IAP ACCELERATOR BASED FACILITY FOR SIMULATION AND STUDIES OF RADIATION INDUCED DEFECTS IN MATERIALS

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Report presents the programme and status of the works conducting at IAP NASU on the creation of the nanoanalytical center based on the electrostatic accelerators. The main purpose of the center is to investigate structure and composition of the reactor materials as well as to validate computer modeling of the radiation defects.

1. INTRODUCTION

Due to the necessity to shorten a long cycle of the new reactor material development novel fields of the MeV energy accelerators application appear. These accelerators are used for simulation of the radiation defects accumulation, hydrogen and helium content in the reactor materials. This allows to reduce significantly material test time and to select the most perspective materials for intrareactor tests. The second field of the MeV accelerator application is validation of the modern potentials and different empirical parameters used while computer modelling of the material radiation damages (ab-initio, molecular dynamics, Monte-Carlo etc.). Precision electrostatic accelerators and well-proven nuclear methods open possibilities for mentioned investigations and supplement possibilities of the synchrotron radiation sources and SNS facilities while their considerably smaller cost and affordability for the research institutes and universities. High resolution is of great importance for measurements of impurity distribution and damages 3D profiles in the materials. To date available resolution over surface is of 0.1 μm and depth resolution is of nanometre values. Existing photon and neutron sources are far to reach these possibilities.

Research work done at the Institute of Applied Physics of the National Academy of Sciences of Ukraine (IAP) includes the development of electrostatic accelerators for the simulation of the radiation damage and 3D characterization of the reactor materials structure and composition. IAP laboratories are well-equipped with different instrumentations and support services for the investigation of all aspects of the composition, microstructure and defect properties of reactor materials. 2 MV electrostatic accelerator is a facility dedicated to ion microanalysis of materials from atomic to microscopic levels. Some capabilities of this instrument include: Particle Induced X-ray Emission, Rutherford Back Scattering, Rutherford Forward Scattering, Nuclear Reaction Analysis, Scanning Ion Microanalysis, Ion Luminescence Spectroscopy. Different analytical instruments are also available: Laser Mass-Spectrometer with position sensitive detector, Cf^{252} Desorbtion Mass Spectrometer, Mass Spectrometer with soft ionization, Atomic Absorption Spectrometer and others.

The laboratory for ion implantation research is equipped with a high-current ion implanter with replaceable ion sources capable of operating at 150 kV. This instrument is used for high dose ion implantation and modification of surface layers of solid samples. Presently this team is busy with the design and construction of a high-current (I~50 mA) H^+/H-ion source and a cluster source.

Now we have started to assemble the AMS-4130 Accelerator Mass Spectrometer purchased from the HVEE company and intended for isotope mass analysis. Our working schedule for 2009-2010 includes the construction of another electrostatic accelerator to produce electron/positron/ion beams of energies approaching 6 MV which are to be used in both microanalyses and simulations of radiation damage at ultralow temperatures.

2. NUCLEAR MICROANALYTICAL TECHNIQUES WITH HIGH LATERAL AND DEPTH RESOLUTIONS

Laboratories engaged in reactor materials research require instrumentation capable of providing full microscopic information on the test material under identical experimental conditions. Typically, this information concerns crystal structure, grain size analysis, morphological and crystallographic texture, impurity atom depth profiles, type of chemical bond, electronic structure, impurity lattice and surface location, defect depth profiles, internal magnetic and electrostatic fields, etc.

The analytical equipment available at IAP permits one to combine several techniques in a single instrument, extract quantitative information, avoid contamination and destruction of samples.

