New experimental target chamber for simultaneous PIXE, PIGE RBS and PESA analysis

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ABSTRACT

A new experimental target chamber for simultaneous PIXE, PIGE, RBS and PESA analysis has been recently set into operation at 3.5MeV Van de Graaff accelerator of Nuclear Physics Institute at Řež. The target chamber is mostly used for the size resolved atmospheric and combustion aerosol analysis and for the biological and environmental samples analysis. However a variety of other samples including industrial and solid state physics applications have been also analysed. A computer control three axes sample changer can reach every point within the 5x50cm frame and an angle from -30° to 90° between the sample normal and the incident beam can be adjusted. The chamber is equipped with two Si(Li) detectors used for low and high Z element analysis, 30% HPGE detector for PIGE analysis and two surface barrier detector for RBS and PESA analysis. An original system for the independent dead time corrections using the RBS monitor (based on detection of protons back-scattered from 0.5µm thick Ni foil) counts gated by the dead time signals from individual spectroscopic lines is applied.

Keywords: PIXE, PIGE, RBS, PESA, IBA, Target chamber

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1. INTRODUCTION

About two years ago, a new experimental target chamber for ion beam analysis (IBA), was set into operation at Nuclear Physics Institute at Rez near Prague. The 3.5MeV Van de Graaff electrostatic accelerator serves as a source of accelerated H and ⁴He ions. The chamber was design to be used for simultaneous measurements by more analytical techniques. At present, we can use up to four independent spectral lines. The most common arrangement used is the set-up with two PIXE (particle induced X-ray emission analysis) Si(Li) detectors (Low Z, 30mm², 170eV resolution and High Z, 80mm²,190eV resolution), 30% HPGE detector for PIGE (particle induced gamma-ray emission) analysis and surface barrier detector for RBS (rutherford backscattering) analysis at 165 degree scattering geometry. Another detector for the proton elastic scattering analysis (PESA) can be used instead one of the PIXE detectors (or HPGE). The chamber is designed to allow a maximum diversity for different experiments set-up. In the following text, some examples of chamber use are described.

2. EXPERIMENTAL

The chamber is designed to be fully computer controlled. The computer controls the whole procedure of the sample measurement, carousel moving and data acquisition. The VNC viewer computer code can be used to check the process anywhere from the local net. An original system consisting of thin Ni foil RBS detector and set of independent counters gated by dead time signal from individual spectral lines is used for on line dead time correction separately for each detector. The chamber is equipped with three axes sample holder, which can move the samples by 50cm vertically and 5cm horizontally. Further an angle from -30° to 90° between the sample normal and the incident beam can be adjusted. The samples are
inserted into 55 x 600mm sample frames, which can be individually designed for different sample types, as membrane filters, pressed pellets or samples from cascade impactors. Variety of other samples can be also fixed into this relatively large sample holder.

3. RESULTS AND DISCUSSION

3.1 ANALYSIS OF AEROSOL SAMPLES

An analysis of the atmospheric aerosol samples is a major application for which target chamber was designed. The example (on fig.1) shows a size-resolved study of the atmospheric indoor-outdoor aerosol composition in the Prague region. The Berner type low-pressure impactor (BLPI) [1] was used to collect the aerosol particles. The individual aerosol deposit spots (shown below on picture) were analyzed by PIXE at two beam energies of 1.31MeV and 2.93MeV. The RBS and PIGE spectra were also collected. The typical PIXE spectra measured at 2.93MeV proton beam energy is depicted on the left side of figure 1. On the right side of the picture the rough mass-size distributions for four selected elements and one pair of indoor-outdoor measurements are also shown (Blue-outdoor distribution, violet-indoor distribution). More about this study will be presented at [2].

3.2 OTHER APPLICATIONS

Recently a study of the fluorine determination in thick biological samples comparing INAA, PGA and PIGE has been done at our institute. The PIGE measurement was done in here described chamber. More about this study can be found in [3]. The PIGE method is also suitable for other light element determination as B, Li, Na, Mg, Al, in environmental, biological and geological samples.

The target chamber was designed to allow a maximum variability during the experiments. The next example (on figure 2.) shows the in situ measurement of the H, C and O content in the 12µm thick polyethylene terephthalate (PET) foil during the high energy implantation with the 1.76MeV alpha particles. The transmission energy recoil detection analysis (ERDA) at zero degree scattering angle geometry and RBS analysis were performed simultaneously. The Ni-foil monitor was removed during this measurement and the implanted dose was controlled by the RBS spectra signal height. Results of this measurement will be presented at [4].

Figure 1. En example of the PIXE analysis of the BLPI impactor sample.
3. CONCLUSION

During the first two years of operation the chamber was successfully used for a variety of analytical tasks and it has been proved that it is well designed for different kind of analytical techniques and various samples.

The simultaneous measurement by more IBA techniques gives several advantages as, more complex characterisation of measured sample (more elements determined, information about sample thickness and structure, mass resolution for RBS etc.), independent control of analytical procedures if some elements are analysed by more methods, independent monitoring of collected charge by the RBS technique.

There are also some disadvantages of simultaneous measurements, for instance, in many cases it is difficult to find optimal conditions (as beam energy, sample geometry, counting rates) which will optimally suited for all methods.

The simultaneous measurement gives also a possibility of advance spectra evaluation where the information about the sample composition or structure obtained by one method can be used to improve the analytical results obtained by another method. This could be done in successive iterative mode or by simultaneous fitting of different types of spectra. There is still a lack of appropriate computer codes for such kind of data evaluation.

ACKNOWLEDGEMENTS

This work was supported by the GACR under the GRANT No. 205/03/1560

REFERENCES