Nanocomposites and nanomaterials

Analysis of nanosized multilayer structures by X-ray diffraction and SNMS

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The nanosized multilayer periodic structures (superlattices) are widely used in the advanced ultraviolet and X-rays optoelectronic devices. Their physical properties are determined by the elemental and component composition, the thickness, the homogeneity and structure of deposited layers, the presence of mechanical stress and structural defects and etcetera.

Development of the superlattice production technology requires the stepwise control of structure parameters by the analytical methods that have the nanometer depth resolution and also to provide the quantitative information about the structure and component composition of such objects. To get the crucial information about the multilayer structure can be used a combination of analytical methods such as the High-resolution X-Ray Diffractometry (HXRD) and Secondary Neutral Mass Spectrometry (SNMS).

In the present study the technique of analysis of the nanosized Mo/Si and AlGaN/GaN multilayer structures by HXRD and SNMS was developed. The structures were created by the metalorganic chemical vapor and magnetron depositions on the silicon and sapphire substrates. The deposition rates of each layer were obtained from the diffraction spectra at the different process conditions. It was established that the growth rate of individual layers in AlGaN/GaN superlattice depends on the deformation state (the growth rate increasing with the mechanical stress increasing). Simulating of diffraction spectra of Mo/Si superlattices and comparison with the SNMS experimental data are shown the molybdenum silicide phase formation at the interface. Thicknesses of such silicide layers depend on the mode and order of deposition and are: 0.5-0.8 nm Si on Mo and 1-1.5 nm for Mo on Si. The combination of HXRD and SNMS methods allows to found the optimal sputtering conditions for the investigated superlattices during the layer by layer analysis and to obtain the depth resolution of SNMS method better than 1.0 nm. Also it is allowed to make the corrections of simulation of X-ray diffraction spectra and improve the accuracy and reliability in determining the structural parameters.