A great variety of nuclear analytical techniques include those which utilize energetic ion beams and provide high lateral resolution. Thus, neutron- or gamma-activation which is now in widespread use has very high sensitivity (10^{-12} to 10^{-13} g) and is also applied to microanalysis. As a rule, however, high accuracy can be achieved with these techniques by means of radiochemical separation, which makes them unsuitable for fast multielemental analysis. The measurement of the depth profile using neutron or gamma activation is rather time-consuming and has uncertainties connected with the distribution of recoil atoms. The advantages of activation techniques are clearly seen in the analysis of the impurity content in the bulk of material where low detection limits (10^{-10} at.%) place them in the highest imposition in the competition with other methods. Microanalysis with ion beams has increasingly more applications to measurements of the surface impurity concentration. The basic advantages of these techniques are high accuracy reaching 1 to 3%, good lateral resolution (~0,l μm) and depth resolution (~nm) (Tabl. 1). High depth resolution allows nondestructive measurement of depth profiles. Nuclear microanalytical techniques based on a strict quantitative theory of scattering and nuclear reactions, generally do not require reference standards while in practice it is useful to employ standards to simplify measurements (especially in PIXE). These techniques are nondestructive and capable of identifying every element with as low detection limit as 10^{-6} at.%. The thickness of the layers examined depends on the ion energy and can be several μm at energies in the MeV range. Precisely controlled heavy ion beams now available permit helium and hydrogen depth profiles to be measured to high accuracy and good lateral resolution typical of nuclear microanalysis.

Table I

Typical properties of different microanalytical techniques

Technique	Elements detected	Depth resolution, nm	Lateral resolution, μm	Depth probed, μm	Detection limit, at.%	Accuracy, %
RBS	Z>1	0.3-30	0.5-5	1-10	10^{0} -10^{-3}	1-2
NRA	Z<50	5	0.5-5	1-10	10^{-1} -10^{-6}	3-5
PIXE	Z>3	500	0.5-5	1-10	10^{-3} -10^{-5}	3

At present, the lateral resolution provided by nuclear microprobes is as good as 0.1 μm. Improvements in beam focusing systems and increased ion source brightness promise a further reduction below 0.1 μm. The nuclear microprobe has two distinct advantages over the electron one: firstly, lower detection limits and, secondly, as distinct from electrons, ions are far less subject to scattering. For example, a 3 MeV proton beam after passing through a Ni foil 25 μm thick is only scattered by 0.25 μm, permitting depth analysis of films in the range of thicknesses smaller than 10 μm. The nuclear microprobe applied to single crystals has another attractive feature. Channeling and blocking affects can be employed to locate impurities in the surface as precisely as 0.02 Å, to extract quantitative information on surface atom thermal vibrations and surface chemical reactions, to

locate impurities in the lattice to a precision of 0.1 to 0.2 Å and identify the defect type and determine their concentration.

Nuclear microanalytical techniques are based on physical processes induced in the specimen by bombardment with charged particles of energy of a few MeV. The intensity of the radiations subsequently emitted from the specimen, their energy spectra and angular distributions, which depend on the ion species and energy, provide a significant body of information about the composition and structure of the specimen analyzed. The microanalytical techniques currently in widespread use employ elastic scattering, nuclear reactions, and particle-induced X-ray emission. To these techniques we can add charged particle activation analysis which is also a powerful instrument for the determination of trace elements.

2.1. Rutherford Backscattering (RBS)

Elastic scattering of light ions (typically protons and helium ions) is the most commonly used technique. The cross section for ion elastic scattering at low energies is practically similar to that for Coulomb scattering, the efficiency of the ion counting with semiconductor detectors approaches 100%, and the ion stopping power is known well enough, permitting the concentration of the element of interest to be measured using RBS to an accuracy of 1-2% without resorting to any standards.

The best resolution is achieved for ions scattered at angles close to 180°, so this technique is commonly referred to as backscattering spectrometry. Using incident ions of greater mass one can improve mass resolution. However, it is not usual practice to employ ions heavier than helium ions because of considerable radiation-induced damage in detectors and analyzed samples. In the case of thick samples the optimum conditions are realized if the mass of the element to be determined is greater than the mass of the host atoms.

