APPLICATION OF ELECTROSTATIC TANDEM IN ALMATY FOR ANALYSIS OF BERYLLIUM FOILS AND RADIOACTIVE PARTICULATES.

A.Arzumanov, A.Borisenko, I.Gorlachev, A.Eliseev, S.Lysukhin, A.Platov, A.Tuleushev,
Institute of Nuclear Physics, Almaty, Kasakstan.

Abstract

The article presents an analytical techniques in current use on electrostatic tandem UKP [1] at Almaty, INP. PIXE, RBS, and NRA techniques have been used for thickness measurements of Be-foils prepared by vacuum deposition technique and for analysis of impurities in it. As an illustration of proton microprobe application the measurement of Fe, U and Pu element distribution maps of soil particulates from Semipalatinsk Nuclear Test Site are presented.

1 INTRODUCTION.

The Institute of Nuclear Physics in Almaty is the only Kazakstan Institution with a significant activity at the national level in the field of physics with accelerators, its application and associated technology. In INP, accelerators have been used primarly for basic research in nuclear and atomic physics. However, there has been a significant increase in application in materials research by broad variety of different advanced techniques using ion beam analysis. This was especially fruitful after comissioning in 1988 in INP of heavy ion electrostatic accelerator. A rather broad program is in progress around this facility. Presently the Tandem is being upgraded in the frame of a program, aimed at improving beam energy stability and decreasing beam energy spread and improving its reliability. This article gives a brief summary of just a few examples of using electrostatic tandem in INP especially in connection with powerful techniques of ion beam analysis.

2 NUCLEAR ANALYTICAL TECHNIQUES IN PRESENT USE ON TANDEM.

Accelerator based analytical techniques PIXE, RBS and NRA were developed in the INP for surface analysis of structure and element composition of wide spectrum of samples. As well the proton microprobe techniques was developed for measurement of elements distribution maps and thickness uniformity measurements of foils along a sample.

1.1 Investigation of Be-foils by accelerator based analytical methods

The possibilities for Be-foils preparation by magnetron deposition in vacuum have been studied in Almaty INP since 1996.

The thickness measurements of thin Be-foils (less than 5 μm) was performed by Nuclear Reaction Analysis. Nuclear reaction $^{9}Be(p,\gamma)^{10}B$ with resonance energy 1084 keV [2] was used in this case. Figure 1 gives gamma yield of resonance reaction as a function of proton energy for typical Be sample. As it indicated in the picture, Be foil thickness corresponds to 8 keV proton energy loss at 1 MeV and averages ~140 nm (these calculations were

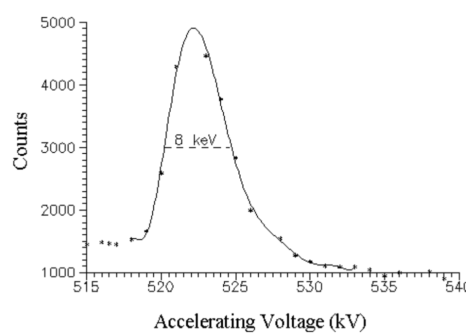

Fig. 1 Yield curve of nuclear reaction $^{9}Be(p,\gamma)^{10}B$, energy of resonance 1084 keV

carried out using TRIM software). The quality of produced Be foils are strongly depends of amounts of impurities in deposited layers. PIXE techniques was used for impurity measurements in Be foils. It can be seen in Figure 2 that at least such elements as Ti, Cr and Fe are presented in Be foil.

Proton Rutherford backscattering technique was used to measure concentration depth profile of light elements O, N, C in berillium samples. Fig. 3 shows RBS spectrum of protons at the incident energy 840 keV for Be target with distinct peaks of oxigen and carbon. Presence of accompanying nuclear reaction $^{9}Be(p,\alpha)^{6}Li$ and $^{9}Be(p,d)^{8}Be$ [2] gives rise to high energy part of spectrum induced by α-particles and deutrons (the rise is marked off by '?' sign on spectrum).

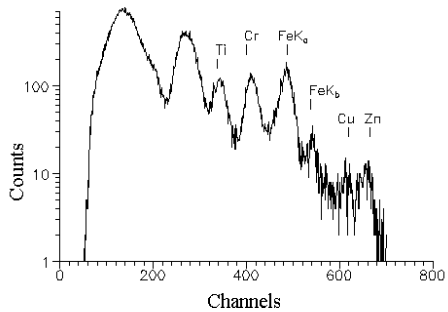

Fig.2 Characteristic PIXE spectrum resulting from irradiation of Be foil by protons with energy 680 keV.

