopy methods like low-frequency oscillations of surface shape and mechanical stresses.

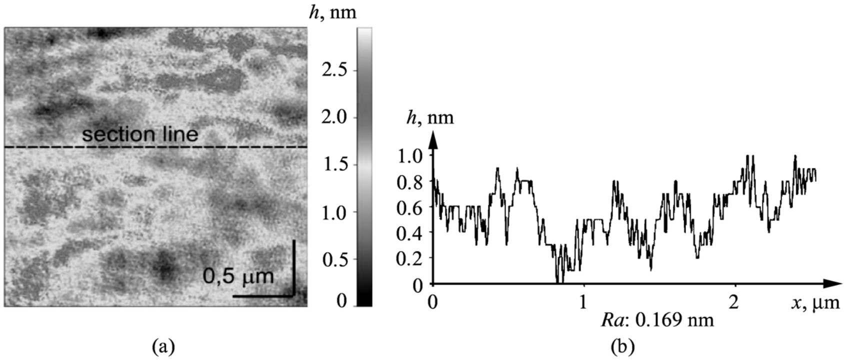

Fig. 1. Phase image of surface of extra-smooth laser mirror (a) and section of phase image (b)

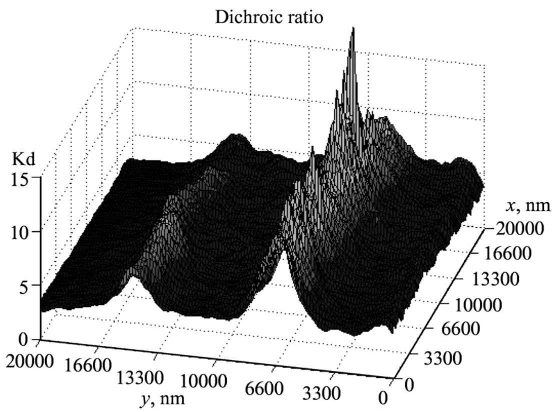

Fig. 2. Distribution of dichroic ratio of polarizing coating

One more important application of MIM is non-destructive testing of quality of multi-layer dielectric coatings during production of laser mirrors. Methods developed by us make it possible to measure metrologically trustworthy the roughness of a surface with Ra = 0.2–0.3 nm.

Polarization studies of thin films and photonic crystals. Complete control over polarization implemented in MIM makes it possible to carry out unique ellipse metric studies of thin films of various materials. Testing of quality of the LCD display coatings is an important practical application of such studies. An example of determination of dichroic ration of polarizing coating is presented.

MIM makes it possible to visualize optically active areas of crystal nanostructured materials like photonic crystals.

Conclusions. Performed researches have shown prospectivity of MIM application for non-destructive examination of optic properties of materials and development of new methods for testing the quality of complex multi-layer coatings.