Energy spectra of elastically scattered ions provide depth distribution information for all the impurities present. The depth resolution can be improved by means of a glancing geometry where the angle of incidence (or scattering) on the target surface is small. Moreover, the depth resolution depends on the beam energy spread (in electrostatic accelerators energy spread can be decreased to 100 eV), beam energy straggling in the sample and the geometry of the experimental setup. Surface-barrier detectors provide a depth resolution of 100-300 Å. High-resolution magnetic spectrometers at IAP as well as the glancing geometry permit the depth resolution to be improved to 30-50 A. The use of high-resolution, but low-transmission spectrometers leads to greater duration of the analysis and thus, longer exposition of the sample to the analyzing beam. The decreased angle between the beam direction and sample surface also creates problems in the interpretation of the data due to the migration of the beam on the target. RBS is especially useful for studying heavy impurities in a light matrix. In favourable cases, the profiles are measured to an accuracy of 2-5%. The thickness of the analyzed layer depends on the ion energy, amounting to a few um for energy of 2 MeV sufficient for most applications. To examine samples of greater thickness one has to increase the ion energy. As a rule, the analysis of the data recorded is unambiguous; difficulties, however, arise where the impurity concentration is large and varies with depth.

2.2. Nuclear Reaction Analysis (NRA)

A beam of light ions accelerated to MeV energies impinges on the sample surface to produce emission of charged particles, neutrons and gamma-rays. Since at bombarding energies below 3 MeV which are generally used in commercial accelerators for materials analysis, the Coulomb barrier inhibits reactions with heavy elements, the NRA technique is normally indicated for profiling light elements. Although the energy of incident ions is rather low, the mechanisms underlying the nuclear reactions are far from simple. Reactions with protons and helium ions normally proceed via the formation of a compound nucleus. As a result, their cross sections abound in numerous narrow resonances whose position and width exactly correspond to the parameters of the compound nucleus excited states. Reactions with d, t and ^{3}He lead to very high excitation energies of the compound nuclei (in the region near the giant dipole resonance), their cross sections

including considerable contributions from direct processes. There are, however, numerous exceptions to this rule. Thus, in the cross sections for the interactions of deutons with light even-even nuclei (e.g. ^{4}He, ^{12}C, ^{16}O, etc.) one can observe pronounced resonances, while in the radiative capture and inelastic proton scattering sometimes direct processes occur whose contribution to the cross section is significant in the non-resonance region. The absolute concentration of the element of interest is determined from the measured resonant reaction yield as well as the energy spectra of the emitted particles.

For sufficiently narrow resonances nuclear reactions provide depth resolution of 1 to 10 nm. The resolution provided by nonresonant reactions is limited by the detector resolution and beam energy straggling in the sample. The resolution achievable with semiconductor detectors amounts to tens of nm, e.g. the ^{16}O(d,a)^{14}N reaction provides a depth resolution of 13 nm and detection limit of 0,1 ppm. Tabl. 2 presents data on the detection and spatial resolution limits of this technique.

Table 2

Detection limits and lateral resolution for some resonant nuclear reactions

Element	Nuclear reaction	Resonance energy, keV	Resonance width, eV	Resolution, nm	Detection limits ($1:10^6$)
Hydrogen	^{1}H(^{15}N,αγ)^{15}C ^{1}H(^{19}F,αγ)^{16}O	6385 6421	6000 45000	4 23	30 100
Lithium	^{7}Li(p,γ)^{8}Be	441	12200	220	0,15
Boron	^{10}B(α,p)^{13}C ^{11}B(p,γ)^{12}C ^{11}B(p,α)^{8}Be	1507 163 660	18000 5200 300000	30 130 50	5000 50 100
Carbon	^{12}C(p,γ)^{13}N ^{13}C(p,γ)^{14}N	457 1748	31700 135	650 330	
Nitrogen	^{14}N(α,γ)^{18}F	1531	600	2	
Oxygen	^{18}O(p,γ)^{15}N	898 633	2200 2100	5 20	5
Fluorine	^{19}F(p,γ)^{16}O	340	2300	25	0,1
Natrium	^{23}Na(p,γ)^{20}Ne	592	600	15	0,5
Magnesium	^{24}Mg(p,γ)^{25}Al	223	<32	0,6	
Aluminium	^{27}Al(p,γ)^{28}Si	405 992	87 105	1,1 10	100
Phosphorus	^{31}P(p,γ)^{28}Si ^{31}P(p,γ)^{32}S	1018 1147	<300 <160	10	100 50
Argon	^{40}Ar(p,γ)^{41}K	1102	90	7	2000
Titanium	^{48}Ti(p,γ)^{49}V	1361	50	10	20
Chrome	^{52}Cr(p,γ)^{53}Mn	1005		9	100