This circumstance deteriorates sensitivity of the method for quantitative analysis of light elements.

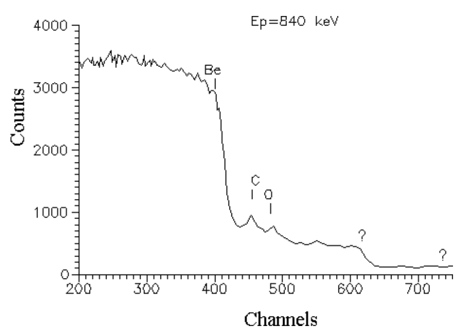

Fig. 3 Characteristic RBS spectrum resulting from irradiation of Be foil by protons with energy 840 keV.

1.2 Determination of nickel diffusion into copper by NRA

At the time being work on different radioisotopes production at the isochronous cyclotron of INP is in progress. For preparing reliable cyclotron isotope targets different procedures are used. As an example Ni target used for production of ^{57}Co is considered. Nickel is electroplated on copper backing, and the target is annealed in vacuum. Arisen diffusion layer between nickel and copper determines in main part mechanical rigidity of the target. In this connection the electrostatic tandem is used for investigation of Ni diffusion depth and its profile at different conditions of annealing. In fig.4 distribution of Ni before (curve 1) and after annealing at 300°C during 2 hours (curve 2) and at 450°C during 2 hours (curve 3) is presented. For this procedure Resonance Nuclear Reaction ^{58}Ni(p,γ)^{59}Cu at the energy 1424 keV was used.

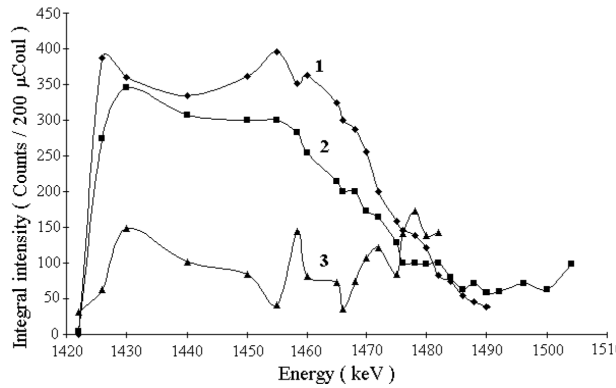

Fig.4 Characteristic NRA spectra for determination of Ni distribution before and after annealing

3 NUCLEAR MICROPROBE ANALYSIS OF RADIOACTIVE SOIL PARTICULATES.

Institute of Nuclear Physics in collaboration with other scientific organizations of Kazakstan and Russia is conducting investigations on artificial radionuclides pollutant distribution at Semipalatinsk Nuclear Test Site with the aim to study the influence of radioactive pollutants on environment and human health. At the time being the systematic data on distribution and form of existence of transuranium elements in the region are absent. The aim of the reported work is to measure elemental composition of radioactive polluted soil particulates from Semipalatinsk for understanding of nature of these particulates , their origin and behaviour in environment during long period of time. The main features of microbeam facility such as high sensitivity, non destructive analysis of matter make it an ideal instrument for conducting research and give an unique opportunity to investigate the separate "hot" radioactive particulates . It consists of collimator system, movable Faraday cup , vacuum pumping station, subsidiary slits, doublet of electrostatic quadrupole lenses, electrostatic deflector and target chamber. Total length of the system is about 6 m. Fig.5. shows the layout of the UKP microbeam line. The computer model of the channel was made with the help of the MULE program. The measurement of the microprobe sizes was executed on quartz glass. Optical microscope with 100-times amplification was focused directly on frontal surface of the quartz glass, where a beam was entered. By adjustment of object collimators, secondary slots and high voltage on electrodes of focusing system it was possible to obtain a size of the probe on a target equal to 13×13 μm^2 with a current ~1 nA. Scanning with microprobe is performed ‘step by step’, with spectra acquisition in each point. The acquisition stop in each point was made by integral of a current on a target.

