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NUCLEAR MICROANALYSIS AT PNPI ELECTROSTATIC ACCELERATOR

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The light ione beams have been used widely for microanalysis of solids by means of nuclear physics techniques: proton indused X-ray emission [PIXE], nuclear reaction analysis [NR] and Rutherford backscattering spectrometry [RBS]. Element composition of the bulk materials, the structure of the films and the outer layers of the solid, concentration profiles are generally considered in microanalysis of solids. The RBS and NR methods have been used for investigation of interactions of layers in multilayer multielement structures. Also detection of trace elements is actual too.

The experimental installation for element analysis was designed at PNPI electrostatic accelerator. It consists of the target chamber, Si(Li)- and crystal-diffraction spectrometers for X-rays [1], planar Si detectors for ions [2] and Ge(Li)-spectrometer for γ-rays. Spectra from the detectors are collected with CAMAC electronics and stored on MERA-60 and SM-1425 computers. The parameters of the experimental installation are given in Table 1.

The nuclear physics techniques are undestructive, highsensitive and precise. However the possibilities of the PIXE, RBS and NR methods for detection of elements with low and high atomic numbers and for measurement of their contents in the sample are different. The RBS is more sensitive to heavy elements (with atomic number Z greater then 30). In favorable cases 10^{12} at/sm^2 can be detected. In spite of the lower sensitivity for high Z elements the PIXE can give better element resolution then RBS. Nuclear reactions are ideal for the detection of low Z ($Z < 16$) impurities and hence complement RBS and PIXE. The RBS and NR techniques can give depth distribution of elements in a sample.

The simultaneous usage of these methods allows to obtaine detail and precise information on element composition from one experiment. Analytical characteristics of nuclear technigues are given in Table 2.

Table 1

Parameters of the experimental installation

Ions accelerated	p,d
Ions energy	(0.3 - 1.6) MeV
Energy resolution $\Delta E/E$	10^{-4}
Beam intensity on the sample	(1 - 10^4) nA
Beam diameter	(1 - 8) mm
Vacuum in target chamber	10^{-6} Torr
Number of samples in chamber	10
Accuracy of beam intensity measurement	$\sim$ 1%
Energy resolution of spectrometers:	
Crystal-diffraction at $E_x = 6.4$ keV	30 eV
Si(Li) at $E_x = 6.4$ keV	190 eV
Ge(Li) at $E_\gamma = 1.33$ MeV	2.1 keV
Planar Si at $E_\alpha = 2.5$ MeV	8 keV

Table 2

Analytical characteristics of nuclear physics techniques

Elements identified	Li - U
Elements resolution ΔZ	1
Sensitivity	(10^{-1} - 10^{-5})%
Accuracy	(3 - 5)%
Thickness of investigated layer	(0.01 - 10) μm
Depth resolution	< 10 nm
Lateral resolution	$\pm$ 0.5 mm

The methods have been applied for investigation of multilayer HTSC-structures [3,4] and semiconductor films of InP [5]. The results obtained allow to develop at Ioffe PTI RAS a new technologies for production of microelectronic devices.

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