2.3. Particle-Induced X-ray Emission (PIXE)

Ions incident on solid targets produce X-rays resulting from target atom ionization. A typical X-ray spectrum shows the characteristic X-ray lines imposed on a continuous spectrum which is due to bremsstrahlung of secondary electrons ejected by the ion impact on the matrix atoms. The characteristic line intensities and energies depend on the energies and probabilities of transitions between the atom energy levels. Thus, by measuring X-ray spectra with a sufficiently high energy resolution the matrix composition can easily be determined. As a rule, for the analysis the lines of highest intensity are chosen corresponding to the transitions between the lowest-lying levels. The cross section for the matrix atom ionization by incident ions is greatly enhanced

as the electron binding energy is decreased (low Z) and the ion energy is increased.

The analytical capability of the PIXE technique depends on the X-ray photon yield contributing to the continuous spectrum. Compton scattering of gamma-rays from the nuclear reactions also contributes to the continuous spectrum. In the case of nonconducting samples the target voltage may reach 10 kV. The X-ray bremsstrahlung energy in breakdown may be as high as 10 kV, seriously deteriorating the experimental conditions. Taking into account the above-mentioned effects, the lower detection limit in PIXE is estimated to be 10^{-5} wt.% for thin samples and 10^{-4} wt.% for thick samples. This is a little better than conventional X-ray fluorescence analysis can provide, and far better than the value achievable with the electron probe. The advantage of PIXE is that it provides rapid multi-elemental trace analysis. However, light elements with $Z<10$ are not readily detected with standard semiconductor detectors.

The excitation of characteristic X-rays occurs within a thin subsurface layer, the X-ray yield being largely controlled by the incident ion energy. This circumstance can be employed for rough depth profiling. An alternative technique providing, however, as poor depth resolution consists measuring in the X-ray yield for various angles of incidence.

2.4. Charged-Particle Activation Analysis (CPAA)

Charged-particle activation analysis is mostly used to determine elements with $Z<10$ in the cases where alternative techniques fail to provide the required sensitivity. The CPAA procedure is well established and was described in detail by many authors.

2.5. Channeling

Channeling can complement any of the above-mentioned techniques to improve sensitivity, locate impurity atoms in the crystal lattice more precisely, unambiguously determine the defect type and concentration, etc. If the incident ion beam is aligned with a major crystal axis, the yields of nuclear reactions with atoms sitting on substitutional sites will be decreased essentially since the incident ion does not undergo collisions with neighbouring atoms in the lattice.

The lattice location of impurity atoms can be determined by measuring the yields of backscattering, X-ray production or nuclear reactions as a function of the degree of alignment of the incident ion beam with respect to a major crystal axis. The precision achieved taking account of the distribution of the ion flux density across the channel and along the penetration depth is 0.1-0.2 Å even though the studied element is present in the matrix in concentrations ranging from a few hundredths to a few thousandths of wt.%. Ion channeling in crystals can successfully be used for profiling radiation-induced defects in implanted samples with thicknesses in the range of a few hundred to a thousand angstroms. The defect concentration and depth distribution are obtained from the backscattering apectrum of the channeled ions. The dechanneling cross section as a function of the ion energy is specific to a type of defect: $\sigma \sim E^{-1}$ for randomly displaced atoms, $\sigma \sim E^{1/2}$ for dislocations, $\sigma \sim E^{0}$ for voids and stacking faults, and $\sigma \sim E^{-1/2}$ for interstitials. In a real material a variety of defects are normally present in varying concentrations. This situation can be cleared up by using channeling incombination with the perturbed angular correlations or positron annihilation.

2.6. Nuclear Microprobe

The attempts to apply superior analytical capabilities of nuclear techniques have led to fast progress in the development of ion beam systems. The most popular are the so-called Russian quadruplet. It should be noted, however, that doublet and triplet configurations are easier to operate and provide a-beam spot of practically similar size. The beam energy spread has a pronounced influence on the chromatic aberrations in the ion optical system so it is quite understandable that the best results have been obtained with electrostatic accelerators. The beam intensity is now limited by the ion source brightness to 1nA. Considerable effort is being invested into the development of automated beam scanning system to determine the impurity atom distribution in the sample surface. The PIXE technique with semiconductor detectors shows the greatest potential. The improved efficiency of the X-ray detection is expected to result in about an order-of-magnitude reduction in time

required to measure two-dimensional distributions of elements, and hence, less severe radiation damage in the sample. Perfect ion beam diagnostics based on the detection of secondary electrons can be borrowed from electron microscopy. The attempts to create a scanning transmission ion microscope for energies in the MeV range have met with considerable success. Ion beams permit the density distribution in thin samples to be studied by measuring the ion energy loss.