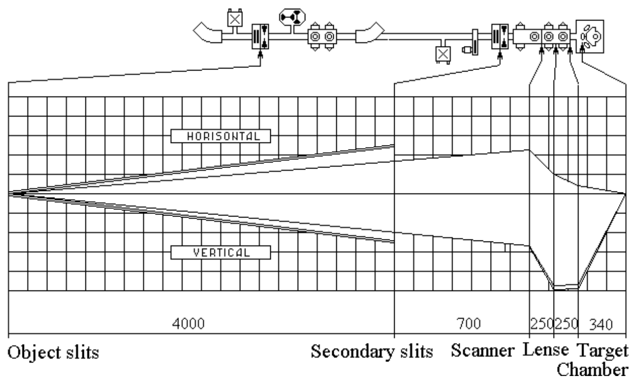

Fig.5 The layout of a microbeam facility. Sizes are given in millimeters.

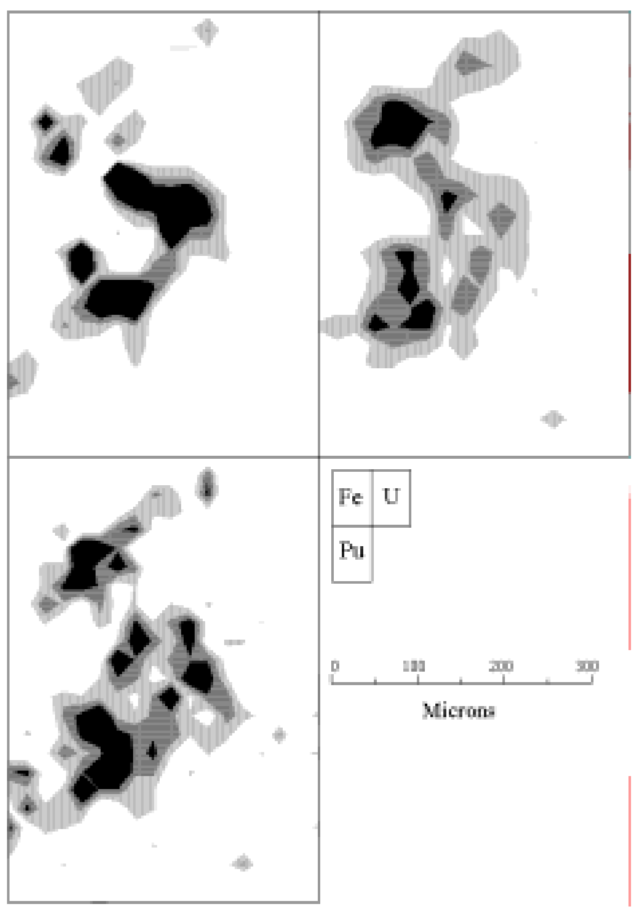

Fig.6 Maps of Fe, U and Pu distribution in the particulate from SNTS.

Maps of Fe, U and Pu distribution in a particulate are represented on fig.6, residual radioactivity has an increased background. The particulate was selected from ground from Semipalatinsk Nuclear Test Site. A size of a particulate was ~450 × 500 μm^2. Beam spot on the target was ~30 μm. There was no need to reduce a beam spot because of a large grain of a particulate surface. Step of scanning was 25 μm. As it can be seen on fig.6, distribution maps for all three elements are almost coinside. These measurements are a base for understanding of processes, occurring at high temperature and pressure. This work is still in progress.

4 CONCLUSIONS

After upgrading of the electrostatic tandem accelerator in Almaty different advanced nuclear physics analitical methods were developed including microbeam technique. They have allowed to perform a number of experiments on determination of thickness and purity of beryllium foils, on depth profile measuring of the cyclotron isotopes target, and also to obtain maps of Fe, U and Pu distribution in radioactive particulates taken from Semipalatinsk Nuclear Test Site. These experiments will be continued.

Acknowlegments

Authors would like to express their gratitude to ISTC for support of this work.

REFERENCES

[1] Golubev V.P., Ivanov A.S., Nikiforov S.A. et al. ″Design features and operational parameters of charge-exchange heavy ion accelerator UKP-2-1″. Proc. of the 2-nd EPAC, Nice, France, June 12-16,1990, v.2, 1852-1854.

[2] M. Shaanan, R. Kalish and V. Richter, Nucl. Instr. and Meth. B16 (1986) 56.