As follows from the above considerations, nuclear microanalysis has matured to a powerful structure probe. High accuracy by quantitative elemental provided analysis and possibility of measuring impurity depth profiles without layer removal compensate for relatively high cost of sophisticated equipment for nuclear microanalysis. Moreover, if we add to the above advantages quantitative information on the impurity lattice- and surface location, defect type and concentration, application of the analytical instrumentation to high-energy ion implantation, a rapidly growing number of commercial accelerators and an expanding scope of their application are quite understandable.

Along with distinct advantages, nuclear microanalysis has an evident limitation which is the ion-induced radiation damage in samples.

3. THE IAP MICROANALYTICAL FACILITY

Fig. 1 shows general view of the IAP microanalytical facility. The electrostatic accelerator was designed and constructed at the National Science Center "Kharkov Institute of Physics and Technology", National Academy of Sciences of Ukraine specially for the analytical application in nuclear science and technology [1,2]. The first version of this facility included the analyzing magnet with bending function in order to decrease its cost. Vacuum system and beam transport system were maximum simplified. This limits analytical capacities and application field of the facility. During the last few years modernization and further development of the facility, i.e. entirely replacement of the vacuum system, improvement of the beam transport system and construction of new analytical channels have been accomplished at IAP. In the framework of updating analyzing and bending magnets and quadrupole electrostatic lenses were designed at IAP and manufactured at Research Institute of Electrophysical Equipment, St. Petersburg, Russian Federation.

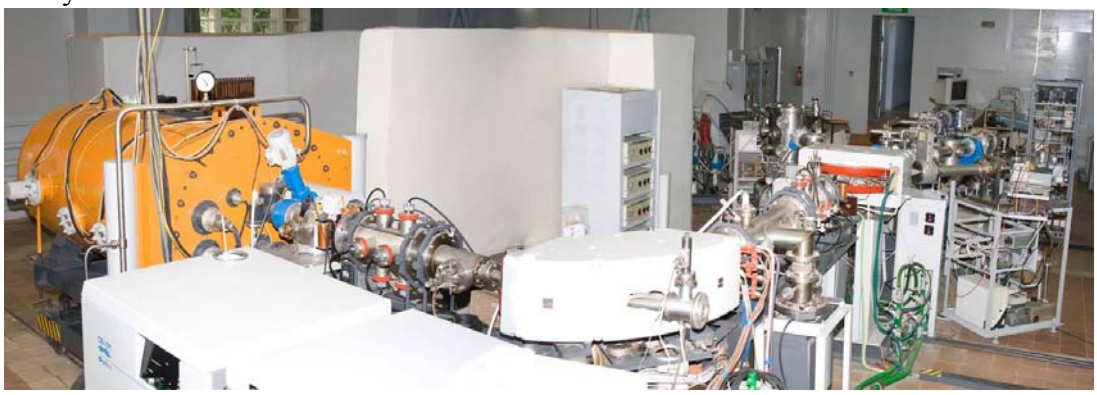

Fig. 1. IAP microanalytical facility

Electrostatic accelerator is intended for the proton beam and helium ion production and characterized by the following performance data:

- energy, MeV……0.3-2.0
- energy stability, %.....0.1
- ion type……..H^+, He^+
- proton beam current, μA……up to 50
- operating mode……..continuous
- weight, tone……3.0

In order to obtain high quality ion beams accelerator construction was modified by using ion source with permanent magnet system to increase plasma density and preliminary beam focusing [3,4], and by reconstruction of the high-voltage column and charge transporter improvements [5,6].

Fig. 2 shows block scheme of the IAP microanalytical facility.

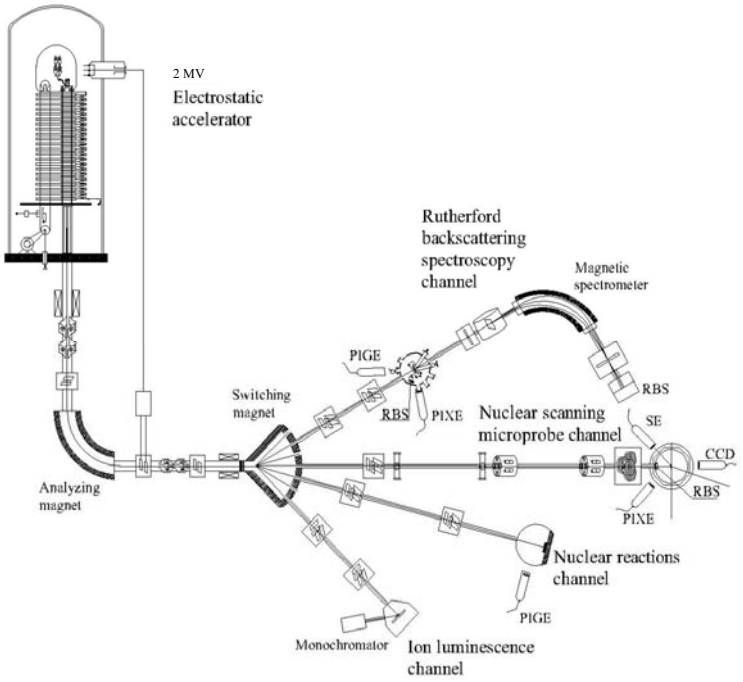

Fig. 2. Block scheme of the IAP microanalytical facility

4. ANALYTICAL END STATIONS

Fig. 3 shows general view of the analytical channels of the microanalytical facility. The facility includes four analytical channels, i.e. nuclear scanning microprobe channel, Rutherford backscattering channel, nuclear reaction channel and ion luminescence channel.

Rutherford backscattering channel with high resolution. Magnetic spectrometer with double focusing described in [7] was taken as the base of this end station. General view of the spectrometer is shown in Fig. 4.

Fig. 3. Analytical channels of the microanalytical facility

Fig. 4. Magnetic Spectrometer

This spectrometer with sector-shaped unified magnetic field has the following parameters: radius of the particle trajectory curvature in magnetic field is 320 mm, shear angle at the entrance and outlet are 46^0 and $4^051'$, respectively, gap width is 16 mm, gap height is 106 mm, distance from the source (target) to entrance into the magnet and from the magnet outlet to the detector are 400 and 700 mm, respectively. Measured value of the spectrometer solid angle is $(3.56\pm0.23)\cdot10^{-3}$ steradian. Magnet with the scattering chamber are mounted on the platform permitting to rotate it $0\text{-}150^0$ to the left and $0\text{-}20^0$ to the right related to the incident beam [5].

The facility was equipped with precision power supply [8], microprocessor controller of the data acquisition, magnetic field measurer, current integrator, power supply of the charged particle detector and preamplifier for this detector. All listed units of the spectrometer except of the magnet, platform and some parts of the vacuum system were designed and constructed at IAP. The vacuum pumping system of the spectrometer was also modified. In addition, software permitting to automate control and data acquisition during the experiment was developed [6].

Fig. 5 presents dependence of the device energy resolution on the slit width measured on a silicon sample with proton energy of 1 MeV.

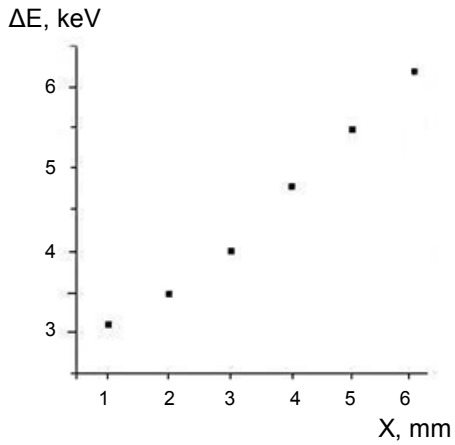

Fig. 5. Energy resolution vs slit width

Resonance nuclear reaction channel. The channel is intended for the impurity distribution profile depth measurements in the materials. Using of the proton resonance reaction allows to obtain high spatial resolution. This channel can be applied only for light elements.

Ion luminescence channel. The channeincludes a crystal monochromator operating in the wavelength range of 300-800 nm. The channel is applied to investigate chemical composition of impurities in materials.

Nuclear microprobe channel. Microprobe channel [9] is positioned at a zero angle of the bending magnet (Fig.6).

Fig. 6. Microprobe end station

The beam focusing on the target is realized by the microprobe forming system based on a separated "Russian quadruplet" with two integrated doublets of magnetic quadrupole lenses of new design [10]. Yoke and poles of each doublet are produced of a single peace of soft magnetic iron by electric erosion technique (Fig. 7). This allows to provide quadrupole field symmetry and high precision of the lens adjustment. The scanning system consists of four ferromagnetic coils. The coil commutation (X, Y,Y, X) provides a conventional scanning mode of the focused beam in the range of ±500 μm for the post-lens arrangement of the scanning system with frequency up to 5 kHz. Also (X,Y, -Y,-X) commutation permitting beam-rocking scanning mode is possible. To control beam current in the scanning coils a specific power supply was developed which was synchronized with the data acquisition system [11,12].

The target chamber is equipped with a secondary electron detector, PIXE detector (semiconductor detector AMPTEK® (XR-100CR)), scanning system, circular charged particle detector (annular surface-barrier detector ORTEC® (TC-017-050)) and CCD-equipped optical microscope. Target positioning system has two degree of freedom (X-Y). Target holder can hold up to 16 samples.

Fig. 7. Doublet of magnetic quadrupole lenses of new design

Microprobe resolution in the microanalysis mode was determined using focused beam scanning of the standard copper net with step of 1000 cell per inch and further detection of

the secondary electron emission. Fig. 8,a shows secondary emission image of the single cell. Figs. 8,b,c show secondary electron yield during the scanning in X and Y directions. Processing of the secondary electron yield diagrams shows that microprobe resolution in the microanalysis mode with I~150 pA is 2 μm (FWHM).

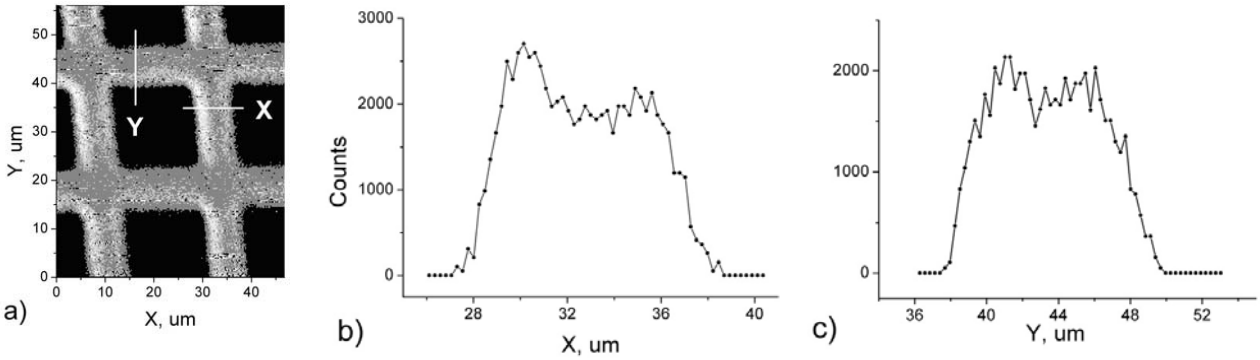

Fig. 8. Single cell of the copper net with step of 1000 cell per inch (a); secondary electron yield in X and Y directions, respectively (b, c)

5. ACCELERATOR BASED MASS SPECTROMETER

Construction of the AMS isotope mass spectrometer, model 4130, manufactured by HVEE, the Netherlands, based on the 1 MV tandem accelerator is scheduled by IAP for next year. Equipment has been already supplied to the Institute and commissioning is planned to be start in May 2009. The mass spectrometer is expected to be used for carbon-14 dating with following application with other isotopes in materials science, environmental protection, medicine etc.

6. LASER ISOTOPE MASS SPECTROMETERS

Laser mass-spectrometers developed at IAP come in two versions. Fig. 9 shows a general view of the laser mass spectrometer with a coordinate-sensitive detector in the focal plane. Also shown is the spectrum of a sample containing stannum and antimony of natural abundance. The other laser mass-spectrometer is equipped with an ICP-unit.

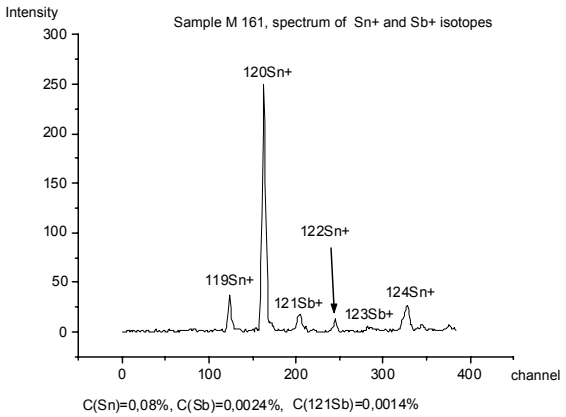

Fig. 9. Laser isotope mass-spectrometer with coordinate-sensitive detector

7. FUTURE PLAN

Study of reactor materials requires development of new experimental basis to investigate radiative defects of the reactor materials. Measurement of positron life time in materials is effective method for the low-sized defects examination. Max Planck Institute, Stuttgart, Germany has transferred to IAP an analytical facility based on the Pelletron-6 accelerator permitting to obtain positron beams with variable energy up to 6MeV. A general view of the accelerator before its

demounting and transportation to IAP is presented in Fig. 10. This accelerator is equipped also with analytical channel to measure hydrogen and helium distribution profiles in the reactor materials. This area becomes topical due to development new materials for the fast neutron reactors and the ITER fusion reactor. Analytical parameters of this channel are presented in Tabl. 3 [13].

Fig. 10. This accelerator is equipped also with

Table 3

Analytical parameters of the pelletron-6 acelerator

Methods	Type	Ions	Application	Sensitivity	Resolution
RBS	Standard	1-2 MeV He	med., heavy	10 atppm	10 nm
	Special		med., heavy	0.1 atppm	50 nm
	Special		med., heavy	1000 atppm	0.1 nm
ERDA	Standard	3 MeV He	H	10 atppm	100 nm
	Special	4.5 MeV Ne	H	1000 atppm	0.5 nm
	Special	1.5 MeV Ar	Light atoms	1000 atppm	0.2 nm
NRA	Standard	p, d, 3He	Light atoms	10-1000 atppm	100 nm
PIXE	Standard	3MeV p, He	No light atoms	1-10 atppm	none

Construction of the laboratory building and facility mounting are scheduled for 2010.

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УСТАНОВКА ИНСТИТУТА ПРИКЛАДНОЙ ФИЗИКИ НА БАЗЕ УСКОРИТЕЛЯ ДЛЯ МОДЕЛИРОВАНИЯ И ИЗУЧЕНИЯ ДЕФЕКТОВ МАТЕРИАЛОВ, ВЫЗВАННЫХ РАДИАЦИЕЙ

В.Е. Сторижко

Представлены программа и состояние работ, проводимых в Институте прикладной физики по созданию наноаналитического центра с использованием электростатических ускорителей. Главной целью центра является исследование структуры и состава реакторных материалов, а также компьютерное моделирование радиационных дефектов.

УСТАНОВКА ІНСТИТУТУ ПРИКЛАДНОЇ ФІЗИКИ НА БАЗІ ПРИСКОРЮВАЧА ДЛЯ МОДЕЛЮВАННЯ ТА ВИВЧЕННЯ ДЕФЕКТІВ МАТЕРІАЛІВ, ВИКЛИКАНИХ РАДІАЦІЄЮ

В.Ю. Сторіжко

Представлено програму та стан робіт, що проводяться в Інституті прикладної фізики по створенню наноаналітичного центру з використанням електростатичних прискорювачів. Головною метою центру є вивчення структури та складу реакторних матеріалів, а також комп'ютерне моделювання радіаційних дефектів.